



SCHEDULES

for

**Design, Construction and Maintenance of the AURIC Hall Building for
Phase - I in Shendra-Bidkin Industrial Area (SBIA), Aurangabad,
Maharashtra State on EPC Basis (Package - IV)**



September 2016

Managing Director

Aurangabad Industrial Township Limited

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SCHEDULE-A

Schedule A – The Project Site

1.0 The Site

- 1.1 Site of the AURIC Hall Building located as a part of the CBD of AURIC - Shendra Industrial Area is as described in **Annexure-I** of this Schedule-A.
- 1.2 The dates of handing over the Site to the Contractor are specified in **Annexure-II** of this Schedule-A.
- 1.3 An inventory of the Site including trees and any other immovable property on, or attached to, the Site shall be prepared jointly by the Employer Representative and the Contractor, and such inventory shall form part of the Agreement.
- 1.4 The Draft Land Use Plan showing the AURIC Hall Building Site is specified in **Annexure-III**. The applicable Development Control Regulations for the site are the Integrated Industrial Area DCRs issued vide notification (No. TPB 4314/20/CR-32/2014/UD-11) dated August 1, 2015
- 1.5 Information on the topographic condition and levels within the site is given in **Annexure-IV**
- 1.6 The status of the Environment clearances is given in **Annexure-V**.
- 1.7 The overall site plan for the AURIC Hall Building is given in **Annexure-VI**.

Annexure I – Site

1. Site

The AURIC Hall building site admeasures 11,335 sq.mts and is located in the North-western part of the CBD campus of AURIC-Shendra. The AURIC Hall site has a 45m Road ROW on the western side and the main access to the building is from the 45m Road ROW on the northern side of the plot. The eastern side of the plot is proposed as an open space and a potential public parking area where as the southern side is bounded by another developable plot.

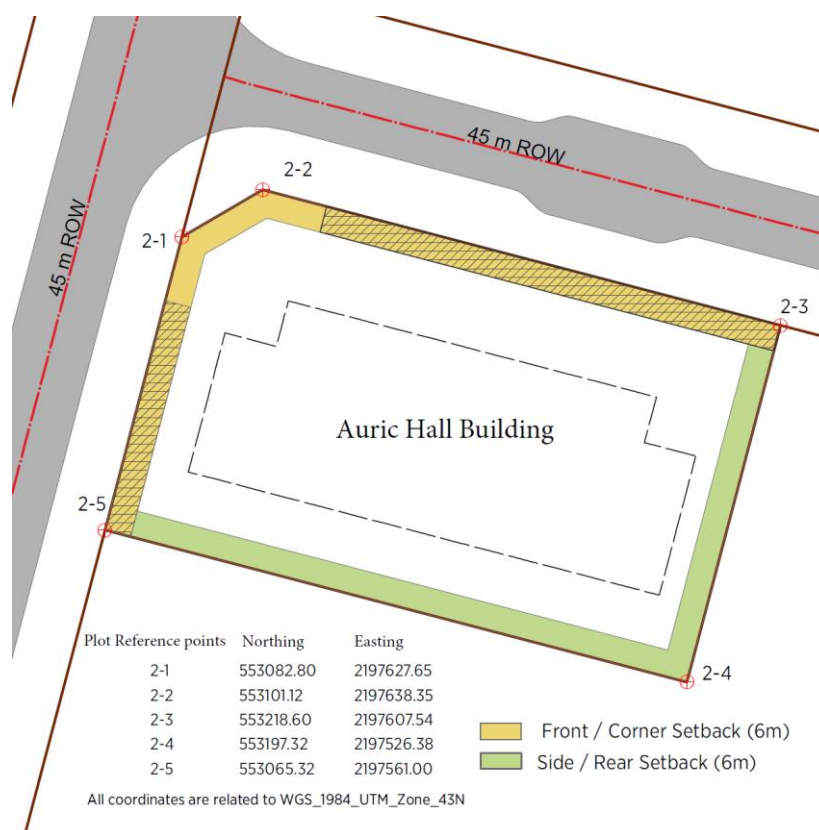


Figure 1: Location map of the AURIC Hall Building site within the CBD of AURIC-Shendra Industrial Area

Future infrastructure connections for water supply, power supply, ICT, sewerage network and storm water disposal will be available long the northern and western road ROWs. Additional common parking and open space is planned on the eastern side of plot.

The site for AURIC Hall Building lies within the following coordinates:

(refer Figure 1) (All coordinates are related to WGS 1984 UTM Zone 43N)

Plot Reference Point	Northing	Easting
2-1	553082.8036	2197627.647
2-2	553101.1184	2197638.35
2-3	553218.6024	2197607.536
2-4	553197.3172	2197526.384
2-5	553065.324	2197561.004

1.1 Seismicity

The AURIC Shendra Industrial Area falls under the Zone III of the Seismic zoning map of India – IS: 1893-2002.

1.2 Existing Features and Utilities / Services

There are no utilities/Services available on site.

Annexure II – Land Details

1. Proposed Land Use

The land on which the building is proposed is the land under ownership of MIDC acquired under the MID Act for the development of AURIC – Shendra Industrial Area. The proposed land use is that of Amenity Plot (Central Business District) where permissible uses include commercial buildings and office buildings etc.

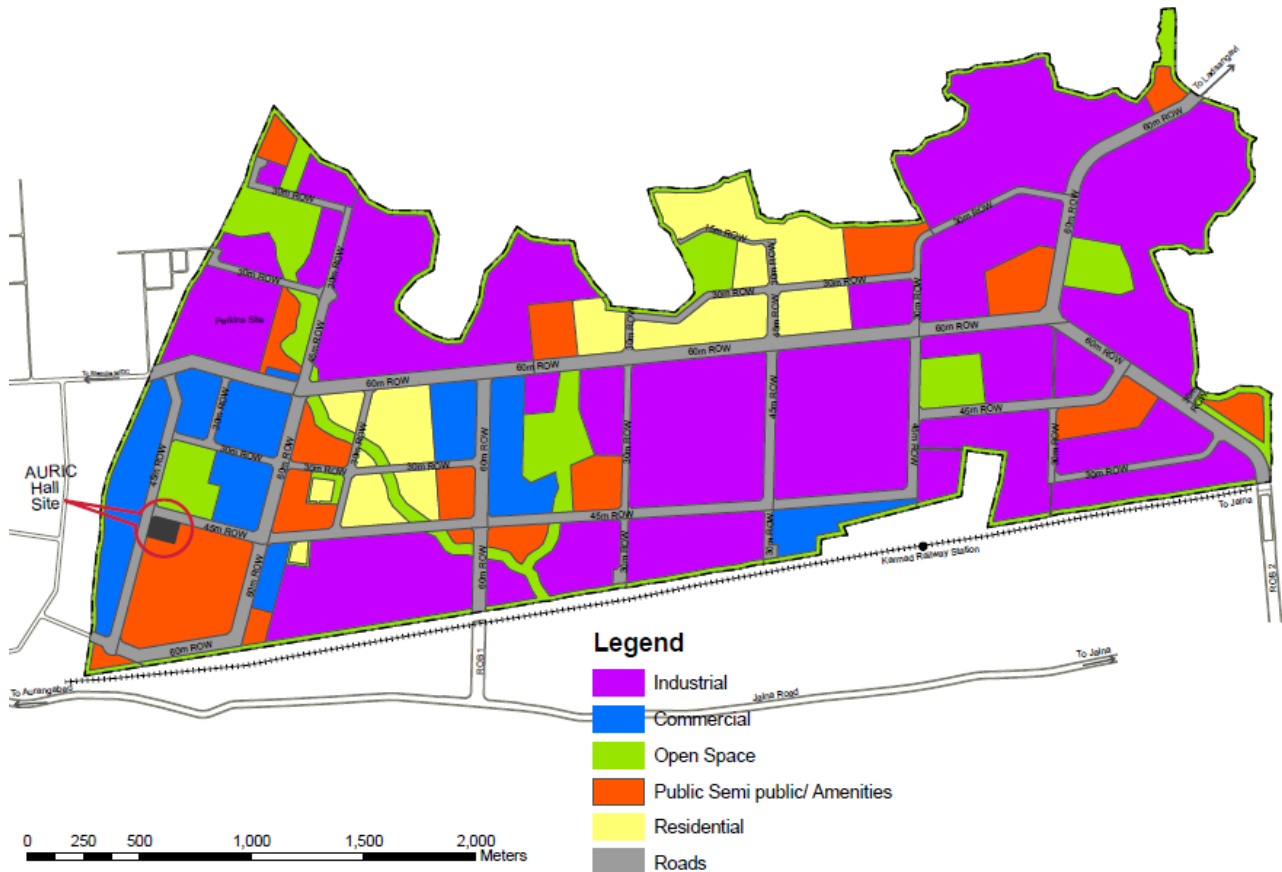
2. Handing over site to the Contractor

Details of handing over of Site to Contractor are given in table below:

S. No.	Site Details
1	The size of the plot available for the construction is approximately 134m X 84m with a total area of 11,336 sq.mts. The site is a corner plot and abuts a junction of two roads with 45m wide ROW. The site for the AURIC Hall building will be handed over as per the Contract Conditions.

Annexure III – Proposed Land Use Plan for AURIC – Shendra Industrial Area (Schedule-A)

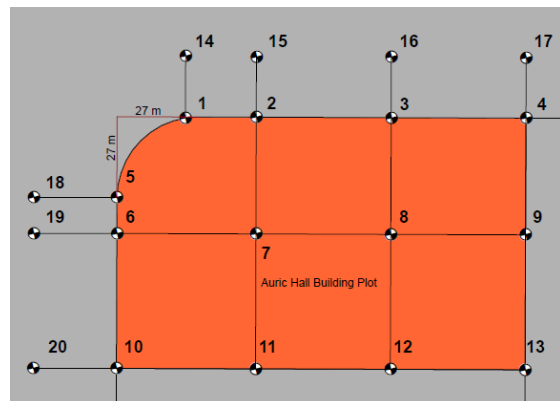
The site for the AURIC Hall Building superimposed on the land use plan for AURIC – Shendra Industrial Area is shown below.



Annexure IV – Site Topography (Schedule-A)

1. The site slopes from the north-west to the south-east and there is a general grade difference of about 5 to 6 meters in the site. As such the site would have needed to be filled up by about 40 to 5 meters to bring it up to the road level – however the proposed architectural design of the AURIC Hall Building takes advantage of the terrain to create a Lower Ground Floor that helps in constructing the building according to the site's topographical features.

There are no significant large trees, ponds, water bodies or HT lines within the plot boundary. Tests to determine water level, details on soil condition and correct mapping of the rocky outcrops will need to be conducted by the contractor. However, it is anticipated that hard or fractured rock and soft rocky strata is just below the surface. A boundary map with coordinates for reference of spot levels is provided below. FRLs are provided where a finished road is anticipated as per the master plan. Elsewhere the existing ground levels are provided as per the table below.



Reference Point	Northing	Easting	Finished Road Level	Ground Level
1	553108.6	2197636	590.49	589.1
2	553131.4	2197630	590.278	588.07
3	553175.1	2197619	589.883	586.32
4	553218.6	2197608	589.486	584.27
5	553079.8	2197616	590.193	587.83
6	553076.7	2197605	589.903	587.93
7	553121.7	2197593	**	587.37
8	553165.2	2197581	**	584.32
9	553208.7	2197570	**	583.24
10	553065.3	2197561	588.8	585.65
11	553110.3	2197549	**	585.66
12	553153.8	2197538	**	584.3
13	553197.3	2197526	**	583.22
14	553113.8	2197656	590.658	589.15
15	553136.6	2197650	590.447	588.28
16	553180.1	2197639	590.052	586.93
17	553223.7	2197627	589.655	584.97
18	553052.9	2197623	590.193	589.29
19	553049.9	2197611	589.903	589.07
20	553038.5	2197568	588.8	586.52

Annexure-V – Environmental Clearance
(Schedule-A)

The Environment clearance for AURIC - Shendra industrial Area has been obtain vide MOEFCC's order dated June 18 2015

Schedule B - Scope of Works

(See Clause 2.1)

1. Development of the Project

Development of the AURIC Hall Building at Shendra, Aurangabad, shall include design and construction of the following as described in this Schedule-B and in Schedule-C. However, the execution of Interiors cost shall not be quoted as part of the price submission. The price of the execution of interiors will be decided by the Employer on the item basis following due process of rate analysis after approval by the Employer of Designs and Specifications submitted by the EPC Contractor.

General

Contractor shall be responsible for making the facility fit for the intended purpose while performing all of its obligations covered under the Contract Document in its entirety. The work shall be done in accordance to the drawings approved by the statutory authorities.

Currently tender drawings and Design Criteria; Brief Technical Specifications for certain items of work are available. Scope includes further detailing, as deemed necessary (without changing the foot print of the proposed buildings, space planning and, design intent), developing required specifications, preparing Good for Construction (GFC), coordinated drawings and construct in accordance with the same. The scope shall also include preparation of as-built drawings before handing over the work to the Employer, maintaining the Quality assurance & Quality control (QA&QC) including control, corrective actions, reporting and arranging for regular inspections by all concerned.

It will be the responsibility of the Contractor to obtain IGBC Gold rating for New Construction or GRIHA 4 star rating for this building. The buildings are to be designed as per NBC, locally applicable development control regulation and the latest applicable IIA norms and other statutory requirements. The contractor shall also be responsible for obtaining necessary permits and clearances including any applicable building permissions from the competent authority.

As deemed necessary by the Employer/Employer's Engineer/PMNC, Contractor shall execute necessary mock-ups of all items/activities related to the Work performed required under this Contract as indicated below and the cost for the same shall be deemed to be included in the Contract price.

The Bidders are advised to visit the site before submitting the Proposal for the works.

The Scope includes all temporary works required for the completion of works, testing and commissioning and handover till Defect Liability Period.

The Scope includes all consumables required for the completion of works, testing and commissioning and handover till Defect Liability Period.

Appendix B I: Details of Population

Appendix B II: Details of Built-up area

Appendix B III: Scope of Architectural Works

Appendix B IV: Scope of Civil and Structural Works

Appendix B V: Scope of Electrical works

Appendix B XVI: Tender Drawings

Appendix B VI – HVAC Works

Appendix B VII – Fire Fighting

Appendix B VIII – Plumbing

Appendix B IX – Fire Detection Alarm System, Smart Card Based Access and CCTV Surveillance

Appendix B X – IGBC NC

Appendix B XI – Storm Water Drainage Network

Appendix B XII – Sewage Treatment Plant (Package STP)

Appendix B XIII – Solid Waste Management

Appendix B XIV – Integrated Building Management System (IBMS)/ Building Automation System (BAS)

Appendix B XVI – Tender Drawings

2.0 Specifications and Standards

The AURIC Hall Building at Shendra, Aurangabad shall be designed and constructed in conformity with the Specifications and Standards given in Schedule-D.

Appendix B I – Population Details*(Schedule-B)*

Population Details are as per given below in Table 1.

Table 1: Population Details: Summary of habitable areas in the building

	Floor Area	Occupancy
	(Excluding terraces)	(10 sq.mt./Person)
	sq.mt.	Persons
Lower Ground Floor	619	62
Ground Floor	4,252	425
First Floor	2,994	299
Second Floor	2,847	285
Third Floor	2,400	240
Fourth Floor	2,778	278
Fifth Floor	2,228	223
Terrace Floor	187	19
TOTAL	18,305	1,830

Appendix B II – Built-up Area Details*(Schedule-B)*

Built-up area details are as given below in Table: 2

Table 2 : Built up Area Details

FLOORS		No.	Area(Sqm)
Lower Ground Floor Plan	BUA	1	619
	Parking & Drive Way	1	5043
	Gas Bank	1	16
	TOTAL		5678
Ground Floor Plan	BUA		2701
	Terraces	2	210
	Atrium	1	1551
	External Canopy	2	363
	Security Cabin	3	31.5
	Meter Room	1	40
	TOTAL		4896.5
First Floor Plan	BUA	1	2994
	Terrace	0	0
	TOTAL		2994
Second Floor Plan	BUA	1	2847
	Terrace	4	376
	TOTAL		3223
Third Floor Plan	BUA	1	2400
	Terrace	0	0
	TOTAL		2400
Fourth Floor Plan	BUA	1	2778
	Terrace	3	322
	TOTAL		3100
Fifth Floor Plan	BUA	1	2228
	Terrace	2	226
	TOTAL		2454
Terrace Floor Plan 1	BUA	1	186.7
	Terrace	0	0
	TOTAL		186.7
Terrace Floor Plan 2	OHT	2	151.8
	TOTAL		151.8
TOTAL Built up Area			25084
Ground Coverage			4595.70

Appendix B III – Architectural Works*(Schedule-B)***1.1 Scope**

The scope includes design, detailing, procurement, supply, construction, furnishing, testing and execution for AURIC Hall Building at Shendra, Aurangabad.

Items of work include:

- RCC Framed Structure
- AAC Blockwork
- Gypsum Plaster
- Painting
- Flooring & Finishing
- Doors including Fire & Glass doors & Automatic Sliding Glass Doors.
- Windows
- Glazing and Façade works
- Drywall Partition / Glass Partition
- Ceiling Finishes
- Wall Finishes
- Waterproofing & insulation works
- Polycarbonate roofing for Atrium
- Fabrication including railing works
- Movable Acoustic Partition
- Toilet Cubicles
- Compound Wall & Entrance Gate
- Mechanical Stack Parking System
- Any other works shown in the Appendix B XVI but not specifically mentioned above.

1.2 Look and Feel of the Project

The Contractor shall study the drawings (Appendix B XVI), visualizations, specifications, material finishes indicated in the contract document and understand all parameters of the design including the architectural look & feel intent of the design. All Finishes as per the Architectural Appendix B V - Drawing No. AH/T/A6.6.

1.3 Construction Documents / Documents

The Contractor shall provide multiple options of the design of necessary element of the Work for the Employer's Engineer to review along with Employer / PMNC.

1.4 Mock-Up

The following mock-ups as per Table no 4 shall be demonstrated by the Contractor:

Table No 3: Mock-up

Item	Extent / Size
1. Facade / Glazing systems	Height - One floor Width - 03 modules [including one operable module, if any]
2. Aluminium Screen	4.2 M x 4.2 M including all module sizes
3. MS decorative works	Full height Width – Minimum 2 modules
4. Window glazing	One window module, Minimum with 2.4M, height 2.55M
5. Roofing	6M x 6M
6. All internal and external finishing items including but not limited to toilets, flooring, wall cladding, doors, false ceiling, etc.	Toilets - 01 module including all fittings, fixtures and modular partitions Hard & soft finishes - approx 5 sq. m., including all typical interfaces and details.
7. Railings in glass and others	Min 2.0 RM including all types of details [turns, bends, ends, etc.]
8. Planter and seating in atrium	One module
9. Internal glazing at atrium	Height – one floor Width - 03 modules [including one operable module, if any]
10. Compound wall	Full height of wall Width – 2 modules minimum including jail panels

Documents at Site

The Contractor shall maintain in a conspicuous place on the site a copy of development permission and a copy of approved drawings and specifications

Appendix B IV – Civil and Structural Works*(Schedule-B)***1.1 Scope**

The Contractor shall carry out, and be responsible for the design of the Works, of AURIC HALL, ancillary structures, compound wall, fencing, security cabins, pavements, hardscape, water bodies, drains, etc. The Scope of Work includes but is not limited to the following in relation to the design, construction, and maintenance of the Works:

- Prepare Design Basis Report based on the design intent and submit for approval.
- Carry out Structural Design based on approved Civil Structural Design Criteria.
- Submit Structural stability certificate for all structures and components from government authority at his own cost.
- Proof checking by accredited agencies at bidders cost before submitting for the approval of the Employer.
- Setting out the works: Site Topographic Survey and Geotechnical Investigations as deemed necessary by the Contractor. Site Clearing, Site Grading, and Excavation including excavation for sump pits / lift pits.
- Piling, foundation & substructure works.
- Implement Anti termite treatment / Waterproofing / Insulation works.
- Superstructure RCC works.
- Masonry.
- Plastering.
- Structural Steel work.
- Ancillary PCC / RCC works including equipment foundations / pedestals, etc.

1.2 Design Philosophy

Civil and Structural works shall be designed as RCC Structure and not as a Steel structure. For large spans in building PT (Post tensioned) slabs and beams shall be adopted. This shall fulfill all the codal provisions and specifications as stated under Bureau of Indian Standards (BIS) and National Building Codes (NBC) or any other relevant standards.

Appendix B V – Electrical Works*(Schedule-B)***a.1 Scope**

The scope of work shall cover the design, engineering, manufacture, assembly, testing at manufacturer's works / test labs, supply, delivery, properly packed for transport to site, unloading, storing at site of all equipment, erection and commissioning, test at site, performance guarantee test run, training of Employer's personnel and handing over of the complete electrical system along with mandatory spares as per the terms & conditions. The scope of work shall comprise of, but not limited to the following:

- Power Supply system from nearest Compact Sub Station to Ring Main Unit.
- Power requirement for the development.
- Compliance to IGBC for Gold rating.
- High Side and Low Side equipment requirements such as Transformers and Switchgear.
- Non-segregated phase Busduct and sandwich Busduct with all associated accessories.
- Main Power Control Centers (PCC), Sub-Power Control Centers (Sub-PCC) and Motor Control Centers (MCC).
- Power Distribution boards.
- Automatic Power Factor Correction Panel with capacitors.
- Metering system.
- All HT/LT Power, control cables.
- Cable carrier system with necessary cabling accessories such as cable glands, lugs, termination and jointing kits etc.
- Fire proof sealing system comprising of fire stops and fire breaks.
- Lighting system including Fittings and fixtures.
- Common area lighting and outdoor Lighting system comprising of lighting distribution boards, lighting transformers, light fittings, lighting poles, Power socket, associate lighting switches/sockets, associated cable, conduit and wiring.
- DG Backup System with Diesel Storage Capacity.
- DG synchronizing panel.
- 110V DC systems complete with one battery set, 2 x 100% BC (Float cum boost chargers), DCDB.

- Electrical SCADA system.
- Earthing system comprising of Earthing Electrodes, Earthing strips/ conductors and associated accessories.
- Lightning Protection system as per early streamer emission method.
- Solar PV system for AURIC Building.
- Miscellaneous items such as Local control push buttons, Welding Receptacles
- Safety Equipment's such as rubber mats, sign boards
- All related civil works required for completion, commissioning but not limited to trenches, foundations etc.
- Maintenance requirements as per Schedule E.

a.2 System Design Requirements

The following design criteria shall be considered by the Contractor for the equipment and services supplied under this contract:

- Safety to personnel and equipment during the operation and maintenance.
- Reliability of service.
- Minimum fire risk.
- Ease of maintenance and convenience of operation.
- Automatic protection of all electrical equipment through selective relaying system.
- Electrical supply to equipment within the design operation limits.
- Adequate provision for future extension and modifications.
- Fail safe features.
- Suitability for applicable environmental factors.
- Maximum interchangeability of equipment.
- The design and equipment shall ensure satisfactory operation under variations of voltage $\pm 10\%$, frequency (+) 5% to (-) 5%, combined voltage and frequency 10% for A.C., -15% to +10% for DC as may be met under operating conditions, including those due to starting loads and short circuit and other fault conditions.
- The contractor shall calculate the total power requirements for the development by summing up the power requirement for each floor in according to the design requirements.
- The power allocation of 138 VA/sqm (13VA/sft for) load shall be provided for the office areas

including the common utilities such as plumbing, HVAC, firefighting, elevators, etc. This shall cater for the lighting, power and other systems installed.

- The contractor shall submit load calculation with the tender for the development taking into account the acceptable diversity factors and providing a margin of (10%) contingencies for the total power for the peak hour loads. The internal electrical power shall be tapped from the riser / electrical room located on each floor.
- System grounding.
- 11 kV: Unearthed system.
- 415 V: Solidly earthed.
- Fault level (For all equipment).
- 11kV: 31.5 kA for 1 Sec.
- 415V: 50 kA for 1 Sec.
- 230V: 12kA for 1 Sec.
- 110V DC: 10kA for 1Sec.

a. Specific requirements for Electrical Equipment's

The following are the additional design requirements shall be considered.

b. HT and RMU Panel

- RMU panel shall be metal clad, self-standing dust proof construction, outdoor cubicle type fitted with incoming load break isolators and outgoing feeders as vacuum circuit breakers with aluminium bus bar, fully draw out type. Degree of protection of RMU panel shall be IP65 or better.
- Required margin of (20%) shall be considered while sizing the bus bars and breakers for switchgear
- The relays in the 11kV RMU and 11kV HT panel shall be numerical type with IEC 61850 compatibility.

c. Dry Type Transformer

- Two no's of 11/0.433kV, adequately sized dry type, two winding, 50 Hz, natural air cooled with ON LOAD tap changer. The tap changer will be provided with
- +5% to -15% taps in steps of +1.25% on HV side.
- The transformer shall be 2 x 100% configuration i.e. it shall be sized such a way that if one transformer fails other transformer capable to cater full load.

- Transformer shall be designed such that the maximum efficiency shall be at 50% of its loading.
- 11/0.433 kV, Transformer LT side shall be suitable for terminating the 415V non-segregated phase Busduct and HT side shall be suitable for cable terminations.

d. Busduct and Rising Main

- Non-segregated phase Busduct shall be TPN, Bus bar material shall be of high conductivity electrolytic Aluminium conductor. Bus duct shall have degree of protection better than or equal to IP-54.
- 415V rising main bus bar shall be of sandwich construction and made up of high conductivity electrolytic aluminium conductor, non-ventilated design and the degree of enclosure protection shall be IP 52.
- Each Rising Main shall be equipped with an end feed unit / MCCB panel, at both ends.

e. Main LT Panel and Sub-Distribution panels

- Main LT panels shall be metal clad, self-standing dust proof construction, fully draw out type and IP 54.
- For feeders rated more than 400A, ACB with Numerical protection/built in microprocessor release, discrete multi-function meters or metering as part of ACB shall be provided. For all other rating feeders Microprocessor based MCCB shall be used. All ACB feeders shall be compatible for remote control, metering and monitoring.
- Incomer and busbar shall be rated for full load current of the total load connected plus a margin of 20%, rounded off to the next standard rating. All outgoing feeder modules from each PCC shall be rated for the full load current plus 10% margin, rounded off to the next standard rating. All PCC shall be provided with 20% spare feeders.
- Incoming feeders shall be provided with ACB breaker with Numerical protection relay compatible with IEC 61850.
- For remote metering in SCADA for current, line voltage, bus voltage, kW, KWH either separate transducers or soft data shall be taken through communication of Numerical relays/MFM's looped and interfaced to SCADA. Architecture shall be submitted for approval.

f. Control Philosophy

- A highly reliable, microprocessor-based Electrical SCADA system complying with International automation standard IEC – 61850 shall be provided for the AURIC building Electrical System Control, metering and monitoring. All HT and LT switchgear shall be controlled from SCADA.
- Each switchgear whose incomer, buscoupler and outgoing breaker feeder are controlled from

SCADA shall be provided with two IEC-61850 compliant managed ethernet switches. The IEC-61850 compliant numerical relays shall in turn be connected to both these switches either to form a ring or radially connected, so that loss of one connection does not result in loss of communication with any device. These switches shall be provided with fibre optic (FO) ports for interconnection with other switchgear switches, which form part of the IEC-61850 LAN network. Further interconnection to the SCADA shall be through redundant server.

g. APFC Panel

- Automatic Power Factor Correction (APFC) capacitor panels with capacitor bank of adequate kVAR rating to maintain the power factor of 0.98 lag at main LT panels.
- All Poly Propylene (APP) type Capacitor banks shall be housed in APFC Panel cabinet.

h. Motors

- Motors shall be energy efficient (IE2) squirrel cage induction type, TEFC, IP-55 enclosure (including terminal boxes and bearing housing) with Class-F insulation (and temperature rise limited to Class B).
- Lockable Stop Push Button (press to stop and key to release) shall be provided near to the each equipment. The enclosure shall be engineering plastic (scratch resistant), weather proof, corrosion resistant, dust and vermin-proof, suitable for mounting on wall or structures. The enclosure shall have degree of protection not less than IP55.

i. DC System

- The DC system shall be designed to cater the loads for control, protection and indication of 11kV switchgear, 415V breaker controlled feeder, control panel, DG AMF panel, RTCC panel shall be designed for 110V DC battery with 2 hours back-up time.
- 110V, 2 x 100%, float cum boost charger with a common 100% tubular lead acid battery shall be provided which shall be located in utility building ground floor level.

j. DG Set

- Emergency DG set shall be designed for only emergency services i.e. common area lighting, Fire Fighting services, partial set of lifts, utility pumps, etc. Considering the same, DG Set rating shall be approx. 2 nos. 500KVA at 85% loading. The Prime rated DG set shall be an Indoor type open construction mounted on base frame through anti vibration mounts. The cooling system for DG set is radiator type. The DG room shall be acoustically insulated along with panels to limit the noise in line with the norms as set by pollution control board.

k. Solar PV System

- As per IGBC NC requirement (confirmation from IGBC NC consultant, to be appointed by EPC Contractor) in order to achieve the required credentials.
- Grid interactive solar PV system is proposed to cater this requirement. The system shall be with inverter mounted with PV panels.
- Solar module shall be multi crystalline type, employing lamination technology using established polymer (EVA) and Tedlar / Polyester laminate.

l. Power, Control Cables and Cable carriers system

- The cables shall be 11000V un-earthed grade, single / multicore, stranded aluminium, XLPE insulated with PVC inner sheath, armoured and overall sheathed with specially formulated Fire Retardant Low Smoke (FRLS) PVC. Single core cables shall have aluminium wire / formed wire armour, whereas multicore cables shall have galvanised steel strip armour.
- LT power cables shall be 1100V grade, single / multicore, stranded aluminium conductor, XLPE insulated, with PVC inner sheath, armoured and outer sheath made of specially formulated FRLS PVC compound.
- The overall voltage drop shall be limited to 5% and the voltage dip shall be limited to 15%.
- The LT control cables shall be 1100V grade, multicore, 2.5 sq.mm cross section, stranded copper conductor having 7 strands, PVC insulated, inner PVC sheathed, galvanised steel wire/formed wire armoured and outer sheath made of FRLS PVC compound conforming to the performance requirements outlined above shall be used . The cables shall conform to IS:1554 (Part-I) - 1988 / IEC-502 (1983) in all other respects.
- Cable carrier system shall be designed for 70% loading.
- Power cables and control cables shall run in different shafts. Separate riser and trays shall be provided for the LV system.
- All cabling/wiring works shall be concealed wiring except for risers and in other areas where public or tenants do not have access or approved areas by the Employer.

m. Lighting system

- Electronic ballasts should be used. Light fittings should be installed with effective reflectors. Mercury light fittings should not be used; instead Metal halide/sodium light fittings shall be used.
- The luminaries shall be selected to suit architectural, functional and aesthetic requirements.

n. UPS system

- UPS are provided for critical system loads, servers and work stations, BMS, FACP (Fire Alarm Control Panel) & FARP (Fire Alarm Repeater panel), CCTV and Emergency lighting etc. with 3hrs battery back-up.
- The UPS will be 3ph to 3 ph, 50 Hz, Modular type, On-line, Redundant UPS power supply and with static bypass. The UPS output will be connected to the UPS DB for further distributions.
- During normal operation, the AC Supply will be fed to UPS Distribution boards through UPS and a small trickle charging current will be feeding to tubular lead acid battery for charging. Once the AC supply fails, for a momentary time till the DG picks up the battery will feed the UPS distribution loads through UPS.

Appendix B VI – HVAC Works

(Schedule-B)

1.1 Scope

The scope of works shall cover the design, engineering, Supply, Installation, Testing and commissioning of the complete Air-Conditioning (air cooled chillers) and Ventilation (ACV) System of AURIC Building. The scope includes all the related things like procurement, manufacture, testing at manufacturers' works, packaging, transportation, shipping, unloading at port, transportation to site, unloading, storage, insurance, transportation from stores to erection site etc.

AURIC Building will be an IGBC (NC) Gold Building (minimum) and IGBC Green New Buildings v 3.0 - Fourth Addendum August 2015 to be followed.

1.2 System Design Requirements

- Inside design temperature for all areas except server room should be: 24 +/- 1 °C.
- Inside design temperature for Server Room and Control Room should be: 22 +/- 1 °C with relative humidity of 50% +/- 5%.
- Ambient Conditions of Aurangabad to be followed are :
- Summer Ambient @ 1%
- Dry Bulb Temperature : 102°F (38.9°C)
- Wet Bulb Temperature : 73°F (22.7°C)
- Relative Humidity : 24%
- Dew Point : 59°F (15.0°C)
- Grains / Lb : 76
- For occupancy details, heat load summary sheet to be followed.
- N + 1 redundancy shall be provided for chillers, pumps, etc.
- Double skin AHU shall be provided at all floor levels and treated fresh air units at terrace of each building.
- Air –conditioning [High side] will be designed and provided for all areas of AURIC Building and low side shall be provided only in their main entrance lobbies, lift lobbies, IBMS, UPS & battery rooms, public grievances, stationery, counters, etc.
- For Server Room air cooled Precision Units to be installed to maintain temperature. Necessary humidifiers, heaters to be considered for Precision Units to maintain humidity conditions. The

configuration of Precision Unit will be $N + 1$ for both Server Room

- Air conditioning shall also be provided to services plant room where deemed necessary by the Contractor's designers to maintain the equipment's in optimum working condition.
- The air conditioning system shall preferably comprise central chilled water plant consisting of chillers, ideally suited for the nature of this project, pumps providing chilled water to air handling units, fan coil units complete with control panels, pipe works, valves, fittings, ductworks, grilles, dampers, etc. with necessary insulation / acoustic works.
- Cooling load requirement shall be based on heat load calculation to be submitted with tender, the no of chillers and pumps shall be configured for the duty and minimum one no of stand by operation. The building data to be considered as follows:

Exterior Glass/ Glazing	a. Single Glazed Unit Shading Co-efficient = 0.62 BTU/hr. ft². °F U-value = 1.00 BTU/hr. ft². °F b. Double Glazed Unit without screen Shading Co-efficient = 0.41 BTU/hr. ft². °F U-value = 0.34 BTU/hr. ft². °F c. Double Glazed Unit with screen Shading Co-efficient = 0.33 BTU/hr. ft². °F U-value = 0.30 BTU/hr. ft². °F d. Atrium Roof (with Polycarbonate sheet with Aluminum Sections) U-value = 0.30 BTU/hr. ft². °F
Exterior Wall/ Spandrel	a. U value (for Without screen) = 0.34 BTU/hr. ft². °F b. U value (for With screen) = 0.24 BTU/hr. ft². °F

- Mechanical ventilation shall be provided to escape stairs, toilets, kitchens, services and

equipment areas and any other areas to comply with the authorities' requirements. All M&E rooms shall be adequately ventilated to ensure maximum room temperature to be maintained not more than 30 °C.

- Life Safety System parameters for lift well /stairwell pressurization, car park and smoke exhaust shall be followed as.

Lift well Pressurization system	Air Quantity needed to maintain 20 Pa more pressure than adjoining areas
Staircase Pressurization system	Air Quantity needed to maintain 20 Pa more pressure than adjoining areas
Smoke Evacuation	12 Air changes per hour
Car Park Ventilation	15 Air changes per hour (Pollution Mode) : 30 Air changes per hour (Fire Mode) : With Ducted System & CO Sensors

- Sufficient space shall be provided for maintenance and repair works in the plant room. Mechanical Ventilation System should be provided in plant room to ensure proper operating condition is achieved. All pumps and chillers should be provided with proper drain pipe system to the nearest floor traps. Floor should be waterproofed. Balancing valves & isolating valves (butterfly / gate / ball) flow valves should be installed in the chilled water and condenser water system. Appropriate vibration and acoustics measures should be implemented.
- Vibration isolators for all Air-conditioning and Ventilation equipment.
- Complete framework required for mounting grills/louvers in masonry works is deemed to be included in Air-conditioning and Ventilation Contractor scope.
- Painting of equipment, piping and supports of the Air-conditioning and Ventilation system as per National Building Code (NBC) or standards of the employer.
- Automatic controls and instruments including control cabling.
- Motor Control Centre and Cables.
- Wiring and earthing from MCC panels to various refrigeration, air conditioning and mechanical ventilation equipment, control wiring and interlocking.
- All the Air-conditioning and Ventilation system shall be provided with the connectivity to Building Management System (BMS) with a potential free contact. The Contractor shall provide

the minimum interface & connectivity of the Air-conditioning and Ventilation system to the BMS

- VFD & VAV for AHUs, VFD for secondary pumps, life safety etc. to be considered.
- Provide larger size sleeve for crossing of pipe, conduits & cables through fire rated wall/partition. The sleeve shall be sealed with fiberglass and fire sealant.
- Fire/smoke dampers shall be installed to maintain integrity of fire compartmentalization. The vendor shall submit installation details and obtain approval prior to execution at site.
- Balancing, testing and commissioning of the entire Air-Conditioning and mechanical ventilation system.

1.3 **Associated Works**

- The complete electrical work related to air conditioning services, shall be carried out by Contractor.
 - The scope includes the associated civil works like providing RCC/PCC foundations, pedestals for equipment like water chilling machines, AHUs, pumps
 - & fans etc., and necessary plumbing works like providing floor and condensate drains in the equipment rooms.
 - All associated Electrical Works are also in the scope of Contractor. These shall be installed in accordance with approved shop drawings of, and under direct supervision.
 - All associated Plumbing Works are also in the scope of Contractor. Detailed specifications are mentioned in the electrical section. These shall be installed in accordance with approved shop drawings of, and under direct supervision.
- a) Providing soft makeup water (Commercial hardness 0 ppm and pH 6.5 to 8.0) at chilled water expansion tank.
 - b) Providing sump pumps and necessary piping for drainage of air conditioning plant room and other machine rooms located below ground level.
 - c) Providing floor drains in cooling tower area and in air handling unit rooms.
 - d) Disposal of condensate drain from fan coil units / ceiling suspended units beyond the condensate drain riser.

1.4 **Battery Limits:**

- The battery limits on the low side works to be considered are as under:

For the Ground, Fifth Floor and Public Area low side works, complete air-conditioning system to be considered including the BTU meter, AHU / CSU / PEC Units, Valve Station, AHU / CSU Panel, Cabling, Fire and Volume Control Dampers, VFD, VAV Boxes, Ducting, Duct insulation, Grilles / Diffusers, etc.

For the First to Fourth Floors, low side works, air-conditioning system to be considered includes the BTU meter, AHU / CSU / PEC Units, Valve Station, AHU / CSU Panel, Cabling, Fire and Volume Control Dampers, VFD, VAV Boxes, etc. However, Ducting, Duct insulation, Grilles / Diffusers, etc. not to be considered since internals will be executed by the end user / tenant.

Appendix B VII – Fire Fighting

(Schedule-B)

1.1 Scope

The Scope of works shall cover the design, engineering, Supply, Installation, Testing and commissioning of the complete Fire Fighting system including Fire alarm system of AURIC Building. The scope includes all the related things like procurement, manufacture, testing at manufacturers' works, packaging, transportation, shipping, unloading at port, transportation to site, unloading, storage, insurance, transportation from stores to erection site etc.

1.2 System Design Requirements

- Main design components include Wet risers and the hydrant System including all pumps and pipe networks.
- Pumps shall be of three types, namely 2400 lpm & 85 m head electric, 2400 lpm 85 m head diesel driven, and 200 lpm & 85 m head jockey pumps. Pump capacity should be as per NBC/NFPA standards or as per local fire CFO requirement.
- All Accessories, but not limited to field instruments like pressure gauge & pressure switch and control cabling including junction box, erection hardware, etc., to MCC & diesel engine control panel should be included.
- Electrical panels, Cabling & earthing from MCC panels to various firefighting system, control wiring & interlocking.
- Instrumentation and Control equipment shall be complete with primary elements, initiating contacts for alarms, instrument impulse lines, fittings, power and control cables with suitable glands and terminations and instrument installation hardware.
- 4mm thick wrapping & coating for underground piping with proper testing.
- Sprinkler System for the complete development (within the scope of this contract).
- Contractor shall carryout the hydraulic calculation using validated software.
- Fire extinguisher including mounting fixtures, anchor bolts, clamps, structures, etc. for all buildings in all the areas.
- Photo luminescent signage.
- Fire alarm system
- Firewater Storage at underground of utility building and Terrace level of each building.

- Yard hydrant system around AURIC Building.
- Four nos. Internal hydrant system in each level.

1.3 **Associated Works**

- The complete electrical work related to Firefighting including, but not limited to installation of pumps, shall be carried out by Contractor.
- All associated Plumbing Works are also in the scope of Contractor.
- The Scope includes the associated works like Structural works for pipe supports for above ground pipes, wall supports, hose cabinet supports, etc., Civil works like wall opening, chipping of foundation, grouting of foundations, sand filling and compacting for underground pipes, etc.
- Painting of equipment, piping, supports etc. with 2 coats of primer & 2 coats of synthetic enamel as per IS: 5 shade 536 (Fire Red).
- Supply of One set of special erection and maintenance tools and tackles.
- Start up and Essential spares.
- Recommended spares for 5 years operation.
- Anchor fasteners required for pipe supports of all the systems which are engineered by vendor and all anchor bolts, nuts, washers and inserts to be embedded in concrete for the equipment and piping.
- Shop inspection (in Vendor's works & at project site after installation along with all required calibrated measuring instruments).

Appendix B VIII – Plumbing

(Schedule-B)

1.1 Scope

The Scope of works shall cover the design, engineering, Supply, Installation, Testing and Commissioning of the complete Plumbing system including Internal and External Water Supply, Internal and External drainage including Sewerage, Storm water drainage, Rain water harvesting system of AURIC Building. The scope includes all the related things like procurement, manufacture, testing at manufacturers' works, packaging, transportation, shipping, unloading at port, transportation to site, unloading, storage, insurance, transportation from stores to erection site etc. The scope shall also include compliance to IGBC NC for Gold rating.

1.2 System Design Requirements

For Utility Building additional features to include:

- a) All the transfer pumps, connection between underground tanks and transfer pumps, related piping, valves and accessories etc.
- b) Auto level sensors with required controls like solenoid valve for each tanks (both underground tanks and overhead tanks) for automatic operation of transfer pumps.
- c) Transfer pumps (1w + 1s) for each potable water & non-potable water system Water supply pipes in Utility building
- d) Separate piping from utility building to each overhead tank through trench with required supports.
- e) Overhead fire water tank to be connected with ground floor public toilet for recirculation of water.
- f) Complete distribution of potable and non-potable water distribution for each building.

Overhead Tank Capacities

Over Head Tank (0.5 days Storage)	AURIC BUILDING
Fire water tank (E-4&5/14, Table 23, Part 4 of NBC)	20,000 ltrs.

Underground Tank Capacities

Under Ground Tank	Capacity
Potable	73,500 ltrs. (in 2 compartments)
Non Potable	82,800 ltrs. (in 2 sections)
Fire water tank (Table 23, Part 4 of NBC)	200,000 ltrs. (in 2 compartments)

- Works to include for air vents, PRV, water meters, valves, pressure gauges, water hammer arrestors, Nalni traps, Floor gratings, Gully trap, grease trap, man holes, inspection chambers, required piping connections etc.
- Required capacity hydro pneumatic system with required controls and instruments at Pump Room level for each domestic water system and flushing water system with comprising 2 nos. of working pumps of 50% cap. of total flow rate required & 1 no. of same cap. standby pump for the building. Flow rate for domestic pump is as per design requirement.
- Required capacity booster pumps with pressure sensor system with required controls and instruments at terrace level for each drinking water system and flushing water system with standby for each building.
- Cabling & earthling from MCC panels to various plumbing/ sanitary system, control wiring & interlocking.
- Field instruments like pressure gauge & pressure switch and control cabling including junction box, erection hardware, etc., to MCC
- Instrumentation and Control equipment included in the package unit shall be complete with primary elements, initiating contacts for alarms, instrument impulse lines, fittings, power and control cables with suitable glands and terminations and instrument installation hardware.
- Supply & Installation of following complete Sanitary Fixtures and Fittings as per the model and make mentioned in the tender specifications.
 - a) EWCs (Model: Hindware Make cat.no.20024, Viega concealed flush tank cat. Nos. 8864.4 2 / 4 ltrs).
 - b) Lavatory basin (Model: Below counter wash basin – Hindware (493 X 413) cat.no. 10051
 - c) Urinal with sensor system (Model: 60002 Hindware & Jaguar Concealed urinal flush sensor 51077).
 - d) Pantry sink.
 - e) Shower assembly.
 - f) Cocks & taps.
 - g) ABS Rinsing spray.

- h) Janitor sink.
- i) Hand drier, tower ring, soap dispenser, toilet paper holder, twin coat hook etc.
- j) Following Jaguar make sanitary fixtures shall be considered:
 - Continental Bib cock straight CON. 047.
 - Continental Pillar cock straight SNR-CHR-51021.
 - Continental Health Faucet CAT NO. 563.
 - Continental Angular cock CON. 059..
 - Florentine Sink cock extended FLR-5309N.
 - Florentine Stop cock straight FLR 5083N.
- k) Fixture flow rate are as per below table however contractor needs to ensure same is in compliance with IGBC requirement.

Sr. No.	Fixture	Flow Fixture (With Aerators)
1)	Water Closet	2/4 LPF
2)	Urinal	1 LPF
3)	Hand Wash	1.4 LPM @ 60 PSI
4)	Kitchen Sink	1.4 LPM @ 60 PSI

1.3 Associated Works

- The complete electrical work related to Plumbing works including, but not limited to cabling and earthing of various fixtures and control wiring shall be carried out by Contractor.
- The Scope includes the associated works like Structural works for pipe supports for above ground pipes, wall supports, hose cabinet supports, etc., Civil works like wall opening, chipping of foundation, grouting of foundations, sand filling and compacting for underground pipes, etc.,
- Painting of equipment, piping, supports etc. with 2 coats of primer & 2 coats of synthetic enamel as per relevant IS codes.
- Start up and Essential spares.
- Recommended spares for 5 years operation
- Anchor fasteners required for pipe supports of all the systems which are engineered by vendor

and all anchor bolts, nuts, washers and inserts to be embedded in concrete for the equipment and piping.

- Supply of One set of special erection and maintenance tools and tackles.
- Cutting holes, chases & like through all types of walls /floors and finishing for all services crossings, including sealing, frame works, fire proofing, providing sleeve, cover plates, making good structure and finishes to an approved standard.

Appendix B IX – Fire Detection Alarm System, Smart Card Based Access and CCTV Surveillance

(Schedule-B)

1.1 Scope

The scope includes design, detailing, procurement, supply, installation, equipping, testing, commissioning and execution of ICT Solution consisting of Fire Detection & Alarm System and Public Address system, Smart Card based Access Control System, CCTV Video Surveillance System, Boom Barriers, Network Management System, Visitor Management System, BMS for common areas of AURIC Building block, BEC block, Utility block and ancillary structures, in accordance with the tender requirements.

1.2 System Design Requirements

a. For Fire Detection system and Public Address System

- The system shall comprise of heat and smoke detectors, manual call points, hooters and Public Address System.
- The system shall comprise of microprocessor based addressable fire detection system.
 - (i) Integrated smoke and heat detectors.
 - (ii) Manual call points.
 - (iii) Hooter sounders with flashers.
 - (iv) Ceiling mounted speakers for PA system.

b. Smart Card based Access Control System

The features in the design should include:

- (i) Contact less card based solution.
- (ii) Visitors pass with company detail.
- (iii) Manually / Remotely operated Boom barriers for vehicle movement.
- (iv) Electrically operated door lock.
- (v) The location of access control locations should include all critical locations like the services areas, locations where visitors are not allowed, roof, lift machine areas.
- (vi) RFID cum biometric readers for doors.
- (vii) Electromagnetic door locks (600 lbs, Smart Cards (Mifare Desfire, 4KB) with dual side

printing with colour in front & B&W on back. Plastic Card Holder with Lanyard).

c. CCTV Video Surveillance System

- The main objective is to monitor and record the activities, movement of people and vehicles through entry points inside the building, to monitor perimeter.
- Cameras to be positioned at all areas to enable a total secured building.
- Video Cameras should be - IP Mini Dome Color IR, 2 MP, Varifocal lens

d. Boom Barrier System

- 4-meter boom barrier with safety photocell, support stand, magnetic loop detector, copper loop and other accessories, transponder technology system, key operated selector switch, flashing light etc.

e. Network Management System

- The features in the design should include:
 - (i) 12 Port Managed Network Edge / Access Switch, 10/100 Mbps with POE.
 - (ii) 8 Port Managed Network Edge / Access Switch, 10/100 Mbps.
 - (iii) 24 Port Managed Network Aggregation Switch, 10/100 Mbps.
 - (iv) Network Management Server / Workstation with software.
 - (v) Network Rack (42U).
 - (vi) PVC Conduit pipe + installation.
 - (vii) AT6 Cable + installation.

f. Visitor Management System

- The features in the design should include:
 - (i) Work stations.
 - (ii) Smart Cards (Mifare Plus, 1KB) with dual side printing with B&W in front & B&W on back. Plastic Card Holder with Lanyard to be supplied.
 - (iii) Laser Printers (A4 Size printing).
 - (iv) Smart Card Printer (Dual side thermal-dye sublimation Card Printer with dual side lamination.

1.3 Associated Works

- All associated electrical / civil work related to above works including, but not limited to cabling, earthing and structural works for support / fixing of various fixtures, wall openings, grouting, foundations, sand filling and control wiring shall be carried out by Contractor.
- The Contractor will carry-out any interfacing / Integration of the systems as required between the systems and also with the BMS (Lift, AHU, Lighting, DG Set Panels)
- Required UPS Power only will be made available by the Employer. The power cabling & Ethernet / Optical Fiber cabling, Ethernet Switches and other network hardware shall be provided by the Contractor.

Appendix B X – IGBC NC

(Schedule-B)

1.1 Scope

The objective of the Contractor is to help the Employer meet all sustainability goals (including IGBC NC) set for the project. The Contractor shall also help the Employer secure IGBC NC-Gold rating for this project through IGBC NC Ver 3

1.2 Design Requirements

- The Contractor shall facilitate complete green-building certification process for the project.
- The Contractor shall assess all available building data to understand and maintain current design goals and strategies for detail design and construction. All available building information shall be made available to the Contractor for the same. In case the information is not available, the Contractor shall make suitable assumptions and cross check with the Employer (including IGBC NC facilitator).
- The project is registered with IGBC for IGBC NC certification and is aspiring for Gold rating under IGBC NC V 3.0 for India . To achieve Gold rated IGBC NC certification the project has to follow certain best engineering practices and select materials that are compliant with the IGBC NC rating system. Hence the following roles and responsibilities have been identified for the Contractors to ensure that the project achieves this target.
- In addition, the Contractor will appoint a suitable Contractor/consultant for the documentation and submission of documents to IGBC for approval.

1.3 Associated Works

- The appointed consultant shall be responsible for the certification of the building as IGBC NC Gold certified building.
- All associated works like collection of Information, assessment and documentation of information, final submission and weekly reporting to the Employer on the progress is included. This should also include all the analysis but not limited to energy analysis, daylight simulation etc.

Appendix B XI – Storm Water Drainage Network

(Schedule-B)

1.1 Scope

The Scope of Work for proposed storm water drainage system under this contract includes but is not limited to the following in relation to the design, supply, construction, testing and commissioning of storm water drainage system of the Works.

- Storm water collection and disposal system.
- Excavation, dewatering, ramming, refilling, and disposal of surplus excavated soil for pipe / box trench.
- Construction of all type inspection chambers.
- Supply, laying jointing, testing and commissioning of RCC NP-3 pipe/ precast RCC rectangular drains with all section sizes as indicated in the layout plan of storm water drainage system.
- Hydraulic Testing and commissioning of the entire work.

Length and conduit details of storm Drains in side AURIC Building plot is provided in Table 11 below:

Table 11 : Length and conduit details of storm Drains in side AURIC Building plot

Conduit Description	Length (m)
Box - 0.3 x 0.3 m to 0.6 m	935.0
Box - 0.45 x 0.4 m to 1.0 m	20.0
Total Length	955.0

Appendix B XII – Sewage Treatment Plant (Package STP)*(Schedule-B)***1.1 Scope**

The scope shall include design and construction of the following as described in this Schedule-B and in Schedule-C.

This bid is for the design, engineering, manufacture, supply, installation, testing and commissioning and operation of package STP system excluding the Civil Work execution in line with the details given in this document.

The capacity of the STP is approx. 105KLD. However, Bidder to design the actual capacity as required for the project.

The scope of work includes all mechanical and bought-out equipment, piping, electrical and instrumentation work. The turnkey supplier shall provide all the drawings and details as required for the Consultant to carry out civil design and for a separate civil Contractor engaged by the Client at site to carry out the civil work for the STP. Turnkey supplier has to consider visits to site at key stages for guiding the civil Contractor, if required, to ascertain that work is carried out as per the drawing requirements.

1.2 Design Requirements

The Sewage Treatment Plant (STP) will be based on MBR Process (Membrane Bioreaction) and to be designed based on the various details mentioned in i.e. Basis of design. The sewage treatment plant will be suitable for semi-automatic operation, wherein starting/tripping/ of all the pumps will be controlled by level sensors provided in the tank. Pumps will start once water level reaches desired high level and will stop once water level in the tank lowers down to desired low level. Filter backwash operations will be semi-automatic. All other operations including chemical dosing and sludge draw off will be suitable for semiautomatic operation. Various details of sewage treatment plant will be as mentioned below.

Appendix B XIII – Solid Waste Management*(Schedule-B)***1.1 Scope**

The scope of works is to ensure that the entire solid waste generated in the AURIC Building is treated and managed. It includes collection and segregation of waste at source using colour coded bins under hygienic conditions and then treating it using organic waste composter including disposal of recyclable and inert.

1.2 Collection and Segregation of Solid Waste

- 100% collection of solid waste from all facilities.
- Segregation of waste at source.
- Separate wet and dry waste collection system.
- Collection at pre-informed time (two times a day) from all waste generation source.
- Provision of three colour coded bins (wet, dry and recyclables) for waste collection from common areas.

1.3 Treatment of Biodegradable waste using Organic Waste Composter

- Design, construction, supplying, erection, testing and commissioning of Organic Waste Composter (OWC).
- The capacity of the OWC is approx. 225 kg capacity. However Bidder to design the actual capacity as required for the project.
- Demolishing the existing structures, if any, on the site.
- Supply, erection testing & commissioning of the mechanical and Electrical & Instrumentation equipment
- Providing walkways and platforms of minimum 1.2 m width as access.

1.4 Disposal of Recyclables and Inert

- The recyclables like paper, plastic and metal to be stored in the utility area for a maximum duration of 15 days and then be sold to authorised vendors for handling recyclables.
- The inert to be stored in utility waste handling area and will be sent to the nearest authorised municipal solid waste landfill site.
- Any hazardous waste generated from the complex like used DG oil; old batteries etc. to be

handed over to SPCB authorized hazardous waste handling vendors.

1.5 **System Requirements**

Design, construction, supply, erection, testing and commissioning of approx. 225 Kg capacity. Composter with walkway and platform 1.2 m wide.

1.6 **Associated Works**

- Preparation of process, electrical and mechanical component design.
- Integration with other civil, mechanical, and electrical, integration with proposed architectural, construction of the main structure.
- Associated civil, electrical and other services works.
- Demolishing the existing structures, if any, on the site.
- Construction of civil engineering works for the platform.
- Supply of all spares required during performance run and during 36 months of O & M period.
- The recyclables like paper, plastic and metal to be stored in the utility area for a maximum duration of 15 days and then be sold to authorised vendors for handling recyclables.
- The inert to be stored in utility waste handling area and will be sent to the nearest authorised municipal solid waste landfill site.
- Any hazardous waste generated from the complex like used DG oil; old batteries etc. to be handed over to SPCB authorized hazardous waste handling vendors.
- The compost from the treatment of organic waste should be used for landscaping in the AURIC Hall building Complex.

Appendix B XIV – Integrated Building Management System (IBMS)/ Building Automation System (BAS)

(Schedule-B)

1.1 Introduction

An **Integrated Building Management System (IBMS)** or a more recent terminology **Building Automation System (BAS)** is a computer-based control system installed in buildings that controls and monitors the building's mechanical and electrical equipment such as Plumbing, Heating, Ventilation, Lighting, Power System, Lifts/ Elevators, Fire Alarm & Detection Systems, including the security systems like; Public Address System, Access Control, CCTV Surveillance & Intrusion systems.

1.2 Scope

The System provider shall furnish and install a fully integrated Building Management System (BMS), incorporating distributed control techniques and standard open communication networks. The system shall be implemented as an integrated, open solution, which enables Service Center connectivity through standard Building Operating System (BOS) interface.

The integrated systems shall include controls and monitoring of the whole building (BMS and Security) and common areas wherever applicable.

Integrated Building Management System shall include the control and monitoring of the following subsystems:

- Building automation (cooling/heating control, ventilation control, pumps, etc.).
- Lighting control of common areas.
- Access control system for common areas.
- CCTV Video monitoring system for common areas.
- Fire Detection & Alarm system for common areas.
- Elevator Control.
- Pump Control.
- Back-up power / UPS Control.
- Water consumption metering.
- Electricity consumption metering.
- Cooling energy consumption metering.

1.3 System Requirements

The IBMS shall consist of software and hardware; the software program configured in a hierarchical manner that integrates the various subsystems.

System integration shall enable significantly lower energy consumption, real-time control and monitoring, and dynamic graphics according to needs. System integration shall create better environmental air quality, radically improved energy performance and increased water efficiency, according to requirements of IGBC NC and other Green Building standard and initiatives.

System integration shall also allow for efficient system maintenance and full-scale service provisioning with radically lower cost and better quality services. Easy access to building systems shall ensure that everything is in perfect condition and functions in the optimal way at all times. Should anything disturbing happen, immediate response shall be available. Integration shall facilitate undisturbed conditions in the building and sustainable development through minimized energy consumption, first- class security and significantly lower life cycle costs.

1.4 System Architecture / Specifications

The system shall be implemented as an integrated, open solution, which enables Service Center connectivity through standard Building Operating System (BOS) interface.

The System Architecture shall consist of four levels:

- Service Level.
- Management Level.
- Control Level.
- Field Level.

The system shall be completely modular in structure and freely expandable at any stage. Each level of the system shall operate independently of the next level up as specified in the system architecture. For example, Control Level shall operate independently without support from Management Level. The system shall be fully consistent with the latest industry standards.

To enable efficient functional system integration and to provide maximum flexibility and to respond to changes in the building use, the system offered shall support the use open protocol and Internet communication technologies.

1.4.1 Service Level shall allow the systems to be connected without additional software to one or

several Service Center(s), for providing centralized remote monitoring, alarm and fault detection of connected building management and security systems.

1.4.2 **Management Level** shall provide a uniform view to all systems through the open Building Operating System (BOS) platform. All the systems - controls of cooling, ventilation and lighting, consumption measurements, access controls, fire alarms and CCTV systems - shall be integrated with the BOS using device drivers.

1.4.3 **Control Level** shall consist of a distributed network of smart controllers, which communicate to each other subsystems using compatible interfaces. Connectivity towards Management Level shall utilize standard TCP/IP protocol.

1.4.4 **Field Level** shall consist of sensors and devices with industry standard interfaces.

1.4.5 **Systems** shall be accessed through the Building Operating System (BOS). System must have two main user interface types – professional user interface and occupant user interface.

1.4.6 **Professional User Interface:**

The system shall enable a client-based User Interface for professional usage and for central monitoring of systems (Service Center usage). The professional User Interface shall allow for at least the following:

- Alarm monitoring and alarm handling by multiple operators.
- Intruder alarms.
- Fire alarms.
- Alarms from electrical and mechanical systems.
- System maintenance alarms.
- Video monitoring.
- Remote diagnostics, energy optimization and trending.
- Set-point adjustment.
- Control optimization.
- Peak load management.
- Trending.
- Remote diagnostics of system/devices.
- Preventive maintenance.

- Consumption reports for energy management and billing.
- Logs and reporting.
- User profile and role management.
- Access rights management.

The professional User Interface shall be implemented as a client application, which includes an automatically adapting tree structure of the building, building's parts, individual spaces, different systems and parts of systems. The tree structure can be used for navigation through the system.

All subsystems connected to Building Operating System can be accessed through the same graphical User Interface. The client software can be installed to unlimited number of remote computers or laptops. The client software shall allow for remote Internet usage of several sites using the same client.

The professional User Interface shall show system views, floor plan views, trend view, alarm view and event log view per building and system layer. Any alarm shall be shown in red color in both graphical views and tree structure. Each alarm message shall include shortcut to relevant graphical system and floor plan view.

1.4.7 Occupant User Interface

The browser-based occupant User Interface shall be generated automatically using the structure of the building defined in the Building Information Model. The browser-based User Interface shall utilise latest web technologies, such as AJAX. The user interfaces shall provide easy access to frequently needed functionality, such as lighting controls, temperature set point modifications, alarms, and configuration of scenes and modes of the space. The same user interface functionality shall be usable through any device with a browser.

The browser-based occupant User Interface shall allow for at least the following actions:

- Changing the mode of the space.
- Modifying the mode settings of the controlled devices.
- Changing the set-points.
- Modifying the control settings (e.g. dimming level).
- Manual controls.
- Door controls.
- Camera views.
- Alarm list browsing.

The I/O Summary (Hard Points and Soft Points) and IBMS Objective is as under:

Input Output SUMMARY (HARD POINTS)

Sr. No.	Description	AI	AO	DI	DO		Scope Of Work
	HVAC Chillers						
1	Chiller Start/Stop Command				1	Relay output @ 2 amp, 230 V	Chiller Panel shall accept Potential free contact from BMS
2	Chiller Trip/Fault Status			1			Potential Free Contact shall be provided by Chiller Panel to BMS
	Chiller local / remote status			1			Potential Free Contact shall be provided by Chiller Panel to BMS
3	Chiller Fan Run Status			1			Potential Free Contact shall be provided by Chiller Panel to BMS
4	Chilled water Common header supply temperature	1				Immersion Type Temperature Sensor with Thermowell	Immersion Type Temperature Sensor with Thermowell to be provided by BMS Vendor .
5	Chilled water Common header return temperature	1				Immersion Type Temperature Sensor with Thermowell	Immersion Type Temperature Sensor with Thermowell to be provided by BMS Vendor .
6	Chilled water return Header Flow Rate	1				Flow Meter	Flow Meter to be provided by BMS Vendor .
7	Chilled water outlet supply temperature at each chiller	1				Immersion temperature sensor with thermowell	Immersion Type Temperature Sensor with Thermowell to be provided by BMS Vendor .
8	Chiller Isolation Valve open/ close command & Status			1	1	Butterfly Valve	Butterfly Isolation Valve to be provided by BMS Vendor .
9	Condensor Isolation Valve open/ close command & Status			1	1	Butterfly Valve	Butterfly Isolation Valve to be provided by BMS Vendor .
10	Outside Ambient Temperature & RH	2				Temperature cum Humidity Sensor	Temperature cum Humidity Sensor to be provided by BMS Vendor .
11	Pressure Monitoring at Return Header	1				Pressure Transmitter	Pressure Transmitter to be provided by BMS
	HVAC CHW Primary Pumps						
1	CHW Primary Pumps Start/Stop Command				1	Relay output @ 2 amp, 230 V	Starter Panel shall accept Potential free contact from BMS
2	CHW Primary Pumps Run Status			1		Water DP Switch	Water DP Switch to be provided by BMS Vendor .
3	CHW Primary Pumps Trip Status			1			Potential Free Contact shall be provided by Starter Panel to BMS
4	CHW Primary Pumps Auto/Manual status			1			Potential Free Contact shall be provided by A/M Switch to BMS
	HVAC CHW Secondary Pumps						
1	CHW Secondary Pumps Start/Stop Command				1	Relay output @ 2 amp, 230 V	Starter Panel shall accept Potential free contact from BMS
2	CHW Secondary Pumps Run Status			1		Water DP Switch	Water DP Switch to be provided by BMS Vendor .
3	CHW Secondary Pumps Trip Status			1			Potential Free Contact shall be provided by Starter Panel to BMS
4	CHW Secondary Pumps Auto/Manual status			1			Potential Free Contact shall be provided by A/M Switch to BMS
5	CHW Secondary Pumps VFD Speed Control		1				VFD Panel shall accept Potential free contact from BMS
	HVAC CHW Radiant Cooling Pumps						
1	CHW Secondary Pumps Start/Stop Command				1	Relay output @ 2 amp, 230 V	Starter Panel shall accept Potential free contact from BMS
2	CHW Secondary Pumps Run Status			1		Water DP Switch	Water DP Switch to be provided by BMS Vendor .
3	CHW Secondary Pumps Trip Status			1			Potential Free Contact shall be provided by Starter Panel to BMS
4	CHW Secondary Pumps Auto/Manual status			1			Potential Free Contact shall be provided by A/M Switch to BMS
5	CHW Secondary Pumps VFD Speed Control		1				VFD Panel shall accept Potential free contact from BMS

Input Output SUMMARY (HARD POINTS)

Sr. No.	Description	AI	AO	DI	DO	Description	Scope Of Work
HVAC	AHU with VFD						
1	AHU Fan ON/OFF command				1	Relay output @ 2 amp, 230 V	AHU Panel shall accept Potential free contact from BMS
2	AHU Auto/Manual status			1			Potential Free Contact shall be provided by AHU Panel to BMS
3	AHU Trip Status			1			Potential Free Contact shall be provided by AHU Panel to BMS
4	AHU Run Status.			1		Air differential pressure switch across the blower.	BMS vendor shall provide Air differential pressure switch and all accessories for blower status.
5	AHU Filter Status			1		Air differential pressure switch across the filter.	BMS vendor shall provide Air differential pressure switch and all accessories for filter status.
6	Duct static pressure sensor	1				Duct type Pressure sensor	BMS vendor shall provide Duct static pressure sensor with all accessories.
7	CHW 2-Way Valve Control & position feedback	1	1			Two way CHW valve control with portion feed back.	HVAC vendor shall provide 2-way modulating type motorised valve with all accessories.
8	Return air Temperature sensor.	1				Duct mount Temperature Sensor	BMS vendor shall provide return air duct type temperature sensor with all accessories.
9	Supply Air Temperature and RH	2				Duct mount Temperature Sensor	Duct mount Temperature Sensor to be provided by BMS Vendor
9	Chilled Water Inlet and Outlet Immersion Temperature Sensor	2				Immersion Temp Sensor Temperature Sensor	Duct mount Temperature Sensor to be provided by BMS Vendor
10	VFD speed control		1				VFD Panel shall accept Potential free contact from BMS
11	VFD speed Trip Status			1			Potential Free Contact shall be provided by VFD Panel to BMS
12	Return Air Co2 level Monitoring	1				Duct Mount CO2 sensor	CO2 Sensor to be provided by BMS Vendor
13	Return Air Damper Status & Command	1	1			Damper actuator by HVAC vendor	HVAC vendor to provide modulating type motorised Damper actuator with all accessories
14	Fire damper status & ON/OFF Command			1	1		HVAC vendor to provide fire damper actuators with potential free contacts. BMS vendor to lay the power cable and control cable with in the AHU room. Fire dampers shall be closed and AHUs shall be switched off in case fire signal.
15	Fire Status (Note: Directly to be connected to starter panel to trip in case of Fire. Fire status needs to be monitored in BMS)			1			From Control Module of FAS
HVAC	Treated Fresh Air Fan						
1	TFA Fan ON/OFF command				1	Relay output @ 2 amp, 230 V	AHU Panel shall accept Potential free contact from BMS
2	TFA Auto/Manual status			1			Potential Free Contact shall be provided by AHU Panel to BMS
3	TFA Trip Status			1			Potential Free Contact shall be provided by AHU Panel to BMS
4	TFA Run Status.			1		Air differential pressure switch across the blower.	BMS vendor shall provide Air differential pressure switch and all accessories for blower status.
5	TFA Filter Status			1		Air differential pressure switch across the filter.	BMS vendor shall provide Air differential pressure switch and all accessories for filter status.
7	CHW 2-Way Valve Control & position feedback	1	1			Two way CHW valve control with portion feed back.	HVAC vendor shall provide 2-way modulating type motorised valve with all accessories.
8	Return air Temperature sensor.	1				Duct mount Temperature Sensor	BMS vendor shall provide return air duct type temperature sensor with all accessories.
13	Return Air Damper Status & Command	1	1			Damper actuator by HVAC vendor	HVAC vendor to provide modulating type motorised Damper actuator with all accessories
15	Fire Status (Note: Directly to be connected to starter panel to trip in case of Fire. Fire status needs to be monitored in BMS)			1			From Control Module of FAS
HVAC	Kitchen/Toilet Exhaust Fans / Ventilation Fans						
1	Fan Start/Stop Command				1		Potential Free Contact shall be provided by Panel to BMS
2	Fan Run Status			1			Potential Free Contact shall be provided by Panel to BMS
3	Fan Trip Status			1			Potential Free Contact shall be provided by Panel to BMS
4	Fire Status			1			Potential Free Contact shall be provided by Panel to BMS

Input Output SUMMARY (HARD POINTS)

Sr. No.	Description	AI	AO	DI	DO	Scope Of Work
HVAC	Smoke Evacuation Fan					
1	Fan Start/Stop Command				1	Potential Free Contact shall be provided by BMS to Panel
2	Fan Run Status			1		Potential Free Contact shall be provided by Panel to BMS
3	Fan Trip Status			1		Potential Free Contact shall be provided by Panel to BMS
4	Fire Status			1		Potential Free Contact shall be provided by Panel to BMS
HVAC	Stairwell Pressurisation Fan					
1	Pressurisation Fan On / Off Command				1	Potential Free Contact shall be provided by BMS to Panel
2	Pressurisation Fan On / Off Status			1		Potential Free Contact shall be provided by Panel to BMS
3	Pressurisation Fan Trip Status			1		Potential Free Contact shall be provided by Panel to BMS
4	Auto /Manual Status of Fan			1		Potential Free Contact shall be provided by Panel to BMS
5	Fire Status			1		From Control Module of FAS
HVAC	Liftwell Pressurisation Fan					
1	Pressurisation Fan On / Off Command				1	Potential Free Contact shall be provided by BMS to Panel
2	Pressurisation Fan On / Off Status			1		Potential Free Contact shall be provided by Panel to BMS
3	Pressurisation Fan Trip Status			1		Potential Free Contact shall be provided by Panel to BMS
4	Auto /Manual Status of Fan			1		Potential Free Contact shall be provided by Panel to BMS
5	Fire Status			1		From Control Module of FAS
HVAC	Carpark Exhaust Fan					
1	Jet Fan On / Off Command				1	Potential Free Contact shall be provided by BMS to Panel
2	Jet Fan On / Off Status			1		Potential Free Contact shall be provided by Panel to BMS
3	Jet Fan Trip Status			1		Potential Free Contact shall be provided by Panel to BMS
4	Jet Auto /Manual Status			1		Potential Free Contact shall be provided by Panel to BMS
5	CO Sensor for Air Quality Measuring	1			Co 2 Sensor	
HVAC	Fan Coil unit					
1	ON/OFF Command				1	Potential Free Contact shall be provided by BMS to Panel
2	ON/OFF status			1		Potential Free Contact shall be provided by Panel to BMS
3	trip status			1		Potential Free Contact shall be provided by Panel to BMS
4	Room Temperature			1		Potential Free Contact shall be provided by Panel to BMS
5	Chilled water valve % open command		1			
6	Chilled water valve Status	1				
HVAC	BTU METER					
	Monitoring of BTU Meter	1				

Input Output SUMMARY (HARD POINTS)

Sr. No.	Description	AI	AO	DI	DO	Description	Scope Of Work
HVAC	Flow Meter						
	Flow Measurement for municipal inlet	1				Flow Meter	Flow Meter with Analogue Input to be provided by BMS vendor & installed by PHE vendor
	Flow Measurement for Tanker water inlet	1				Flow Meter	Flow Meter with Analogue Input to be provided by BMS vendor & installed by PHE vendor
	Flow Measurement for Borewell water inlet	1				Flow Meter	Flow Meter with Analogue Input to be provided by BMS vendor & installed by PHE vendor
	Monitoring of BTU Meter						
DG	Diesel Generator						
1	Fuel Tank High/Low Status			1		Flameproof Oil Level Switch	Flameproof Oil Level Switch with High/Low Status
2	DG Set On/Off Status			1			Potential Free Contact shall be provided by Panel to BMS
3	Emergency Stop				1		Potential Free Contact shall be provided by BMS to Panel
4	DG Set Trip Status			1			Potential Free Contact shall be provided by Panel to BMS
5	Fuel Tank Temperature	1				Flameproof Temperature Transmitter	Flameproof Temperature Transmitter
Electrical	HT Panel & LT Panel						
	Input VCB On / Off Status			1			PF Contact terminal at HT /LT panel by Electrical
	Input VCB Trip Status			1			PF Contact terminal at HT /LT panel by Electrical
	Output VCB On / Off Status			1			PF Contact terminal at HT /LT panel by Electrical
	Output VCB Trip Status			1			PF Contact terminal at HT /LT panel by Electrical
	Coupler On / Off Status			1			PF Contact terminal at HT /LT panel by Electrical
	Coupler Trip Status			1			PF Contact terminal at HT /LT panel by Electrical
Electrical	Transformer						
	Winding Temperature			1			PF Contact terminal at Transformer Vendor
	Transformer Trouble			1			PF Contact terminal at Transformer Vendor
Electrical	Generator Synchronizing Panel						
	Incoming Circuit Breaker on/off status			1			PF Contact terminal at Transformer Vendor
	Incoming Circuit Breaker trip			1			PF Contact terminal at Transformer Vendor
	Outgoing breaker on/off status			1			PF Contact terminal at Transformer Vendor
	Outgoing breaker trip			1			PF Contact terminal at Transformer Vendor
	Coupler On / Off Status			1			PF Contact terminal at Transformer Vendor
	Coupler Trip Status			1			PF Contact terminal at Transformer Vendor
Electrical	Sprinkler and Fire Alarm System						
	Butterfly Valve On/Off Status			1			All Floors
	Flow Switch monitoring			1			All Floors
	Monitoring Fire Detection system			1			All Floors
Electrical	Lighting CKt XX On /Off Command				1		Potential Free Contact
	Lighting CKt XX On/Off Status			1			Potential Free Contact
FAS	Server Room						
	Water Leak Detection Alarm			1			
	VESDA Alarm			1			
	Common fault alarm in Gas Release panel			1			PF contact Through GAS Release panel
	Cylinder Low Pressure Alarm Switch			1			PF contact Through GAS Release panel
	Gas discharged Pressure Switch			1			PF contact Through GAS Release panel
	Manual Gas release operated			1			PF contact Through GAS Release panel
	Manual Abort Station			1			PF contact Through GAS Release panel
ELEVATOR	LIFTS						
	Elevator in normal mode,			1			PF Contact
	Elevator in maintenance mode,			1			PF Contact
	Elevator in fire mode,			1			PF Contact
	Elevator in alarm bell status			1			PF Contact

Input Output SUMMARY (HARD POINTS)

Sr. No.	Description	AI	AO	DI	DO	Scope Of Work
PLUMBING	Fire Fighting System					
1	Electrical Hydrant Pump trip status			1		PF Contact
2	Electrical Hydrant Pump on/off status			1		PF Contact
3	Electrical Hydrant Pump Auto/manual status			1		PF Contact
4	Electrical Sprinkler Pump trip status			1		PF Contact
5	Electrical Sprinkler Pump on/off status			1		PF Contact
6	Electrical Sprinkler Pump Auto/manual status			1		PF Contact
7	Jockey Pump Trip Status			1		PF Contact
8	Jockey Pump on/off Status			1		PF Contact
9	Jockey Pump Auto/Manual Status			1		PF Contact
10	Diesel pump trip status			1		PF Contact
11	Diesel pump on/off status			1		PF Contact
12	Diesel pump auto/manual status			1		PF Contact
13	Booster Pump on/off Status			1		PF Contact
14	Booster Pump Auto/Manual Status			1		PF Contact
15	Booster pump trip status			1		PF Contact
PLUMBING	Hydropneumatic System					
	HYDROPNEUMATIC PUMP RUN STATUS			1		
	SYSTEM LINE PRESSURE MONITORING	1				
	HYDROPNEUMATIC PUMP TRIP STATUS			1		
PLUMBING	TANKS/SUMP LEVEL MONITORING					
1	FIRE FIGHTING WATER STORAGE TANK	1				Level Transmitter
2	RAW WATER TANK	1				Level Transmitter
3	TREATED WATER TANK	1				Level Transmitter
4	SOFT WATER TANK	1				Level Transmitter
6	STP SOFTWATER TANK	1				Level Transmitter
7	OVERHEAD FIRE TANK	1				Level Transmitter

Input Output SUMMARY (SOFT POINTS)

TYPE	Point Description	Monitor	Protocol
ENERGY METER	Line Voltage - Red Phase	X	Open Protocol
	Line Voltage - Yellow Phase	X	Open Protocol
	Line Voltage - Blue Phase	X	Open Protocol
	Current - Red Phase	X	Open Protocol
	Current - Yellow Phase	X	Open Protocol
	Current - Blue Phase	X	Open Protocol
	Neutral current	X	Open Protocol
	Frequency	X	Open Protocol
	Power factor	X	Open Protocol
	Active power	X	Open Protocol
	Reactive power	X	Open Protocol
	Apparent power	X	Open Protocol
DG	Frequency	X	Open Protocol
	Generator voltage - Red phase	X	Open Protocol
	Generator voltage - Yellow phase	X	Open Protocol
	Generator voltage - Blue phase	X	Open Protocol
	Generator amps - Red phase	X	Open Protocol
	Generator amps - Yellow phase	X	Open Protocol
	Generator amps - Blue phase	X	Open Protocol
	Generator kW	X	Open Protocol
	Generator KVA	X	Open Protocol
	Generator power factor	X	Open Protocol
	Battery weak	X	Open Protocol
	Battery low voltage alarm	X	Open Protocol
	PLC controller failure alarm	X	Open Protocol
	Emergency stop operated	X	Open Protocol
	Overcrank	X	Open Protocol
	Under frequency	X	Open Protocol
	Over-speed	X	Open Protocol
	High coolant temperature	X	Open Protocol
	Reversed power	X	Open Protocol
	Overload	X	Open Protocol
	Failed to synchronise	X	Open Protocol
	Oil pressure reading	X	Open Protocol
	common shut down	X	Open Protocol
CHILLERS	CHW OUT header temp	X	Open Protocol
	CHW IN header temp	X	Open Protocol
	Evap IN temp CH	X	Open Protocol
	Evap OUT temp CH	X	Open Protocol
	Set point Chiller	X	Open Protocol
	HP comp 1 CH	X	Open Protocol
	HP Comp 2 CH	X	Open Protocol
	HP comp 3 CH	X	Open Protocol
	LP comp 1 CH	X	Open Protocol
	LP comp 2 CH	X	Open Protocol
	LP comp 3 CH	X	Open Protocol
	Unit status	X	Open Protocol
	Comp 1 status CH	X	Open Protocol
	Comp 2 status CH	X	Open Protocol
	Comp 3 status CH	X	Open Protocol
	Run hours H Unit CH	X	Open Protocol
	Run Hours L unit CH	X	Open Protocol
	Local/remote status	X	Open Protocol
	RUN status CH	X	Open Protocol
	Trip status CH	X	Open Protocol
	OUT valve FB CH	X	Open Protocol

Input Output SUMMARY (SOFT POINTS)

TYPE	Point Description	Monitor	Protocol
	Chiller RUN command	X	Open Protocol
	OUT Valve RUN Command	X	Open Protocol
UPS			
	Battery voltage	X	Open Protocol
	DC voltage	X	Open Protocol
	Battery charging/discharging status	X	Open Protocol
	Estimated time before shutdown during battery discharging	X	Open Protocol
	Battery charging/discharging current	X	Open Protocol
	Load on bypass	X	Open Protocol
	UPS in maintenance	X	Open Protocol
	Rectifier failure alarm	X	Open Protocol
	Inverter failure alarm	X	Open Protocol
	Battery discharge alarm	X	Open Protocol
	Low battery warning alarm	X	Open Protocol
	Low battery shutdown alarm	X	Open Protocol
	Battery disconnected alarm	X	Open Protocol
	Overload alarm	X	Open Protocol
	Fan failure alarm	X	Open Protocol
	Power fuse failure alarm	X	Open Protocol
	Output over/under frequency alarm	X	Open Protocol
	Static switch unable alarm	X	Open Protocol
	Bypass not available alarm	X	Open Protocol
	Common alarm	X	Open Protocol
VFD	Motor Direction	X	Open Protocol
	Current	X	Open Protocol
	Frequency	X	Open Protocol
	Run Time	X	Open Protocol
	Output Voltage	X	Open Protocol
	Speed	X	Open Protocol
	Torque	X	Open Protocol
	Power	X	Open Protocol
	Power Consumption	X	Open Protocol
	VFD hand/auto status	X	Open Protocol
	Alarm	X	Open Protocol
ELEVATORS	Emergency stop status	X	Open Protocol
	Emergency alarm status	X	Open Protocol
	Fire man's emergency status	X	Open Protocol
	Run /Stop status	X	Open Protocol
	Fault Indication	X	Open Protocol
	Indication of Equipment Operation	X	Open Protocol
	Floor Level	X	Open Protocol

Sr No	Type of System	Objective
1	Fire Alarm System	The proposed System is an Intelligent Fire Alarm System consisting of Intelligent Multi Sensor Detectors, Heat detectors, Manual Call Points, Control Relay Modules, Monitor Modules, Duct Detectors, and Hooters etc. The proposed Life Safety System should premier with top-of-the-line platform that features intelligent alarm detection and fast, reliable peer-to-peer communications. It should collect data, performs input analysis, gives early detection of fire condition, and gives early notification, central annunciation for speedy evacuation and safeguard against possible hazards. It also provides fast and effective firefighting and consequently minimizes the loss to life and property.
2	Digital Public Address System	The primary objective of the Public Address and Emergency Sound System (PAS) shall be to provide clear announcements during public addressing and one-way voice communication during an emergency; the secondary function shall be to provide background music where required.
3	IP Access Control System + Visitor Management System	Primary Objective is Prevent / eliminate unauthorized entrants to the facility , Restrict movement of people within the facility , Maintain audit trail of people accessing the facility, Log and record visitor details
4	IP CCTV System	The IP CCTV System is intended to function with Various Different IP Cameras Installed all around the Facility on a Network. The Network Video Management System will collect and Process the CCTV Data while the Network Attached Storage will record the Data which can be used for Forensic Analysis. Monitor and record events at all entry and exit points of the facility
5	Building Management System	Reduce Energy Costs, Reduce Operational Costs through centralized operation and control. Effective Use of manpower for other tasks, Increase Operational Efficiency
6	Baggage Scanner System	The X ray baggage scanner helps to find smuggling or hidden contraband, on the other hand, ensure explosives, weapons, narcotics or weapons of mass destruction dangerous and illegal items not in the luggage or bags carried by an individual. X ray baggage scanner can be designed in different modes to satisfy different needs, for every luggage with unique features and tunnel size.
7	Door Frame Metal Detection System	DFMD is to ensure that the person entering the facility is not carrying any hazardous material.
8	Boom Barrier System	
9	Parking Management System	To provide the info on the Parking Space Available in the facility
10	Visitor Management System	To Maintain the Log of Visitor inside the facility. It will also ensure that authorised visitor is allowed inside the facility
11	Fire Extinguisher	
12	Water Leak Detection	Water Detection System is designed for the protection of Computer rooms and other Installations where water leakage can be a hazard. It has applications where there is water-cooling, air conditioning or potential ingress of water and conductive fluids into buildings.
13	Gaseous Based Suppression System - Novec for Server Room	Novec System is used to Extinguish Fire in the Server Room without damaging the IT Equipment
14	Rodent Repellent System for Server Room	The core purpose of the Rodent Repellent system is to eliminate the rodents to enter the facility/ server room / pantry/canteen premises.
15	Very Early Smoke Detection System for Server Room	To Detect the Fire Faster than FAS System in Critical Rooms like Server , HUB Room

Appendix B XV – Tender Drawings*(Schedule-B)*

ARCHITECTURAL		
Sr. No.	Drawing No.	Content
1	AH/T/A0.1	Exterior Views
2	AH/T/A0.2	Interior Views
3	AH/T/A0.3	Site Survey
4	AH/T/A1.1	Site plan
5	AH/T/A2.1	Ground Floor Plan
6	AH/T/A2.2	Lower Ground Floor Plan
7	AH/T/A2.3	First Floor Plan
8	AH/T/A2.4	Second Floor Plan
9	AH/T/A2.5	Third Floor Plan
10	AH/T/A2.6	Fourth Floor Plan
11	AH/T/A2.7	Fifth Floor Plan
12	AH/T/A2.8	Roof Level Plan 1
13	AH/T/A2.9	Roof Level Plan 2
14	AH/T/A2.10	Finishing Schedule
15	AH/T/A2.11	DW Schedule
16	AH/T/A6.1	Ground Floor RCP
17	AH/T/A6.2	First Floor RCP
18	AH/T/A6.3	Second Floor RCP
19	AH/T/A6.4	Third Floor RCP
20	AH/T/A6.5	Fourth Floor RCP

ARCHITECTURAL		
Sr. No.	Drawing No.	Content
21	AH/T/A6.6	Fifth Floor RCP
22	AH/T/A3.1	Elevations – 1
23	AH/T/A3.2	Elevations – 2
24	AH/T/A3.3	Elevations – 3
25	AH/T/A3.4	Elevations – 4
26	AH/T/A3.5	Sections – 1
27	AH/T/A3.6	Sections – 2
28	AH/T/A3.7	Sections – 3
29	AH/T/A7.1	Staircase Detail
30	AH/T/A8.1	Compound wall Detail
31	AH/T/A8.2	Porch Detail
32	AH/T/A8.3	Security & Gate
33	AH/T/A9.1	Atrium Detail
34	AH/T/A9.2	Roof Detail
35	AH/T/A9.3	Toilet Detail-1
36	AH/T/A9.4	Toilet Detail 2
37	AH/T/A9.5	Toilet, Pantry & Store Detail
38	AH/T/A9.6	Executive Toilet
39	AH/T/A9.7	Fritted Glass façade Detai
40	AH/T/A9.8	Structural curtain wall detail (external & Internal)
41	AH/T/A9.9	Gas Bank & Meter Room

ARCHITECTURAL		
Sr. No.	Drawing No.	Content
42	AH/T/A9.10	Screen detail
43	AH/T/A9.13	Reference image
44	AH/T/A9.14	Ground Floor Furniture Layout
45	AH/T/A9.15	Fifth Floor Furniture Layout

STRUCTURAL		
Sr. No.	Drawing No.	Content
1	AH/T/R/GN-1.01	General Notes
2	AH/T/R/MB-C1.01-1	Details at Foundation Level
3	AH/T/R/MB-C1.01-2	Details at Foundation Level
4	AH/T/R/MB-C1.02-1	Details at Footing Tie Level
5	AH/T/R/MB-C1.03-1	Details at Lower Ground Level
6	AH/T/R/MB-C1.04-1	Details at Plinth Level
7	AH/T/R/MB-C1.04-2	Details at Plinth Level
8	AH/T/R/MB-C2.01-1	Details at First Floor Level
9	AH/T/R/MB-C3.01-1	Details at Second Floor Level
10	AH/T/R/MB-C3.01-2	Details at Second Floor Level
11	AH/T/R/MB-C4.01-1	Details at Third Floor Level
12	AH/T/R/MB-C5.01-1	Details at Fourth Floor Level
13	AH/T/R/MB-C6.01-1	Details at Fifth Floor Level
14	AH/T/R/MB-C7.01-1	Details at Terrace Floor Level

STRUCTURAL		
Sr. No.	Drawing No.	Content
15	AH/T/R/MB-C10.01	Details of Staircase 1 & 4
16	AH/T/R/MB-C10.02	Details of Staircase 2 & 3
17	AH/T/R/MB-S1.01	Details of Entrance Porch

HVAC		
Sr. No	Drawing No.	Content
1	DCE/7692/HVAC/01/R-	Lower Ground Hvac Layout
2	DCE/7692/HVAC/02/R-	Ground Floor Hvac Layout
3	DCE/7692/HVAC/03/R-	First Floor Hvac Layout
4	DCE/7692/HVAC/04/R-	Second Floor Hvac Layout
5	DCE/7692/HVAC/05/R-	Third Floor Hvac Layout
6	DCE/7692/HVAC/06/R-	Fourth Floor Hvac Layout
7	DCE/7692/HVAC/07/R-	Fifth Floor Hvac Layout
8	DCE/7692/HVAC/08/R-	Fifth Floor Hvac Layout
LV		
Sr.No	Drawing No.	Content
1	DCE/7692/LV-CTV,ACS&BMS/01/R-	Lower Ground CCTV, ACS & BMS Layout
2	DCE/7692/LV-CTV,ACS&BMS/02/R-	Ground Floor CCTV, ACS & BMS Layout
3	DCE/7692/LV-CTV,ACS&BMS/03/R-	First Floor CCTV, ACS & BMS Layout
4	DCE/7692/LV-CTV,ACS&BMS/04/R-	Second Floor CCTV, ACS & BMS Layout
5	DCE/7692/LV-CTV,ACS&BMS/05/R-	Third Floor CCTV, ACS & BMS Layout
6	DCE/7692/LV-CTV, ACS&BMS/06/R-	Fourth Floor CCTV, ACS & BMS Layout
7	DCE/7692/LV-CTV, ACS&BMS/07/R-	Fifth Floor CCTV, ACS & BMS Layout
8	DCE/7692/LV-CTV,ACS&BMS/08/R-	Roof Plan Level-1&2 CCTV, ACS & BMS Layout
9	DCE/7692/LV-FAS&PAS/01/R-	Lower Ground FAS & PAS Layout

10	DCE/7692/LV-FAS&PAS/02/R-	Ground Floor FAS & PAS Layout
11	DCE/7692/LV-FAS&PAS/03/R-	First Floor FAS & PAS Layout
12	DCE/7692/LV-FAS&PAS/04/R-	Second Floor FAS & PAS Layout
13	DCE/7692/LV-FAS&PAS/05/R-	Third Floor FAS & PAS Layout
14	DCE/7692/LV-FAS&PAS/06/R-	Fourth Floor FAS & PAS Layout
15	DCE/7692/LV-FAS&PAS/07/R-	Fifth Floor FAS & PAS Layout
16	DCE/7692/LV-FAS&PAS/08/R-	Roof Plan Level-1 FAS & PAS Layout
17	DCE/7692/LV-FAS&PAS/09/R-	Roof Plan Level-2 FAS & PAS Layout

PLUMBING		
Sr. No	Drawing No.	Content
1	DCE/7692/PLUMBING/01/R-	Lower Ground Plumbing Layout
2	DCE/7692/PLUMBING-STORM WATER/02/R-	Lower Ground Storm Water Layout
3	DCE/7692/PLUMBING/03/R-	Ground Floor Plumbing Layout
4	DCE/7692/PLUMBING-STORM WATER/04/R-	Ground Floor Storm Water Layout
5	DCE/7692/PLUMBING/05/R-	First Floor Plumbing Layout
6	DCE/7692/PLUMBING/06/R-	Second Floor Plumbing Layout
7	DCE/7692/PLUMBING/07/R-	Third Floor Plumbing Layout
8	DCE/7692/PLUMBING/08/R-	Fourth Floor Plumbing Layout
9	DCE/7692/PLUMBING/09/R-	Fifth Floor Plumbing Layout
10	DCE/7692/PLUMBING/10/R-	Roof Plan Level-1 Plumbing Layout
11	DCE/7692/PLUMBING-U.G.TANK PIPING/11/R-	U.G. Tank Piping Layout

12	DCE/7692/PLUMBING SCHEMATIC/12/R-	Plumbing Schematic Layout
13	DCE/7692/PLUMBING-TYPICAL FLOOR WATER SUPPLY/13/R-	Typical Floor Water Supply Layout
FIRE FIGHTING		
Sr.No	Drawing No.	Content
1	DCE/7692/FIRE FIGHTING-01/R-	Lower Ground Fire Fighting Layout
2	DCE/7692/FIRE FIGHTING-02/R-	Ground Floor Fire Fighting Layout
3	DCE/7692/FIRE FIGHTING-03/R-	First Floor Fire Fighting Layout
4	DCE/7692/FIRE FIGHTING-04/R-	Second Floor Fire Fighting Layout
5	DCE/7692/FIRE FIGHTING-05/R-	Third Floor Fire Fighting Layout
6	DCE/7692/FIRE FIGHTING-06/R-	Fourth Floor Fire Fighting Layout
7	DCE/7692/FIRE FIGHTING-07/R-	Fifth Floor Fire Fighting Layout
8	DCE/7692/FIRE FIGHTING-08/R-	Roof Plan Level-1 Fire Fighting Layout
9	DCE/7692/FIRE FIGHTING-OVER HEAD TANK/09/R-	Over Head Tank Layout
10	DCE/7692/SCHEMATIC FIRE FIGHTING PIPING/10/R-	Schematic Fire Fighting Piping Layout

ELECTRICAL		
Sr. No	Drawing No.	Content
1	DCE/7692/ELECTRICAL- LIGHTING/01/R-	Lower Ground Lighting Layout
2	DCE/7692/ELECTRICAL- LIGHTING/02/R-	Ground Floor Lighting Layout

3	DCE/7692/ELECTRICAL-LIGHTING/03/R-	First Floor Lighting Layout
4	DCE/7692/ELECTRICAL-LIGHTING/04/R-	Second Floor Lighting Layout
5	DCE/7692/ELECTRICAL-LIGHTING/05/R-	Third Floor Lighting Layout
6	DCE/7692/ELECTRICAL-LIGHTING/06/R-	Fourth Floor Lighting Layout
7	DCE/7692/ELECTRICAL-LIGHTING/07/R-	Fifth Floor Lighting Layout
8	DCE/7692/ELECTRICAL-LIGHTING/08/R-	Terrace Floor Lighting Layout
9	DCE/7692/ELECTRICAL-SOCKET/01/R-	Lower Ground Socket Layout
10	DCE/7692/ELECTRICAL-SOCKET/02/R-	Ground Floor Socket Layout
11	DCE/7692/ELECTRICAL-SOCKET/03/R-	First Floor Socket Layout
12	DCE/7692/ELECTRICAL-SOCKET/04/R-	Second Floor Socket Layout
13	DCE/7692/ELECTRICAL-SOCKET/05/R-	Third Floor Socket Layout
14	DCE/7692/ELECTRICAL-SOCKET/06/R-	Fourth Floor Socket Layout
15	DCE/7692/ELECTRICAL-SOCKET/07/R-	Fifth Floor Socket Layout
16	DCE/7692/ELECTRICAL-SOCKET/08/R-	Terrace Floor Socket Layout
17	DCE/7692/ELECTRICAL-SERVICE/01/R-	Lower Ground Service Layout
18	DCE/7692/ELECTRICAL-SERVICE/02/R-	Ground Floor Service Layout
19	DCE/7692/ELECTRICAL-SERVICE/03/R-	First Floor Service Layout
20	DCE/7692/ELECTRICAL-SERVICE/04/R-	Second Floor Service Layout
21	DCE/7692/ELECTRICAL-	Third Floor Service Layout

	SERVICE/05/R-	
22	DCE/7692/ELECTRICAL-SERVICE/06/R-	Fourth Floor Service Layout
23	DCE/7692/ELECTRICAL-SERVICE/07/R-	Fifth Floor Service Layout
24	DCE/7692/ELECTRICAL-SERVICE/08/R-	Terrace Floor Service Layout
25	DCE/7692/ELECTRICAL-MAIN SLD 01/01/R-	Main SLD 01
26	DCE/7692/ELECTRICAL-MAIN SLD 02/02/R-	Main SLD 02
27	DCE/7692/ELECTRICAL-EARTHING SCHEMATIC/01/R-	Earthing Schematic
28	DCE/7692/ELECTRICAL-LIGHTING ARRESTOR/01/R-	Lightning Arrestor Layout

Schedule C - Project Facilities

(See Clause 2.1)

The Contractor shall construct the Project Facilities in accordance with the provisions of this Schedule C. Such Project Facilities shall include:

1.0 Architectural

1. Ground floor atrium flooring in Italian marble – pattern as per drawings.
2. Ground floor atrium planters and seating as per details drawings to include HVAC ducting for atrium.
3. Canopy in structural steel with aluminium jaliwork arches and screens as per detail drawings.
4. Atrium roofing in cellular polycarbonate sheets and structural steel support system.
5. Compound wall with MS jali panels as per detail drawings.
6. Atrium front façade glazing as per drawings.
7. Structural façade glazing on north façade as per drawings.
8. Aluminium jali work on east, west and south facades as per drawings.

2.0 Civil and Structural

1. Earthquake preventive measures: Earthquake cannot be prevented. However, earthquake can be sustained by designing earthquake resistant structures using Indian Standards.
2. Disaster (flooding) resistant building design:
 - a) Elevating as much of the building as possible above the design flood level.
 - b) Designing the building foundation and any portions subject to flooding to withstand design flood conditions and loads.
 - c) Using flood damage resistant materials for any portions of the building below the design flood level.
 - d) Local inhabitants have adopted strategy to overcome problem of flooding, by a raised plinth.

3.0 Ancillary facilities

Ancillary facilities shall be provided in accordance with the provisions as per Schedule B& D and shall include:

- 1) Compound wall in block work with intermittent MS jali panels and piers also in block work.
- 2) 03 Entry / Exit gates with CC TV surveillance.
- 3) 03 Security Cabins

- 4) 02 Entry / Exit ramps to the lower ground parking / service level
- 5) Utilities adjoining the eastern plot boundary

5.1 Electrical Power Supply

The building will be provided with permanent electrical supply, DG & UPS backup power facilities in accordance with the provisions as per Schedule B & D.

Electrical facilities shall include

- 1) 1 x 2000vkVA, prime rated, 415V, 50Hz, Transformer and 2 x 500kVA DG sets with associated accessories.
- 2) Normal and emergency light fixtures.
- 3) Building facade lighting, gate illumination, bollards etc.

6.1 HVAC

The building will be provided with air conditioning, mechanical ventilation and exhaust facilities in accordance with the provisions as per Schedule B & D.

HVAC facilities shall include:

- 1) Air cooled chillers shall be provided as standby in terrace of the building.
- 2) Air cooled Precision Units (n +1 configuration) for Rack Room
- 3) DX units for UPS & Battery Room.
- 4) Copper piping with insulation for DX system.
- 5) Variable Frequency Drive (VFD) for Secondary chilled water pumps and AHUs.
- 6) Pot strainer, air separator, automatic closed type expansion tank etc.
- 7) Ventilation system for toilets, electrical rooms.
- 8) Chilled water piping with insulation

7.1 Firefighting facilities

The building will be provided with Firefighting facilities including wet risers, sprinklers, fire hydrants and portable fire extinguishers in accordance with the provisions as per Schedule D & I and requirements of the statutory authorities.

Firefighting facilities shall include:

- 1) Underground (UG) and Terrace level water tanks for firefighting system

- 2) Fire pumps, external and internal hydrant pumps, sprinkler pumps, jockey pumps
- electric & diesel engine driven
- 3) Piping connection between UG tanks to the suction header, pump connections, further distribution with required valves, accessories etc.
- 4) Required electrical MCC cum instrument control panels with controls like pressure switch etc. to make the system to work automatically.
- 5) Fire extinguishers, internal hydrants and yard hydrants.
- 6) Piping connection between OHT to the wet riser with required valves, accessories etc.
- 7) Internal hydrants with hose reel box, fire hoses, nozzle etc. at each level.
- 8) Piping, valves, accessories required for the complete system.

8.1 Plumbing and Sanitary facilities

The building will be provided with sanitation facilities including fully functional and equipped washrooms and potable water supply in accordance with the provisions as per Schedule B & D.

Sanitary facilities shall include:

- 1) Underground (UG) water tanks for each potable, non-potable and firefighting system in basement of utility building.
- 2) Individual transfer pumps (working & standby) for each system (potable and non- potable) in utility building.
- 3) Booster pumping systems with sensor are proposed for top 3 levels of each building.
- 4) Complete sewage, waste and rain water piping.
- 5) Complete water supply (both potable & non-potable) distribution from OHT to each level.
- 6) Piping connection between UG tanks to the suction header, pump connections etc.
- 7) Sanitary fixtures and fittings.
- 8) Piping, valves, accessories required for the complete system.
- 9) Rain water collection from roof top

9.1 LEED related facilities

Appropriate drawings and details to be submitted along with photographs. Following facilities are to be provided on site during / post construction.

- Dedicated covered storage for HVAC material and equipment. Storage area should be clean and dry.
- Soil erosion and sedimentation control measures.

- Waste collection and segregation area in Utility Building. Refer to LEED Scope of works for detailed requirements.

10.0 Storm water drainage management facilities

- 1) Excavation, dewatering, ramming, refilling, and disposal of surplus excavated soil for pipe / box trench.
- 2) Construction of all type inspection chambers.
- 3) Supply, laying, jointing, testing and commissioning of RCC NP-3 pipe/ precast RCC rectangular drains with all section sizes as indicated in the layout plan of storm water drainage system.
- 4) Site would level in such a way that it is drained out properly.

Schedule D - Specifications and Standards*(See Clause 2.1)*

All designs, materials, works and construction operations shall conform to the Standards and Specifications given below and attached as an annexure.

Where the Contractor intends to use an alternative to these Standards/Guidelines for delivering an equal or better product, he shall be permitted to use such alternative subject to the following conditions:

He shall demonstrate that the proposed alternatives conform to any of the following international Standards, Codes of Practice, Specifications, Guidelines, etc.

In case the Consultant intends to use any alternative material/technology/method, whether patented or otherwise, that is not specifically covered in the Indian or International Standards as listed above, but the use of which has been permitted on similar projects (similar in category of buildings) as the Building Projects, he would be permitted, its use on certification by the owners of such similar projects regarding the continued successful performance of such materials, technologies, methods, procedures or processes for at-least 5 years of the service life of the project. Such a certification shall be supported with details of critical performance parameters.

Such other reference standards published by the following that may be considered:

DIN	Deutsche Industries Norman (German Standards)
AFNOR	Association Francaise de Normalisation (French Standard Institute)
BSI	British Standard Institute
ASTM	American Society for Testing and Materials ANSI American National Standards Institute

The above is the list of codes included for guidance and compliance with applicable portions only and the omission of any from the list does not relieve the contractor from compliance therewith.

Latest version of the Codes, Standards, Specifications, etc., notified/published at least 60 days before the last date of bid submission shall be considered applicable.

Where the Standards and Specifications for a work are not given, Good Industry Practice shall be adopted to the satisfaction of the Employer's Engineer.

1. Structural Works

1.1. Introduction

Aurangabad Integrated City (AURIC) has proposed to construct a AURIC Hall Building within a site area of 2.77 acres at phase – I of Shendra – Bidkin Industrial area, Aurangabad. The building is classified as Business and Office Buildings based upon the type of occupancy as per IS 875 (Part 2). This design basis report will be used for the design of the AURIC Building and allied structures for AURIC.

1.2. Design Brief

This specification enlists different design criteria and methodology adopted in the designing of the Structure. The detailed design and drawings will be prepared as per the structural requirement to fit the project planning and architectural project aspects.

This Design Basis Report is not applicable to the design of the exterior glass curtain wall.

The materials, detailed design and drawings shall conform to all relevant provisions of BIS (Bureau of Indian Standards) codes and standards, and the NBC (National Building Code). If there is any variation between the requirements of the BIS standards and NBC with the requirements stated in this DBR, then the more conservative of the requirements shall be adopted. A list of some important codes and references to be referred to in design are listed in Section 10 of this DBR. The list is not exhaustive list – further reference shall be added based on the design requirement during the detailed engineering stage.

1.3. Structural System

The structural framing of the building is based on the project requirement, functional importance to suit viability of the project.

The structure shall be analysed for different load cases such as dead loads, imposed loads, wind loads, seismic loads, etc. as well as different load combinations amongst either of the above and shall be designed for the maximum intensity to which the structure is expected to be exposed.

1.3.1. Super Structure

1.3.1.1. Structural Columns, Beams and Slabs

To have column free office space and restricted depth of internal beams for services, all long span internal beams will be pre-stressed RCC members. All slabs and other area beams will be RCC members.

1.3.1.2. Structural Roof (Atrium)

The roof for the atrium will be in structural steel rafters and purlins under translucent sheets to allow for defused lighting of the atrium while conforming to the environmental parameters as defined by the architectural use of the area.

1.3.2. Structure below Plinth

1.3.2.1. Foundations

The soil bearing capacity and related parameters are considered according to M/s. Aarvee Associates recommendations. The recommended safe soil bearing capacity is 500 kN/m². (Refer Geotechnical Report).

The footings for columns and shear walls will be sized based on this soil bearing capacity. The type of foundation shall be open (isolated or combined) footings. The depth of foundation shall be up to hard strata or 1.5m from natural ground level, whichever is more. All footings shall be located below the grade slab at the lower ground level. For adjacent footings at different levels, clear horizontal distance between the footings shall be at least twice the difference between the bottoms of footings. If required, plumb concrete shall be used to raise the level of lower footing.

The location of the tie beams between the footings and the lower basement slab shall be determined as per the following:

Tie beam shall be provided if the distance between top of footing and bottom of raft (unsupported length of column) is more than 5.0m.

The soil type proposed to be used in analysis as per Table 1 of IS 1893 (Part 1): 2002 is Type II Medium Soils.

1.3.2.2. Basement Raft

A grade slab shall be provided at lower ground floor bottom slab. As per the geotechnical report, water table is not encountered at the location of the basement raft slabs. The basement raft slab will be designed slab on grade as per its location.

1.3.2.3. Retaining Walls

Two ramps on either side of the building are proposed for access to the lower ground level parking. Ramp slab on grade of required thickness shall be provided, surrounded by retaining walls. Cantilever retaining walls will be provided around the lower ground level parking to retain the difference in level of the soil. In addition to this, a surcharge loading of 10kN/m² will be considered. The earth pressure coefficients for estimating the lateral loads shall be the maximum of (a) 0.33 or (b) coefficient obtained from Coulomb's theory.

1.3.3. Lateral Load Resisting System

Response reduction factor (R) for earthquake resistant design will be 3.0, corresponding to Ordinary Moment Resisting Frames (OMRF).

The mean probable design life of the structure is considered to be 50 years.

The following describes the parameter of the building:

1. Levels : Lower Ground+Ground+5 Upper Floors
2. Plan Dimension : 110 m X 45 m
3. Total Height : 30 m
4. Storey Height : 4.2 m

1.4. Reinforced Cement Concrete (RCC) Structures

All RCC structures will be designed and detailed using the limit state method as per IS 456:2000.

Structural analysis shall be made within the permissible limits and boundary conditions conforming to IS 456:2000 or shall be in accordance to relevant IS codes.

Member sizing and sectional properties assigned shall be dependent on the critical load case or the combination subjected to the building with applicable factor of safety.

For the design of prestressing of the specific beams, the forces and proportioning of the prestressing tendons will be corresponding to the vertical loads only. Additional reinforcement will be provided to these beams in case they are a part of the lateral load resisting OMRF.

Design of water tanks shall be based on consideration of adequate resistance to cracking as well as adequate strength, and shall be as per the requirements of IS 3370:2009.

1.5. Structural Steel Structures

All structural steel structures will be designed using the Limit State Method as per IS 800:2007 or Working Stress Method as per IS 800:1984. Mild steel with minimum yield strength of 250 MPa will be considered in design of structural steel components. Structural analysis shall be made within the permissible limits conforming to IS 800:2007 or shall be in accordance to relevant IS codes.

1.6. Materials

1.6.1. Concrete

All RCC structures will be designed and detailed using the limit state method as per IS 456:2000. Mix proportion of the grade of concrete as per the design requirement shall be considered as per Clause 6.1 IS 456:2000.

Sr. No.	Parameters	Minimum Grade of Concrete
1	Foundation	M50
2	Sub Structure up to Plinth Level	M50
3	Super Structure up to Terrace Level	M50

1.6.2. Reinforcing Steel

Steel reinforcement of various diameters shall be conforming to IS 1786 of grade Fe500 for all the structural components including Foundations, Columns, Beams, Slabs, etc.

1.6.2.1. Clear Cover to Reinforcement

The nominal cover to reinforcement for different RCC elements to meet various requirements of Durability and Fire Resistance, and “Very Severe” exposure condition for elements below plinth, and “Moderate” for elements above plinth, as per Clause 26.4 of IS 456:2000 are mentioned in the table below:

Sr. No.	Element	Value
1.	Foundation	50 mm
2.	Column	40 mm
3.	Beams	30 mm
4.	Slabs	30 mm
5.	Basement Raft	50 mm
6.	Retaining Wall	40 mm

1.6.3. Structural Steel

All structural steel commonly used in general construction, shall before fabrication conform to IS 2062. Mild steel with minimum yield strength of 250 MPa corresponding to grade E250 will be considered in design of structural steel components.

1.6.4. Brick Masonry & External Façade

All unreinforced non-load bearing wall shall be constructed using brick masonry or block masonry of specified class, or Autoclaves Aerated Concrete masonry.

All external brick masonry shall be of 200 mm thick and internal brick masonry will be 115/150 mm thick as per the detailed drawings.

The general external façade of the building will be made of perforated metal screen, which is located at a distance of 0.9m from the face of the structural beam of the building. The screen will be attached to the RCC members (beams or slabs) of the building – the sizing and location of the screen attachments will be as per the screen detailed design.

For design of the beams, load corresponding to 200 thick brick walls will be considered for walls and façade.

1.7. Fire Protection

The information regarding the fire zones for the site is not available. However, since all the buildings in the vicinity of the site are either meant for business (offices) purposes, the site is considered to be in Fire Zone No. 2 (Group E), as per IS 1641 – 1988.

All reinforced cement concrete members and walls shall be proportioned to achieve a minimum of 1.5hr fire rating as per IS 1642 – 1989. Henceforth minimum thickness provided to the members shall abide the requirement as per Clause 21 and Clause 26.4 of IS 456:2000

All structural steel members will be protected with paint (two coats of Synthetic Enamel of approved colour and paint over one coat of Zinc Chromate primer). Any further fire protection for the structural steel members will be adopted, if required, in consultation with the fire and safety consultant.

1.8. Corrosion**1.8.1. Corrosion in Reinforcement**

The environmental exposure conditions, to which all RCC members will be exposed during its working life is “Very Severe” for elements below plinth and “Moderate” for elements above plinth, as per clause 8.2.2.1 Table 3 of IS 456:2000. The design consideration includes use of durable concrete with Ordinary Portland Cement (OPC) of appropriate Grade or Portland pozzolana cement as per Clause 5.1 of IS 456:2000.

Potable water shall be considered for mixing and curing of concrete with permissible limit of Suspended Solids, Chloride and Sulphate content as per Table 1 of IS 456:2000.

The minimum cement content and maximum free water cement ratio shall conform to Table 5 of IS 456:2000.

In order to meet durability requirements, minimum nominal cover shall be determined depending upon the type of exposure conditions as per Table 16 of IS 456:2000.

1.8.2. Corrosion in Structural Steel

For protection against corrosion, minimum thickness of 6 mm will be provided where cleaning of steel is possible. Wherever cleaning of steel is not possible, thickness shall be 8 mm minimum for the design considerations.

1.9 Deflection

Deflection in concrete structures shall be in general limited by adherence to the limits on span by depth ratios for beams and slabs and length to lateral dimension ratios for columns as described in IS 456:2000 or any other applicable relevant codes, provided the condition given in the code for applicability of the ratios are satisfied. Otherwise, deflection calculations will be made to ensure that the deflections are within permissible limits specified in IS 456:2000.

Deflection in structural steel members shall generally be limited to Table 6 of IS 800:2007, unless under circumstances where a different value is more appropriate depending upon the nature of material and intended use of member as per client requirement.

The deflection during earthquake shall conform to requirements of IS 1893 (Part 1): 2002.

1.10 Loads

1.10.1. Dead Loads (DL)

The dead loads of a structure include self-weight and weights of supported permanent loads like brick walls, floor finishes, waterproofing, etc. These will be calculated based on the material and size of the component.

The basic unit weights of these components, as per IS 875 (Part 1) are given below:

Sr.No.	Building Material	Unit Weight
1.	Reinforced Cement Concrete	25 kN/m ³
2.	Plain Cement Concrete	24 kN/m ³
3.	Brick Masonry with Plaster	20 kN/m ³
4.	Roof Waterproofing (Brickbat coba)	20 kN/m ³
5.	Floor Finish	1.25 kN/m ²

1.10.2. Imposed Loads (LL)

The imposed (live) loads imposed on a structure will be as per IS 875 (Part 2), based on the occupancy and usage of the area.

The table below gives the loading used for design the typical rooms. Any room / area not covered below will be designed for loading as per IS 875 (Part 2). The strength of the slabs of the room / area shall be independently qualified to transfer the concentrated loads as specified in IS 875 (Part 2), to the supporting members.

Maximum live load on non-accessible roof will be 0.75 kN/m².

The following minimum loading will be considered based on the occupancy class:

No.	Description of Room / Area	Loading (kN/m ²)
1.	Work area without Machinery	2.5
2.	Work area with Machinery / Equipment	5.0
3.	Cafeterias, Dining Rooms and Kitchens	3.0
4.	Corridors, passages and staircases including Fire escapes	4.0
5.	Toilet and Bathrooms	2.0
6.	Store rooms	3.0
7.	Accessible terraces	1.5
8.	Non-accessible terraces	0.75
9.	Multi-purpose hall	5.0
10.	Rooms for general use with separate stores	2.5
11.	Rooms for general use without separate stores	4.0
12.	Business computing machine rooms (with fixed computers or similar equipment)	3.5
13.	Records/files store rooms and storage space	5.0
14.	Vaults and strong room	5.0
15.	Stationary Stores	4.0
16.	Office area with Light partitions (uniformly distributed load)	2.6
17.	Non-accessible roof	0.75

The loading diagrams of all floor levels for different types of load are available in section 11 of this document.

1.10.3. Wind Loads (WL)

The wind loads imposed on the structure will be based on a basic wind speed of 39 m/s as per IS 875 (Part 3).

The Wind Force F acting on to a particular face of the building is given by:

$$F = C_f A p_z$$

Where,

$$p_z = 0.6 V_z^2$$

$$V_z = V_b k_1 k_2 k_3$$

The coefficients are calculated corresponding to the Design Life of 50 years.

Here,

Basic Wind Speed	(V_b)	:	39 m/s	As per IS 875 (Part 3)
Risk Coefficient	(k_1)	:	1.0	As per Table 1 IS 875 (Part 3)
Height and Terrain Factor	(k_2)	:	varies	As per Table 2 IS 875 (Part 3) Class C & Terrain Category 2
Topography Factor	(k_3)	:	1.0	As per Table 3 IS 875 (Part 3)
Design Wind Speed	(V_z)			As per Clause 5.3 IS 875 (Part 3)
Design Wind Pressure	(p_z)			As per Clause 5.4 IS 875 (Part 3)
Surface Area	(A)			Area of the Face of Building perpendicular to the incident of Wind
Force Coefficient	(C_f)			As per Fig.4 IS 875 (Part 3)

1.10.4. Seismic (Earthquake) Loads (EL)

The site falls in seismic zone II, as per IS 1893 (Part 1) : 2002. Therefore, the seismic loads will be as prescribed for that zone. Importance factor of 1.5 will be used.

The structure will be designed and detailed as per the requirements of IS 456; response reduction factor (R) for earthquake resistant design will be 3.0, corresponding to Ordinary Moment Resisting Frames.

Earthquake loads will be calculated as per IS 1893:2002 (Zone II / 0.1; for Aurangabad).

The total design lateral force or design seismic base shear (V_B) along any principal direction is given by:

$$V_B = A_h W$$

Where A_h is design horizontal acceleration spectrum value as per Clause 6.4.2 of IS 1893 (Part 1): 2002, using the fundamental natural period (T_a) in the considered direction of vibration

$$A_h = \max\left(\frac{ZI}{2R} \frac{S_a}{g}, \frac{Z}{2}\right)$$

Fundamental natural period of vibration (T_a) in the considered direction is given by:

$$T_a = \frac{0.09h}{\sqrt{d}} \quad (\text{as per Clause 7.6.2 of IS 1893 (Part 1): 2002})$$

where, ' d ' is base dimension of building at plinth level in m along the considered direction, and ' h ' is the height of the building

Separation between two adjacent units of the building shall conform to Clause 7.11.3 of IS 1893 (Part 1): 2002.

1.10.5. Temperature Loads (TL)

The city of Aurangabad is close to 45 °C line of the highest maximum temperature isopleths as per Fig.1 of IS 875 (Part 5) -1987 and 2.5 °C line of lowest minimum temperature isopleths as per Fig.2 of IS 875 (Part 5) -1987.

The maximum temperature ever recorded in the city was 46 °C on 25th May 1905 and minimum temperature ever recorded in the city was 2 °C on 2nd Feb 1911. Thus, the maximum change in temperature is about 42.5 °C. Adequate gaps at the expansion joints will be provided to accommodate the movement of the adjacent structures due to temperature variation.

1.10.6. Snow Loads (SL)

It is not required to consider any snow load, as there is no evidence of snow at the site.

1.11. Load Combinations

Following minimum load combinations will be considered as per IS 875 (Part 5). Additional load combinations may be considered as per the requirement of other relevant standards.

Sr. No.	Load Combinations		
1	COMB 00	:	1.5 DL
2	COMB 01	:	1.5 DL + 1.5 LL
3	COMB 11	:	1.2 DL + 1.2 LL + 1.2 EL _x
4	COMB 12	:	1.2 DL + 1.2 LL - 1.2 EL _x
5	COMB 13	:	1.2 DL + 1.2 LL + 1.2 EL _y
6	COMB 14	:	1.2 DL + 1.2 LL - 1.2 EL _y
7	COMB 21	:	1.5 DL + 1.5 EL _x
8	COMB 22	:	1.5 DL - 1.5 EL _x
9	COMB 23	:	1.5 DL + 1.5 EL _y
10	COMB 24	:	1.5 DL - 1.5 EL _y
11	COMB 25	:	0.9 DL + 1.5 EL _x
12	COMB 26	:	0.9 DL - 1.5 EL _x
13	COMB 27	:	0.9 DL + 1.5 EL _y
14	COMB 28	:	0.9 DL - 1.5 EL _y
15	COMB 31	:	1.2 DL + 1.2 LL + 1.2 WL _x
16	COMB 32	:	1.2 DL + 1.2 LL - 1.2 WL _x
17	COMB 33	:	1.2 DL + 1.2 LL + 1.2 WL _y
18	COMB 34	:	1.2 DL + 1.2 LL - 1.2 WL _y
19	COMB 41	:	1.5 DL + 1.5 WL _x
20	COMB 42	:	1.5 DL - 1.5 WL _x
21	COMB 43	:	1.5 DL + 1.5 WL _y

Sr. No.	Load Combinations		
22	COMB 44	:	1.5 DL - 1.5 WL _y
23	COMB 45	:	0.9 DL + 1.5 WL _x
24	COMB 46	:	0.9 DL - 1.5 WL _x
25	COMB 47	:	0.9 DL + 1.5 WL _y
26	COMB 48	:	0.9 DL - 1.5 WL _y

Here,

DL : Dead Load

LL : Imposed/ Live Load

WL_x : Wind Load in X Direction

WL_y : Wind Load in Y Direction

EL_x : Seismic Load in X Direction

EL_y : Seismic Load in Y Direction

1.12. Reference Codes and Standards

The following are the referral codes implemented for Design Consideration:

IS:269 – 1989	Specification for Ordinary, rapid hardening and low heat Portland cement.
IS:383 – 1970	Specification for coarse and fine aggregates from natural sources for concrete.
IS:432 - 1982	Specification for Mild Steel and Medium Tensile Steel Bars and Hard Drawn Steel Wire for Concrete Reinforcement.
IS:455 – 1989	Specification for Portland blast furnace slag cement.
IS:456-2000	Plain and Reinforced Concrete – Code of Practice

IS:516 -1959	Method of test for strength of concrete.
IS:800-2007 and -1984	General Construction in Steel – Code of Practice
IS:816 – 1969	Code of Practice for Metal Arch Welding for General Construction in Mild Steel
IS:875 (Part 1) – 1994	Code of Practice for Design Loads (other than Earthquake) for Buildings and Structures – Part 1 Dead Loads — Unit Weights of Building Materials and Stored Materials
IS:875 (Part 2) – 1995	Code of Practice for Design Loads (other than Earthquake) for Buildings and Structures – Part 2 Imposed Loads
IS:875 (Part 3) – 1996	Code of Practice for Design Loads (other than Earthquake) for Buildings and Structures – Part 3 Wind Loads
IS:875 (Part 5) – 1997	Code of Practice for Design Loads (other than Earthquake) for Buildings and Structures – Part 5 Special Loads and Load Combinations.
IS:1139	Specification for Hot rolled deformed bars
IS:1161 – 1998	Specification for Steel tubes for Structural Purposes.
IS:1343 – 1980	Code of Practice for Prestressed Concrete
IS:1489 – 1991	Specification for Portland Pozzolana cement
IS:1566 – 1982	Specification for Hard drawn steel wire fabric for Concrete Reinforcement
IS:1641 – 1988	Code of Practice for Fire Safety of Buildings (General): General Principles of Fire Grading and Classification.
IS:1642 – 1989	Code of Practice for Fire Safety of Buildings (General): Details of Construction.
IS:1785 – 1983	Plain hard-drawn steel wire
IS:1786 – 2008	High Strength Deformed Steel Bars And Wires For Concrete Reinforcement

IS:1893 – 2002	Criteria for Earthquake Resistant Design of Structures – Part 1 General Provisions and Buildings
IS:2062 – 1999	Steel for General Structural Purposes – Specification.
IS:2062 – 2006	Hot Rolled Low, Medium and High Tensile Structural Steel
IS:2090 – 1983	High Tensile steel bars
IS:2645 – 1975	Specification for integral cement water proofing compounds.
IS:3370 – 2009	Code of Practice For Concrete Structures For The Storage Of Liquids
IS:4990 – 1993	Specification for plywood for concrete shuttering works
IS:6006 – 1983	Specification for Uncoated stress relieved strand for Prestressed Concrete
IS:10790 – 1982	Methods of sampling of steel for prestressed and reinforcement concrete.
IS:13920 – 1993	Ductile detailing of reinforced concrete structures subjected to seismic forces - Code of practice
IS:14268 – 1995	Uncoated Stress Relieved low relaxation seven-ply strand for Pre stressed Concrete – Specification
Conc. Soc.TR-043	Post Tension concrete design handbook (to be used in conjunction with the BS 8110)
ACI 318	Building code requirement for structural concrete & commentary
BS 4447	Specification for the performance of prestressing anchorages for post tensioned construction
BS 4486	Specification for hot rolled and processed high tensile alloy steel bars for the prestressing of concrete
BS 5896	Specification for high tensile steel wire and strand for the prestressing of concrete
BS 8110	Structural use of concrete

	Part 1. Code of practice for design and construction Part 2. Code of practice for special circumstances
BS EN 445	Grout for prestressing tendons – Test methods
BS EN 446	Grout for prestressing tendons – Grouting procedures
BS EN 447	Grout for prestressing tendons – Specification for common grout quality control.
BS EN 934	Part 4. Admixtures for concrete, mortar and grout. Admixtures for prestressing tendons. Definitions, requirements, conformity, marking and labelling.
AA/ HD/ 1628	Aarvee Associates, Geotechnical Investigation Report

3.1 ELECTRICAL WORKS

Standards and Specifications for the Design and Construction of Electrical works are given in this section;

3.2 BACKGROUND

The contractor shall comply with all the minimum requirements of the Design and Construction of Electrical works as per the Latest Standards, Statutory requirements, National Building codes and all other relevant regulations

3.3 CODES AND STANDARDS

The system, design, materials, equipment, installation, testing and commissioning shall, in addition to all other applicable codes and standards, comply with the latest requirements of the following standards, codes, principles and specifications issued by Indian standards or IEC codes :-

3.4 HT VCB - TECHNICAL SPECIFICATIONS

1.1 SCOPE

This specification covers the requirements of supplying of HT OUTDOOR metal clad cubicle switch gear having Vacuum Circuit Breakers. These are general requirements of switchgear panel.

1.1.1 APPLICABLE STANDARDS:

The switch gear panel and components mounted shall confirm to the following latest revisions of relevant Indian or equivalent British or International standards. In case of any conflict between the following standards and this specification, the requirements of this specification shall prevail.

IS: 2516(Part1 sec.2)	Specifications for circuit breakers. General & Definitions (for voltages above 1000V A.C.).
IS: 2516(Part1 sec.3)	Specifications for Alternating (circuit breakers requirements (voltage above 33KV).
IS: 2516(Part 2 sec.2)	Circuit breaker tests voltage (range 1 KV to 33 KV).
IS: 4710	Switches and switch isolators (above 1 KV but not exceeding 33 KV.)
IS: 375	Marking and arrangement of switch gear bus bars
IS: 2707 (Part 1 to 4)	Current Transformers.
IS: 3156	Voltage Transformers.
IS: 1248	Electrical Indicating Instruments
IS: 3231	Electrical relays for power system protection.
IS: 6875h	Control switches and push buttons
IS: 4483	Preferred panel cutout for relays
IS: 9046	HT Vacuum contactors
IS: 3427	Degree of protection provided for metal enclosed switchgear and control gear.
IS: 5578	Guide for marking of insulated conductors.
IS: 5082	Material for data for Aluminum conductors
IS: 3618	Phosphate treatment of iron and steel for protection against corrosion
IS: 6005	Code of practice of phosphating of iron and steel
IS: 5	Painting.
IS: 722	Integrating meters
IS: 2544	Specifications for HV post insulators

1.2 CONSTRUCTION:

1.2.1 The switch gear panel shall be metal enclosed, rigid, free standing, floor mounted draw out, dead front type and fabricated from standard prefabricated, cold rolled sheet steel units. The

- vertical units shall be assembled in such a way that uniform height can be achieved while line up of each vertical units on floor.
- 1.2.2 The minimum thickness of the sheet steel shall not be less than 2.5 mm. Necessary stiffeners shall be provided.
- 1.2.3 The switchboard shall be totally enclosed, vermin -proof, except bus bar compartment. Degree of protection of enclosure shall be minimum IP56 as per IS: 3427. If necessary, openings for natural ventilation louvered with wire mesh shall be provided. For bus bar compartment wire mesh shall be such as to protect against object of 1.0 mm size and above.
- 1.2.4 All doors, removable covers, gland plates and other openings shall be gasket all round the perimeter with neoprene gaskets.
- 1.2.5 Switch gear shall be provided with an ISMC channel as a base frame. Minimum height of the base frame shall be of 100 mm.
- 1.2.6 All doors shall be supported by strong hinges of concealed type and braced in such a manner as to ensure freedom from sagging, bending and general distortion of panel or hinged parts.
- 1.2.7 Switchboards shall be suitable for site conditions as specified in the Technical Data Sheet.
- 1.2.8 Each unit of the switch gear shall be provided with necessary internal sheet metal barrier to form separate components for buses/Indicating instruments/protective relays/control and power cable connection etc. Compartment for cable connection shall allow adequate space for cable pulling, termination and connection work with energised switch gear. Suitable arc propagation barrier shall also be provided. Preferably independent pressure release valves shall be provided for different compartments. Terminal strips for outgoing control cable connection should be accessible to facilitate working and testing with breaker in test/service condition with the energised switchboard.
- 1.2.9 After isolation of the power and control connection of a circuit, it shall be possible to safely carry out maintenance or a repair work in a compartment with the bus bars and adjacent circuits alive.
- 1.2.10 At a future date, it shall be possible to extend the switch gear in either direction. Ends of the bus bars shall be suitably drilled for this purpose. Panels at the extreme ends shall have openings which shall be covered with plate screw to the panel with necessary gaskets.
- 1.2.11 Switch gear shall be vertical isolation and horizontal draw out type.

- 1.2.12 All draw out circuit breaker trucks/trolley of the same rating for all outgoing breakers shall be identically wired/equipped for complete inter-changeability at site. 'Service', 'Test', 'Draw Out' positions of the draw out carriage of the switchboard shall be provided. Automatic safety shutters shall be provided to ensure the inaccessibility of all live parts after the breaker is drawn out.
- 1.2.13 Dummy panels required for rear extensions for cable terminations or to mount the components shall be included in the offer and details of each type of such panels shall be furnished along with offer.

1.3 SAFETY INTERLOCKS:

It shall not be possible to draw out the carriage with circuit breaker closed. The breaker feeder trolley shall remain inside the cubicle even in the 'drawout' position. There shall be distinct overall door for the breaker compartment and it should be lockable. Suitable interlocks to prevent following faulty operations shall be provided.

- 1.3.1 'Plugging in' or 'drawing out' of a closed breaker.
- 1.3.2 'Plugging in' a breaker with earthing isolator closed.
- 1.3.3 'Closing' of earthing isolator with breaker 'Plugged in
- 1.3.4 Pulling out of auxiliary circuit plug with breaker in service position.
- 1.3.5 Pushing in breaker to service position with auxiliary circuit plug not in position.
- 1.3.6 Opening of compartment door with isolating switch in ON position and vice versa.

Necessary mechanical and electrical interlocks between H.T. and L.T. switch gears shall be provided in closing and tripping circuits of breakers which shall be a part of the specification. The total bill of material and scheme designed by the manufacturer will be subject to client/consultant's approval and any addition or deletion shall be binding to the manufacturer on the basis of unit rates available in the offer.

1.4 ACCESSIBILITY:

- 1.4.1 Checking and removal of components shall be possible without disturbing adjacent components. All components shall be easily accessible. It shall be possible to set all

`measuring' and `protective' relays without de-energizing the switchboard. All mounted equipment shall have painted identification labels at the front & rear also. In addition to that identification numbers shall be painted on the panel wall to give permanent identification mark. Mounting of the relays for a particular breaker panel shall be limited to that particular panel.

- 1.4.2 Unused CT secondary terminals must be short circuited and wired to the terminal block. All terminals shall be shrouded with plastic covers to prevent accidental contact.

1.5 BUS BAR ARRANGEMENT

- 1.5.1 The switchboard shall comprise 3 phase bus bars as indicated in the Technical Data Sheet or SLD which shall extend through all units of the switch gear. All phase bus bars shall be of uniform cross section throughout the switch gear and shall be sized to carry continuously the current specified in the Technical Data Sheet or SLD. Bus bars shall be housed in a separate air insulated chamber and shall be accessible for inspection only with special tools. Wire guards/mesh shall be provided inside the sheet steel enclosure to allow visual inspection of bus bars, CT's, PT's and cable terminations and to avoid accidental touch when rear cover is removed.
- 1.5.2 Bus bars shall be made of electrolytic copper and shall be sleeved and joints shall be shrouded. Fiber glass/metal sheet with cast resin bushing partitions shall be provided at every junction between two adjacent cubicles. All bus bar joints shall be shrouded with shrouds having sufficient insulation level suitable for nominal system voltage.
- 1.5.3 Bus bars shall be supported at regular intervals and both, bus bars and the supports shall be adequately sized and braced to withstand the specified short circuit level without permanent deformation. Dynamic stresses shall be calculated on the basis of the specified peak short circuit currents. All bus supports shall be of non carbonizing material resistant to acids and alkalis and shall have non hygroscopic characteristics such as SMC, DMC epoxy bonded fiber glass.
- 1.5.4 Thermal design of the bus bars shall be based on installation of the switch gear in ventilated conditions. The cooling air volume shall take into account only the bus enclosure.
- 1.5.5 The maximum operating temperature of the bus bars at the maximum design temperature inside the panel shall be as per IS: 1272 and IEC 298

- 1.5.6 Bus bars shall be sleeved with colour coded type sleeve having insulation level suitable for nominal system voltage. If the insulating sleeve is not coloured bus bar shall be colour coded with coloured bands at suitable intervals.
- 1.5.7 All bus bars joint and bus tap joints shall be of the bolted type and shall be shrouded. Spring washers shall be provided to ensure good contact at the joint locations and suitable contact grease shall be applied just before making a joint.
- 1.5.8 Positive/live terminal or bus bar shall be located at the top or on the left for vertical and horizontal layout respectively.
- 1.5.9 Sequence of Red, Yellow, Blue phases shall be left to right and top to bottom for horizontal and vertical layout respectively.

1.6 POWER CABLE CONNECTION:

- 1.6.1 The incoming and outgoing power cable connection shall be through PILC/XLPE/PVC cables of various sizes as indicated in the Technical Data Sheet or SLD. Ample space for connection for these cables shall be provided at the rear of the switchboard. In order to avoid accidental contact in the cable compartment while carrying out inspection by opening the back cover, a removable expanded metal barrier shall be provided in the cable compartment.
- 1.6.2 The cable entry of the switchboard shall be from the bottom.
- 1.6.3 Cable lugs and the requisite bushes for sealing power cable entries shall be supplied along with the switchboard.
- 1.6.4 'Cupal' washers shall be provided for copper busbar to aluminum cable terminations.
- 1.6.5 The switchboard shall be supplied complete with supports for clamping outgoing and incoming cables. Terminal blocks shall not be used to support cables. The distance available between cable gland plate and terminal lug shall not be less than 1000 mm for switchgear upto 11 KV. cables.
- 1.6.6 In case, cable termination cannot be accommodated inside the panel, a suitable box for mounting at the rear side and at the bottom of panel shall be supplied. Earth strip shall also be brought to this box. In lieu of this a dummy panel may be provided.

- 1.6.7 The individual switchgear panel shall have adequate space and terminal busbar clearance for accommodating no. of cables as specified in Technical Data Sheet and SLD. The type of cable termination units to be considered shall be heat shrinkable type.

1.7 CONTROL WIRING AND TERMINALS:

- 1.7.1 Inside the cubicle the wiring for control, indication, signaling, protection and instrument circuits shall be done with PVC insulated stranded conductors. The insulation grade shall be 1.1 KV. The wiring shall preferably be enclosed in plastic channels or neatly bunched together.
- 1.7.2 10% spare terminals shall be provided on each terminal block. Conductors shall be terminated with adequately sized compression type copper lugs for connection to equipment terminal block. All auxiliary equipments terminals shall be made with pressure type terminals. Sufficient terminals shall be provided on each terminal block to ensure that not more than one outgoing wire is connected per terminal. Terminal strips shall preferably be separated from power circuits by metal barriers or enclosures. All spares contacts of aux. relays, timers etc. shall be wired upto the terminals.
- 1.7.3 Each wire shall be identified at both the ends by, correctly sized PVC ferrules. Shorting links shall be provided for all CT terminals.
- 1.7.4 For CT circuits 2.5 sq. mm copper conductor shall be used. Other control wiring can be with 1.5 sq. mm copper conductors.
- 1.7.5 Control cables shall enter the switchgear from the bottom/ top. It shall be possible to have the control cable entry from both the left and right side corners at the front portion of the switchgear without cutting any standard part of for these cables are also included in the scope of supply of the switchboard. The cable glands shall be compression type, supporting facilities shall be provided for clamping the control cables. All control cables shall be with 2.5 sq. mm Cu stranded conductors.
- 1.7.6 All inter panel control wiring shall be done by the switchgear supplier. The inter panel wiring shall be taken through PVC sleeves or suitable grommets. Multi pin plug shall be provided and should have scraping earth terminal.

- 1.7.7 Control cable cutout and gland plate shall be provided preferably at the place where the power cable cutout will be provided. Gland plate for the control cables shall be separate from those provided for the power cables.

1.8 CONTROL AND INDICATION:

Breaker tripping and closing devices shall be operated on D.C. supply. The rated D.C. voltage shall be as specified in the Technical Data Sheet. The supply for breaker opening, closing and indication devices shall be provided as under:

- a) One D.C. feeder shall be provided for each bus section. The Bus coupler panel may be fed from any of the two supplies.
- b) One separate 240 V AC supply shall be provided for space heater etc.

Mechanical indication for breaker positions such as ON, OFF, spring charged, test position/Service position shall be provided. Various Electrical indications with colours are indicated below shall be provided.

a)	Breaker 'ON'	-	Green lamp
b)	Breaker 'OFF'	-	Red Lamp
c)	Breaker 'Auto Trip'	-	White lamp
d)	Trip circuit healthy	-	White lamp
e)	DC fail	-	Blue lamp.
f)	Red phase ON	-	Red
g)	Yellow phase ON	-	Yellow
h)	Blue phase ON	-	Blue

1.9 EARTHING CONNECTIONS:

- 1.9.1 Continuous earth bus-bar running throughout the length of the switchboard shall be provided. All doors and movable parts shall be connected to the earth bus with flexible copper connections. Provision shall be made to connect the earthing busbar to the plant

earthing grid at two ends. All non-current carrying metallic parts of the equipment shall be earthed. Earth bus shall be brought back to cable compartment and earthing bolts shall be provided to ground cable Armour. Mating surfaces of all bolted parts shall be specifically zinc passivated to ensure continuity between them.

- 1.9.2 The material of the earth bus shall be copper. The earth bus size shall be minimum 180 mm² copper upto short circuits withstand capacity of 31.5 KA and 300 mm² above 31.5 KA.
- 1.9.3 All instruments, relays and other components shall be connected to earth busbar by means of 650 V grade, PVC insulated, stranded tinned copper conductor of 2.5 sq.mm.

1.10 LABELS AND NAMEPLATES:

- 1.10.1 A nameplate with the switchgear designation at the top of the central panel and separate nameplate giving feeder details shall be provided at front and rear side of each panel.
- 1.10.2 Name plates shall be provided for each equipment (Lamps, PBs, Switches, Relays, Auxiliary contactors etc.) mounted on the switchboard. Special warning plates shall be provided on all removable covers or doors giving access to high voltage cables, bus bars. Special warning label shall be provided inside the switchboard also, wherever considered necessary. Identification tags shall be provided inside the panels matching with those shown on the circuit diagram.
- 1.10.3 Engraved nameplates shall preferably be of 3-ply (Red-white- red or Black-white-Black lamicoid sheets or anodized aluminum or back engraved Perspex sheet nameplates shall be provided. Engraving shall be done with square groove cutters. Hard paper nameplates will not be acceptable. Name plates shall be fastened by Screws and not by adhesives.

1.11 SHEET STEEL TREATMENT AND PAINT:

- 1.11.1 All metal surfaces shall be thoroughly cleaned and digressed to remove mill scale, rust, grease and dirt. Fabricated structure shall be pickled and then rinsed to remove any trace of acid. The under surface shall be prepared by applying a coat of phosphate paint, and a coat of yellow zinc chromate's primer. The under surface shall be made free from all imperfections before undertaking the finishing coat.

- 1.11.2 After preparation of the under surface, the switchboard shall be spray painted with two coats of final paint. Colour shade of final paint shall be smoke gray shade no. 631 as per IS: 5 unless otherwise specified. The finished panels shall be dried in stovings ovens in dust-free atmosphere. Panel finish shall be free from imperfections like pinholes, orange peels, runoff, paint etc. The supplier shall furnish painting procedure details along with the offer.
- 1.11.3 All unpainted steel parts shall be cadmium plated or suitable treated to prevent rust corrosion. If these parts are moving elements, then these shall be greased.

1.12 SPACE HEATERS:

- 1.12.1 Each vertical cubical shall be provided with space heater to prevent moisture condensation and maintain required temperature. The space heaters shall be located at the bottom of the switchboard and shall be controlled through a thermostat with an adjustable setting with single pole MCB with overload and short circuit release in the phase, link in the neutral. The thermostat shall preferably be located in the metering/ relay chamber.
- 1.12.2 Space heater shall be of strip type rated for operation on a 240 V, single phase, 50 Hz., A.C. supply system.

1.13 BASE FRAME:

- 1.13.1 The switchboard shall be suitable to be installed on a base frame supplied in one piece along with foundation bolts. These base channels shall be dispatched two months in advance from the date of dispatch of switchboard so that they can be buried and grouted in the concrete floor. Ample dimensioned oblong holes shall be provided at the bottom of all the switchboards for their installation of base frame. In addition, the switchboard shall have an additional base channel at the bottom with smooth surface.

1.14 BREAKERS:

- 1.14.1 Vacuum circuit breaker shall be used in the switchboard. Exact type and rating shall be as indicated in the Technical Data Sheet.

- 1.14.2 10% spare VCB bottles of each rating shall be supplied along with the switchboard.
- 1.14.3 Vacuum circuit breaker shall be designed with low switching over voltage level and long switching life. The interrupter shall be leak free with a target value of vacuum life as 25 years.
- 1.14.4 The breakers shall have at least 8 NO + 8 NC spare auxiliary contacts. If these are not available an auxiliary contactor shall be used to multiply the auxiliary contacts of the breakers. All auxiliary contacts shall be wired to the terminal block. Auxiliary contacts and limit switches shall be in dust tight enclosures.
- 1.14.5 The breaker shall have motor operated spring charged mechanism. In addition to this, it shall be possible to charge the springs manually, if required. In case the limit spring fails to cut out the spring charging motor when the springs are fully charged the motor shall be automatically decoupled and annunciation for this shall be provided. The control circuit shall be suitable for local as well as remote control. Breaker shall trip free and shall have an anti-pumping device. Breaker operating duty shall be 0-3'-CO-3'-CO except for switchgear line up having motor feeders stage wise, receleration feature in which case the duty shall be 0-0.3"- CO-3'-CO. Whenever a PT is mounted on the breaker carriage all auxiliary wiring shall be done in PVC flexible conduits.
- 1.14.6 Adequate provision shall be made in Vacuum circuit breaker for motor switching to limit the over voltage.
- 1.14.7 Mechanical trip push buttons shall be provided for all the breakers. Mechanical closing device will not be acceptable for motor feeders. Complete motor assembly should have interchangeability with identical rating of the breaker. Each motor breaker feeder shall be provided with an operation counter.
- 1.14.8 All integral earthing system or separate earthing carriage be provided. After withdrawing the circuit breaker, this can be inserted to facilitate earthing of the cables. Unit rate in the panel shall be furnished.

1.15 SWITCHBOARD COMPONENTS:

1.15.1 CURRENT TRANSFORMER:

Current transformers shall generally conform to IS: 2075 and of cast resin type and shall be mounted on the switchgear stationary part. The C.T. ratings shall be as shown in the

Technical Data Sheet or SLD. For general guidance, the protective current transformers shall have an accuracy class `5P' and an accuracy limit factor greater than `10'. Low reactance C.T.s shall be used for protection. Current transformers for instruments shall have an accuracy class 0.5 and an accuracy limit factor less than 5.0. If a metering load is fed from a protection C.T., suitable 1/1 or 5/5 ratio interposing C.T.s shall be used.

1.15.2 VOLTAGE TRANSFORMERS:

- a. The voltage transformers shall be cast resin and draw out type and provided with primary and secondary fuses.
- b. The draw-out mechanism shall disconnect the bus bars and V.T. primary and secondary terminals shall be earthed. The primary connection shall be disconnected before the V.T. or its primary fuses become accessible.
- c. The voltage transformers shall have an accuracy class 1.0 from 10% to 120% of normal voltage.
- d. Secondary and tertiary windings of voltage transformer shall be rated for a three phase line to line voltage of 110 V except as noted.

1.16 MEASURING INSTRUMENTS:

All measuring and recording instruments shall be of square pattern 144 mm x 144 mm flush mounted type. Instruments shall be provided wherever specified in the Technical Data Sheet or SLD. All auxiliary equipment such as shunts, transducers C.T.s, V.T.s that are required shall be included in the supply of switchboard.

1.16.1 AMMETERS, VOLTMETERS, KW METERS

These shall be of moving iron type. The accuracy class shall be 1.0 as per IS: 1248. The range shall be as indicated in the Technical Data Sheet or on the SLD. Ammeters for motor feeders shall have nonlinear compressed scale at the end to indicate motor starting current.

The KW meter shall be suitable to measure unbalanced loads on a 3 phase 3 wire system. The KW and the voltmeter shall operate of a V.T. secondary of 110 volts.

1.16.2 RECORDING INSTRUMENTS:

Unless stated otherwise these shall be of direct writing type with automatic chart by means of a synchronous motor. The minimum chart length shall be of 24 hours. The chart speed shall be 30 mm/hour.

1.16.3 TRIVECTO METERS: (DIGITAL)

The KWH meter shall be 144 mm x 144 mm square, flush mounted, preferably in a draw-out case. It shall be suitable for operation on 3 phase 3 wire system.

1.16.4 FREQUENCY METERS:

These shall be direct reading or digital type square pattern 144 mm x 144 mm size, suitable for flush mounting and shall operate off a V.T. secondary voltage of 110 volts. The standard range shall be 45-50-55 Hz.

1.16.5 POWER FACTOR METER:

The power factor meter shall also be square pattern 144 mm x 144 mm size, suitable for flush mounting and of digital type. The meter shall operate off 110 volts C.T. secondary voltage. The C.T. secondary current shall be as shown on the SLD or Technical Data Sheet. The standard range shall be 0.5-1.0-0.5.

1.17 AUXILIARY EQUIPMENTS:**1.17.1 AUXILIARY RELAYS/CONTACTORS:**

Auxiliary relays/contactors shall generally be used for interlocking and multiplying contacts. Auxiliary contacts shall be capable of carrying the maximum estimated current. In any case their rating must not be less than 5A - for 230 volts A.C. at a power factor between 0.3 and 1, and 2A for 110 volts D.C.(inductive load).

1.17.2 TRIPPING RELAYS:

All tripping relays shall be lockout type with hand reset contacts and shall be suitable to operate off the specified d.c. voltage. These relays shall have self coil cut - off contacts and shall be provided with hand reset operation indicators. Tripping relays will be acceptable in non draw-out cases. The number of contacts shall be as shown on the approved schematic drawings.

1.17.3 PROTECTIVE RELAYS:

All protective relays shall be back connected, draw-out type, suitable for flush mounting and fitted with dust tight covers. Alternatively, 'plug in' type of relays will also be acceptable. The relay cases shall have provision for insertion of test plug at the front for 'testing' and calibration' using an external power supply, without disconnecting the permanent wiring. It shall be possible to short the C.T.'s through the test plugs. Non protection relays can be in fixed execution.

All relays shall preferably be mounted in front of the panel and shall be as specified in the Technical Data Sheet or SLD. The current and voltage coils shall be rated as specified.

All measuring relays shall have 'built in' flags to indicate relay operation. It shall be possible to reset the flag without opening the relay case. Anti fungus treatment shall be provided for all relays.

1.17.4 PUSH BUTTONS:

Push button colours shall be as follows:

Stop, Open, Emergency	- Red
Start - Close	- Green
Trip circuit 'Healthy' check	-Black

Red push buttons shall be on the left side and green push buttons on the right side. Push button ratings shall be 5A at 240 V AC or 2A at 110 V DC (inductive load). Emergency stop push buttons shall be lockable in the operated position.

The key shall be released from the push button in both 'Released' and 'Operated' positions and operation of the push button shall be possible in the key release position. Push button knobs for emergency stop push buttons shall be released to prevent accidental operation.

1.17.5 CONTROL SWITCHES:

All control switches shall be rotary, back connected type having a cam operated contact mechanism. Phosphor bronze contacts shall be used on the control switches. Unless otherwise stated, circuit breaker control switches shall be 3 position spring return to 'neutral' from both 'ON' and 'OFF' positions. They shall have 'pistol grip' handle. Number of ways, locking system, lost motion device if required etc. Two spare ways shall be provided on these switched.

Ammeter and Voltmeter selector switches shall have 'make before break' feature on its contacts. The selector switch shall generally have four positions, three for reading three phase currents and phase to phase voltages respectively and the fourth as off position.

1.17.6 INDICATING LAMPS:

Switchboard type low consumption indicating lamps shall be used. Indicating lamps shall be suitable for the voltage indicated in the Technical Data Sheet. Lamps shall be supplied complete with the necessary current limiting resistor duly tested for its rating. Aging test for the resistors shall have been carried out. Lamps shall be provided with translucent lamp covers to diffuse light.

1.17.7 CUBICLE LIGHTING:

Each cubicle of switchgear shall be provided with interior lighting by means of a 20 W fluorescent tube lighting fixture with ON - OFF switch. The lighting fixture shall be suitable for operation from a 240 V, single phase, 50 Hz, A.C. supply. A 240 V, single phase, 15 A A.C. plug point shall be provided in the interior of each cubicle with an ON - OFF switch for connection of hand lamps.

1.18 DRAWINGS:

The manufacturer shall develop his own general arrangement and schematic drawing adding necessary auxiliary devices, accessories, components particular to supplied equipment, etc. which are required for safe, convenient, efficient and proper operation of the HT switchgear.

Manufacturer shall submit for owner/consultant's approval the single line diagrams, general arrangement drawings, flooring and mounting detail drawings and schematic diagrams.

Owner's/consultant's approval of GA drawings is required before the fabrication of the cubicle is started. Approval of the schematic drawings is required before the manufacturer proceeds with the cubicle wiring. The owner/consultant's approval as the manufacturer's drawings shall not relieve the manufacturer of his responsibility for supplying equipment conforming with the relevant specifications and standards or for any other mistakes, errors or omissions in drawings.

Once manufacturer's schematic diagrams have been finally approved by owner/consultant, the manufacturer shall prepare wiring connection diagrams for each cubicle. These diagrams shall show any wiring inside the cubicle starting from the cubicle terminal strips. These diagrams shall be used by the owner for troubleshooting and shall show any device, terminal and wire number. The manufacturer shall submit all the drawings in four copies for owner/consultant's approval. Manufacturer shall submit four prints and reproducible of schematic, GA and wiring diagrams in final.

1.19 TECHNICAL DATA FOR EQUIPMENTS :

Sr. No.	Item Description	Data Designed by Consultant	Data Furnished by Supplier
1.0	Ambient Temperature	50°	
2.0	Maximum Ambient Temperature	50°	
3.0	Design Ambient Temperature	50°	
4.0	Rated Voltage, Phase and Frequency	11KV, 3pH, 50 Hz.	
5.0	Maximum system voltage	36 KV	
6.0	One-minute power frequency withstand voltage	70 KV (rms)	
7.0	1.2 / 50 / usec. Impulse withstand voltage	170 KV (peak)	
8.0	Short circuit withstand		
8.1	Rated symmetrical breaking capacity – 3 secs	400 MVA, 26.2 KA	
8.2	Peak withstand current	80KAp	
9.0	Continuous rating of bus bars under site	630 A	

Sr. No.	Item Description	Data Designed by Consultant	Data Furnished by Supplier
	reference ambient temp. of 45° C		
10.0	One minute dry withstand power frequency voltage	70 KV	
11.0	Impulse withstand voltage	170 KV	
12.0	Auxiliary supply for using shunt trip at power pack	30 V DC through	
13.0	Auxiliary supply for motor	240 VAC, 50 Hz.	
14.	Maximum temperature of bus bars, droppers, connectors and contact at continuous current rating under site reference temperature	85°C	
15	Bus bar material	Copper (tinned Electrolytic)	
16	Cable entry	Side	
17	Thickness of sheet in mm		
a.	cold rolled	Frame: 3	
b.	frame enclosure	2.5	
c.	Doors / Covers / Partitions	2.5	
18	Colour finish shade	2.5	
a.	Interior	Glossy white	
b.	Exterior	Light gray semi grades glossy shade, epoxy type 631, IS: 5	
19	Earthing Bus		
19.1	Material	Copper	
19.2	Size	Suitable for 93.5 KA for 1 sec.	
20	Earthing conductor		
21.1	Material	Copper	

Sr. No.	Item Description	Data Designed by Consultant	Data Furnished by Supplier
21.2	Size	30 x 6 mm	
22	Bus bar insulation	Air insulated, PVC heat shrinkable type sleeved	
23	Circuit Breakers		
23.1	Type	Vacuum	
23.2	Voltage, frequency and no. of phases	11 kv, 50 Hz., 3 ph	
23.3	Rated Operating duty	0-3'-CO-3'-CO	
23.4	Rated current at site (reference ambient temp)	630A	
23.5	Rated breaking capacity	400 MVA, 21 KA (rms)	
23.6	Short time current withstand 4 for 1 sec. duration	21 KA (rms)	
23.7	Total break time	Less than 5 cycles	
23.8	Type of operating suitable for manual	Manually and motor mechanism charged spring and remote trip and close operations	
23.9	Minimum no. of auxiliary	8 NP, 8 NC on fixed contacts part of breaker for owner's use.	
23.10	Withstand test voltage One-minute power	28	
23.11	Frequency KV(rms) 1.2/50 u sec impulse KV (peak)	75	
24	Auxiliary control voltage		
24.1	For closing coil for tripping coil 30 V	240V, pph, 50 Hz.	

Sr. No.	Item Description	Data Designed by Consultant	Data Furnished by Supplier
	DC through power pack		
24.2	For space heaters and lighting AC with MCB and thermostat unit	240V, 1 Ph, 50 Hz.	
24.3	Motor type	Universal	
24.4	Anti-Pumping feature	Both electrical and mechanical shall be provided	
24.5	Circuit breaker operation	Local control switch for trip and close. Remote electrical trip and close for testing manual	
24.6	Protection required panel	As per single line diagram / Requirement of breaker	
25	Current Transformers		
25.1	Type	Cast resin, bar primary	
25.2	System voltage and frequency	11 KV, 50 Hz.	
25.3	Class of insulations	Class “E” or better	
25.4	Rated primary current ratio	As per the enclosed burden and accuracy single line diagram / requirement of Breaker panel	
25.5	Short time 1 sec. current rating	21 KA (rms)	
26	Voltage Transformers		
26.1	Type	Cast resin	
26.2	Rated voltage – primary	11000 / 3 volts	
	Rated voltage – secondary	415 / 3 volts	

Sr. No.	Item Description	Data Designed by Consultant	Data Furnished by Supplier
26.3	Method of connection		
	Primary	Star	
	Secondary	Star	
26.4	Rated Voltage factor	1.1 constant 1.5 for 30 sec.	
26.5	Class of insulation	Class “E” or better	
26.6	VA burden and accuracy	As per Vendor	
26.7	Withstand test voltage one-minute power frequency	28	
	1.2 / 50 / u impulse KV (peak)	75 KV (peak)	
27	Make of material		
27.1	HRC Fuse	Siemens, L&T, Schneider, Havells	
27.2	Fuse base	Siemens, L&T, Schneider, Havells	
27.3	Voltmeter	AE, rishabh, enercon, trinity	
27.4	Ammeter	AE, rishabh, enercon, trinity	
27.5	Indication lamps	Teknic	
27.6	Relays	Siemens, L&T, Schneider, Havells	
27.7	Power factor meter (Electronic type)	AE, rishabh, enercon, trinity	
27.8	Frequency meter (Electronic type)	AE, rishabh, enercon, trinity	
27.9	Selector switch	Kaycee or equivalent	
27.10	Breaker control switch	GEC Alsthom or equivalent.	

Sr. No.	Item Description	Data Designed by Consultant	Data Furnished by Supplier
27.11	L – R Switc	Kaycee	
27.12	Terminal Block	Elmex / Connect well / Technoplast	
27.13	Wires	Finolex or approved or equivalent	
27.14	Trivector	Secure, Enercon	
27.15	Digital KWH meter	Enercon or equivalent	
27.16	CT / PT	AE . Indcoil / Kappa	
27.17	Push Buttons	Teknic	
28	Cable Box arrangement	BOTTOM ENTRY	
	Incomer	1 No. 11 KV 3C x 185mm ² XLPE Armoured Al. cable	
	Outgoing	1 No. 11 KV 3C x 185 mm ² XLPE Armoured Al. cable	
29	Requirements of Breaker Panel		
29.1	Panel description		
29.2	Quantity	1 No.	
29.3	Basic rating of breaker	630Amps.	
29.4	Type of Breaker	VCB	
29.5	Red, Amber, Green indicating lamps	1 set	
30	Potential transformer, three phase, Epoxy cast resin type, 1100 volts / root 3/110 volts / root 3, 100 VA burden, Accuracy class 0.5h	1 set	
31	A44 mm ² 0- 15 KV voltmeter	1 No.	
32	Voltmeter selector switch	1 No.	
33	144 mm ² 0 – 100 A ammeter	1 No.	

Sr. No.	Item Description	Data Designed by Consultant	Data Furnished by Supplier
34	Ammeter selector switch	1 No.	
35	Electronic type power factor meter	1 No.	
36	Trivector meter (digital) with KVA / KVARH / KVAH with maximum demand indication in KVA	1 No.	
37	Electronic type frequency meter	1 No.	
38	Epoxy cast resin type current transformer having details as under		
38.1	200/1/1 ratio of Class 1 and burden of 15 VA.-2000KVA TRAFO.	1 No.	
38.2	Accuracy class of metering core – 1	0.5	
38.3	Accuracy class of protection core – 21	5 P 10	
39	Relays		
39.1	T.P. IDMTL relay with 2 O/C + 1E/F Element type equivalent to CDG-61 of EE make	1 No.	
39.2	D.C. fail alarm relay equivalent to VAA-21 of EE	1 No.	
39.3	High speed tripping relay equivalent to VAJH -13 of EE	1 No.	
39.4	Antipumping relay equivalent to VAA-11 of EE 4	1 No	
39.5	Auxiliary relay for buccholtz alarm and trip relay equivalent to VAA -21 of EE make	1 No.	
39.6	Auxiliary relay for winding temperature alarm and trip relay equivalent to VAA-21 of EE make	1 No.	

Sr. No.	Item Description	Data Designed by Consultant	Data Furnished by Supplier
40	30 Volts DC shunt trip coil	1 No.	
41	D.C. fail indication lamp with ACCEPT and RESET push buttons	1 set	
42	Emergency trip lockable push button with keys P	1 No.	
43	Trip circuit healthy indication lamp with push button	1 set	
44	Auto trip indication	1 No.	
45	Spring charged indication	1 No.	
46	Common alarm trip and non-trip scheme with ACCEPT, RESET push buttons, relays and hotter for audio indication	1 No.	
47	Space heater with ON-OFF MCB, HRC fuses and thermostat	1 set	
48	Power pack unit for 30 volts D C Output – combined for all breakers	1 set	
49	Adopter / Dummy panel	Quantity & unit rate shall be furnished by the bidder	
50	Prices for spares required for 2 years maintenance free operation rate shall be furnished by the bidder	Quantity & Unit	
51	Cubicle illumination with 20 W tube & ON-OFF switch	1 set	
52	15 A plugs / socket with ON-OFF switch	1 set	
53	Unit prices for all relays and meters for addition by the bidder	Shall be furnished	

A) OIL TYPE TRANSFORMER**1.1 SCOPE**

This specification covers liquid immersed transformers of outdoor duty.

1.2 CODES AND STANDARDS

- A Design, manufacture and performance of equipment shall comply with all currently applicable statutory regulations and safety codes in the locality where the equipment will be installed. Nothing in this specification shall be constructed to relieve the vendor of his responsibility.
- B Unless otherwise specified equipment shall conform to the following latest applicable I.S.
- a) IS: 2026 Power transformer (Part 1 to 5).
 - b) IS: 3639 fittings and Accessories for Power Transformers.
 - c) IS: 335 Insulating oil for transformers and switchgear.
 - d) IS: 6600 Guides for loading of oil immersed transformers.
 - e) IS: 3637 Specification for gas operated relays.

1.3 RATING

The rating, voltage ratio, vector group and type of cooling of transformer, tap changing gear shall be as specified in the enclosed data sheet.

1.4 OPERATION UNDER OVERLOAD CONDITION

It shall be possible to operate all transformers as per loading guide IS: 6600 up to overload of 150% and there shall be no limitations imposed by bushing, tap changes, auxiliary equipment etc. to meet this requirement.

1.5 CONSTRUCTIONAL FEATURES**A General:**

- a) Similar parts, particularly removable ones, shall be interchangeable.
- b) Exposed parts shall not leave pockets where water can collect.
- c) Internal design of transformer shall ensure that air is not trapped in any location.
- d) Material in contact with oil shall be such as not to contribute to the formation of acid in oil surface in contact with oil shall not be galvanized or cadmium plated.

B Core:

- a) The design of the magnetic circuit shall be such as to avoid static discharge, development of short circuit paths within itself or to the earthed clamping structure and the production of flux component at right angles to the plane of the lamination, which may cause local heating.
- b) The magnetic circuit shall be of core type construction. It shall be built out of high grade, non-ageing, low losses, high permeability, cold rolled grain oriented silicon steel lamination.
- c) The finally assembled core shall be free from distortion. It shall be rigidly clamped to ensure adequate mechanical strength and to prevent vibrations during operation.
- d) The core shall be provided with lugs suitable for lifting the complete core and coil assembly.
- e) All parts of the cores shall be of robust design capable of withstanding any shocks to which they may be subjected during lifting, transport, installation and service.

C Internal Earthing:

All metal parts of transformer with the exception of the individual core lamination, core bolts, and associated individual clamping plates shall be earthed.

D WINDING

- a) Winding shall be subjected to shrinking and seasoning process, so that no further shrinkage occur during service. Adjustable devices shall be provided for taking up possible shrinkage in service.
- b) Materials used in the insulation and assembly of the winding shall be insoluble, non catalytic and chemically inactive in hot transformer oil, and shall not often or be otherwise affected under the operating conditions.
- c) Neutral of all star connected winding shall be brought out in open.
- d) The winding shall be designed to reduce a minimum out of balance forces in the transformer at all voltage ratios.

E TANK

- a) Tank shall be made from good commercial grade low carbon steel and shall be of welded construction.
- b) Tank shall be designed to permit lifting, by crane or jacks, of the complete transformer assembly filled with oil. Radiators shall be detachable type connected to the tank through butterfly valves.
- c) The material used for gasket shall be cork neoprene or approved equivalent.
- d) Tank shall be provided with lifting lugs a minimum of four jacking lugs and suitable haulage holes.
- e) The tank cover shall be fitted with pockets for a thermometer and for the bulbs of oil and winding temperature indicators. Protection shall be provided, where necessary, for each capillary tube.
- f) All wheels should be detachable and shall be made of cast iron or steel as required.
- g) Inspection cover on the top shall be provided (for small transformer of 500 KVA and above). Tank cover shall be suitably sloped to prevent accumulation of rainwater.

F Conservator:

- a) A conservator complete with sump and drain valve to meet the requirement of expansion of the total cold oil volume in the transformer and cooling equipment from the minimum ambient temp. to 90°C.
- b) Normally one coil gauge magnetic\ prismatic\ plain type as specified shall be provided.
- c) Conservator shall be fitted with a silica gel breather.

G Filter and Drain Valves:

Each transformer shall be fitted with the filter and drain valves, a sampling device and air release of any pressure.

H Pressure Relief Device:

- a) The pressure relief device shall be provided of sufficient sizes for rapid releases of any pressure.
- b) If a diaphragm is put at the base of pipe, an oil gauge is required on the stand pipe for indicating fracture of diaphragm.

- c) If a diaphragm is used it shall be of suitable design and material and situated above maximum oil level.
- d) An equalizer pipes shall be connected between the pressure relief devices to the conservator or silica gel breather shall be fitted to pressure relief device for relieving or equalizing the pressure.

I Two earthing terminal of required size shall be provided.

J Rating and diagram plates shall be provided as per IS: 2026.

1.6 OIL

- a) Transformer shall be supplied with first filling oil conforming to IS: 335.
- b) Additional oil shall be supplied in non-returnable drums for each transformer.

1.7 VOLTAGE CONTROL

- a) type of control and No. of taps shall be as specified in data sheet.
- b) **Off Circuit Type:** The off circuit tap changing gear shall be operable by means of operating handle equipped with an indicating device to show tap in use and shall be provided with locking arrangement to lock the switch in any position. **NOT REQUIRED FOR THIS APPLICATION**
- c) **ON LOAD TAP Changer:** OLTC with AVR and RTCC panel shall be provided if required. **REQUIRED FOR THIS APPLICATION.**

1.8 BUSHING INSULATORS AND CABLE BOXES

- a) Transformer shall be fitted either with bushing insulators or with cable boxes, as specified. Cable box should be air insulated type.
- b) Cable box shall have sufficient space to facilitate termination if more than one cable terminations are specified, and to accommodate all cable joint fittings or sealing ends including stress/cones etc. Links shall be provided of suitable length for easy termination of cables. Necessary glands and cable sockets shall be provided. Box shall have a drain plug to enable the filling medium removal quickly. Armor earthing pads (2 nos.) shall be provided along-with cable termination kit support.

- c) Non-magnetic cable gland plate shall be provided in the cable box, whenever single core cables are specified.

1.9 TEMPERATURE INDICATING DEVICES AND ALARM

- a) Oil temp. Indicator with/without electrical contacts shall be provided as specified in data sheet.
- b) Winding temp. Indicator shall be provided, if specified with no of contact required.
- c) The tripping contact of winding temperature indicators shall be adjustable to close between 60°C and 120°C and alarm contacts to close between 50°C and 100°C and both shall reopen when the temperature falls by about 10°C.
- d) Connections shall be brought from the device to marshaling box.

1.10 GAS AND OIL ACTUATED RELAYS

- a) A double float type Buchholz relay as per IS:3637 shall be provided. Two electrically independent alarm and trip contact shall be provided. Two isolating valves shall be provided on either side of the relay. Buchholz relay shall be provided with a test cover.

1.11 PAINTING

- a) The interior of transformer tank, other oil filled chambers and internal structural steel work shall be painted with heat resistant, oil insoluble insulating varnish after thorough cleaning of all scales and dust by shot blasting or other approved method.
- b) Steel surfaces exposed to the weather shall be thoroughly cleaned and applied first coat of zinc chromate, second coat of oil and weather resistant paint and final coat of glossy oil and weather resistant non fading paint of shade no 632 of IS :5 (epoxy paint)

1.12 TECHNICAL DATA FOR EQUIPMENTS:

Sr. No.	Item Description	Data Designed by Consultant	Data Furnished by Supplier
1.	General		
1.1	Application	Power Distribution	
1.2	Quantity	Three (3)	
1.3	Installation	Out Door	
1.4	Type of winding	Double wound	
1.5	Rating	2000 KVA	
1.6	Cooling	ONAN	
2.0	Rating		
2.1	No load voltages		
a.	HV winding	11 KV	
b.	LV winding	0.415 KV	
c.	Impulse voltage withstand	95KVp – HV testing 28 KV	
d.	Fault level withstand	18.4 KA rms for 1 sec / 350 MVA	
2.2	Frequency	50 Hz.	
2.3	% age Impedance	App. 5%	
3.0	Losses	App 1 % of rating	
3.1	Full load losses – suggested	As per ECBC norms	
3.2	No load losses - suggested		
3.3	Efficiency at		

Sr. No.	Item Description	Data Designed by Consultant	Data Furnished by Supplier
	100% load at UPF	To be provided by vendor	
	75% load at UPF		
	100% load at 0.8 PF		
	75% load at 0.8PF		
4.0	Winding		
4.1	Material of winding	Copper	
4.2	Winding connection	HV Side - Delta LV Side - Star	
4.3	Vector group	DYn11	
4.4	Temp at full load - winding	55°C above ambient	
4.5	Temp at full load - oil	50°C above ambient	
5.0	Terminal connection		
5.1	HV winding end	H. V Cable box suitable for 185 mm ² x 3 core H.T. XLPE cable – top entry	
5.2	LV winding end	8nos x 400 sq mm x 3.5 C Al XLPE cables – top entry	
5.3	LV winding end Neutral	To be brought out separately	
5.4	Earthing	Solidly earthed	
6.0	Tapping		
6.1	Total tapping range	+10% TO -12.5%	
6.2	Steps	1.5%	
6.3	Tap changer	On load with RTCC	

Sr. No.	Item Description	Data Designed by Consultant	Data Furnished by Supplier
8.0	Dimensions / Weight		
8.1	Dimensions L X W X H	To be specified by vendors	
8.2	Weight without oil and core		
8.3	Weight of core		
8.4	Weight and qty in ltrs for oil		
8.5	Total weight of transformer		

Any other information, if not specified above, but necessary for the evaluation of offer shall be furnished by the supplier.

B) LT PANELS AND ATS

1.0 Scope:

This specification covers performance, design, material, construction, manufacture, inspection, testing, packing forwarding, delivery at site, testing and commissioning of Low voltage panels with all accessories complete in all respects as described in this specification and single line diagrams.

Whether called for specifically or not, all accessories required for normal operation of equipment are deemed to be considered as a part of the contractor's scope of supply. Hardware / fabricated supports required for mounting and installation of the panels is within the scope of work.

It is not the intent to specify completely herein, all details of design and construction of the equipment. However, the equipment shall conform in all respects to high standard of Engineering, design and workmanship and be capable of performing in continuous commercial operation up to the Manufacturer's guarantees in a manner acceptable to the Engineer, who will interpret the meaning of the drawings and specifications and shall be entitled to reject any work or material which is not full accordance therewith.

2.0 Design standards:

All the Panel's shall be metal clad, totally enclosed, rigid, floor mounted, air - insulated, cubical type suitable for operation on three phase / single phase, 415 / 230 volts, 50 Hz.

The panels shall be designed for minimum expected ambient temperature of 45 degrees Celsius, 80 percent humidity and dusty weather.

Should conform to Indian Electricity Act and rules (till last amendment) & approved as per FIA norms.

Applicable IS Standards

Meters (measuring) for analog meters	IS:1248-1958
Installation and maintenance of switch gears	IS:3072-1975
H.d. Air breaker, switch gears and fuses for voltage not exceeding 1000 volts	IS:4047-1977
Selection, installation and maintenance of fuses up to 650 volts	IS:8106-1966
General requirements for switch gear and gear for voltage not exceeding 1000 volts	IS:4237-1967
	IS:2147-1962
Insulated conductor rating	IS:8084-1972
Enclosed distribution fuse boards and cut-outs For voltage not exceeding 1000 volts	IS:2675-1983
Fuse wire used in re-wearable type electric fuses Up to 650 volts	IS:9926-1981
Flexible cords	IS:8130
Shunt capacitors for power systems	IS:2834-1954
Hrc cartridge fuses and links up to 660 volts	IS:2208
Hrc fuses having rupturing capacity of 50 ka	IS:9224
Ac electricity meters: part – 1 general requirements And tests	IS:772 PART 1
Direct acting electrical indicating instruments	IS:1248
Current transformers	IS:2705

Electrical relays for power systems protection	IS:3231
Phosphate treatment of iron and steel for protection Against corrosion	IS:3618
Guide for marking of insulated conductor	IS:5578
Code of practice of phosphating of iron and steel	IS:6005
Factory built assemblies of switchgear and Control-Gear for voltages upto and including 1000v ac and 1200v dc.	IS:8623
Guide for uniform system marking and identification Of conductors and apparatus terminals	IS:11353
Low voltage fuses	IS:13703
Lv switchgear and control gear (part 1 to part 5)	IS:13947
Structure construction (IP-54)	IS:2147
Miniature circuit breaker (MCB)	BS:3871 PART-1 1965 IS:8825 (1996)
Fuse	IS:2000-1962
Air circuit breaker	IS:2516 PART 1,2,3
Contactors	IS:2959 & BS:775
Digital meter	IS:13779
Electrical power & control wiring connection Wiring inside the module for power, control Protection	IS:694 & IS:8130
Danger notice plate	IS:2551-1982 & IS:5-1978
MCCB	IEC 60439-2 / IS:8623-2
SFU	IS:13947 (PART-3) & IEC 60947-3
ELCB	BS 3871 & 4293, IS., CEE 27

2.1 Construction :

Switchboard connection

All connection and tap offs shall be through adequately sized connectors appropriate for fault level at location. This shall include tap off to feeders and instrument/control transformers.

For unit ratings upto & including 63 amps, PVC insulated copper conductor wires of adequate size to carry full load current shall be used. The terminations of such interconnections shall be crimped. Solid connections (busbars) shall be used for all rating above 63A.

All connections, tapings, clamping, shall be made in an approved manner to ensure minimum contact resistance. All connections shall be firmly bolted and clamp with even tension. Before assembly joint surfaces shall be filed or finished to remove burrs, dents and oxides and silvered to maintain good continuity at all joints. All screws, bolts, washers shall be zinc plated. Only 8.8 grade nuts and bolts shall be used for busbar connections.

All nut bolts for busbar shall be high tensile cadmium plated with 2 plain washers and 1 spring washer. Hardware should be provided at cable termination end.

Switchboard Construction and operation

The low-voltage electrical switchboards shall be made up of identified functional volumes including the busbar compartment, switchgear and control gear component compartment, connection compartment and auxiliaries compartment.

The different busbars shall be the main busbars, distribution busbars and auxiliary busbars.

The busbars shall be made of electrolytic Al. with current density of 0.8A/Sqmm.

The compartments shall be located inside a metal enclosure with walls providing protection against direct contact with live parts and guaranteeing a degree of protection IP 2X. The frame, the external panels (doors, side and rear panels, tops) and internal elements (ducts) shall be made of 2 mm thick steel sheet metal and protected by an epoxy-paint coating.

The max height of panel shall be 2375mm including the base channel of 75 x 40 mm ISMC coloured black.

All the panels shall be as per form 3B construction.

Sheet metal elements in the immediate proximity of high current flow generating potential eddy current shall be made of aluminium.

Drawers or air circuit breakers shall have four different positions: connected, test, disconnected and removed. With drawability of upstream and downstream power circuits and of auxiliary circuits shall be total, i.e. in compliance with standard IS – 8326.

The switchboard cover panels shall be removable.

The construction system shall provide a complete set of elements for installing fixed or with drawable switching and protective devices, measurement devices and control / monitoring devices in the switchboard.

The drawers shall be designed such that the rated degree of protection (IP, as per IS 2147: 1962) is maintained whatever their position (connected, test, disconnected, removed).

Switchboard Compartmentalization

For compartmentalized switchboards, separate totally enclosed compartments shall be provided for horizontal busbars, vertical busbars, ACBs, MCCBs, and cable alleys.

Sheet steel hinged lockable doors for each separate compartment shall be provided and duly interlocked with the breaker in "ON" and "OFF" position.

For all Circuit Breakers separate and adequate compartments shall be provided for accommodating instruments, indicating lamps, control contactors and control MCB etc. These shall be accessible for testing and maintenance without any danger of accidental contact with live parts of the circuit breaker, busbars and connections. Panel should be single front operated and cable Entry should be at TOP. Busbar and cable alley access should be from front only.

LDB/PDB should be with double door arrangement. Acrylic cover to be considered on front hinged door. Inside cover should be fixed plate type with MCB cutout features.

Each switchgear cubicles shall be fitted with label in front and back identifying the circuit, switchgear type, rating and duty. All operating device shall be located in front of switchgear only.

A horizontal wire way with screwed cover shall be provided at the top to take interconnecting control wiring between vertical sections.

Separate cable compartments running the height of the switchboard in the case of front access boards shall be provided for incoming and outgoing cables. Outgoing all control and power terminals should be KUT type.

Cable compartments shall be of adequate size for easy termination of all incoming and outgoing cables entering from bottom or top. The construction shall include necessary and adequate and proper support shall be provided in cable compartments to support and clamping the cable in the cable alley / cable chamber.

Min size shall be as follows;

- a. Basbar Chamber should be min. 300mm.
- b. Cable Alley should be min. 300mm wide for termination of one side section(6 Starters).
For LDB/PDB, cable alley should be min 400 mm
- c. Feeder operating height should be max. 1950mm
- d. Feeder width should be min 450mm and higher as per rating
- e. Horizontal dummy chamber at top min 150mm
- f. Feeder height min. – SFU / MCCB, S/D, DOL-300mm and higher as per rating
- g. Minimum Depth -450mm
- h. Only one compartment feeder for PLC/BMS IOs (Marshelling box). Section to section wiring connected with plug in type accessories. (If asked)
- i. Control busbar to be required for control bus.
- j. Lighting (Holder & CFL) + Heater with thermostat to be considered in cable alley with separate control MCB in each alley.

Min fabrication standards shall be as follows;

- a. Load bearing members – Frame-2.0mm
- b. Partitions (if separate) – 1.6 mm
- c. Doors/Covers-2.0mm
- d. Electrical accessories mounting plate-2.0mm
- e. Gland Plate-3.0mm
- f. Lock should be metallic as discussed.

Lifting hook shall be provided for each shipping section.

Vendor shall provide dimensions of MCC. Final GA layout will be approved by TPL.

2.2 Bus Bars

Bus bars shall be made of high conductivity, high strength Al. of ETP grade. Bus bars shall be of rectangular cross sections suitable for full load current for phase bus bars and full rated current for neutral bus bar. Bus bar shall be suitable to withstand the stresses of fault level as specified in SLD. The certification for conductivity of the Al. shall be made available from third party certifying agency if required by engineer.

The bus bars shall be supported on non-breakable, non-hygroscopic epoxy resin or glass fibre reinforced polymer insulated supports able to withstand operating temperature of 110°C at regular intervals, to withstand the forces arising from a fault level as stipulated in schedule of quantities. The material and the spacing of the bus bar supports should be same as per the type tested assembly.

The minimum clearances to be maintained for enclosed indoor air insulated bus bars for medium voltage applications shall be as per IS guidelines. The bus bar shall be as per current density of 0.8 A/Sq.mm Cross Section area.

The bus bar shall be housed in separate compartment and shall be isolated with 3 mm thick FRC sheet to avoid any accidental contact. The bus bar shall be arranged such that min. clearances between the bus bars are as mentioned below:

Between phases – 27 mm minimum

Between phase and neutral – 25 mm minimum

Between phase and earth – 25 mm minimum

Between neutral and earth – 23 mm minimum

The bus bar and interconnection shall be insulated with heat shrinkable PVC sleeves and shall be colour coded in Red / Yellow / Blue / Black / Green to identify the three phases / neutral and earth of the system . The bus bar shall be supported on unbreakable, non-hygroscopic DMC insulated supports (no bakelite material should be used in panel) at sufficiently close intervals to prevent bus bar sag and shall effectively withstand electromagnetic stresses in the event of short circuit capacity of 65KA RMS symmetrical fault for 1 sec and peak short circuit withstand of 105KA minimum.

All bus bar connections shall be done by drilling holes at factory in bus bars and connecting by chromium plated bolts and nuts. Additional cross section of bus bar shall be provided in all panels to cover up for the holes in the bus bars. Spring and flat washers shall be used for tightening of bolts.

All Cu/Al joints (if any) shall be connected with bi-metal sheet.

Neutral link in each feeder to be considered in each TP feeder.

2.3 Instrument Accommodation

All voltmeter and ammeter and other instruments shall be flushed mounted type of size 96X96 mm conforming to class 1.0 to IS 1248 for accuracy. All voltmeter shall be protected with suitable SCPD device.

Instruments and indicating lamps shall not be mounted on the Circuit Breaker Compartment (in case of ACB) door for which a separate and adequate compartment shall be provided and the instrumentation shall be accessible for testing and maintenance without danger of accidental contact with live parts of the Switchboard.

For MCCBs, instruments and indicating lamps can be provided on the compartment doors.

The current transformers for metering and for protection shall be mounted on the solid copper bus bars with proper supports.

On all the incomers of switch boards ON/OFF indicators lamps shall be provided suitable for operation on AC 230 volts supply. All lamps shall be protected with proper protection device. Where phase indicator lamps are to be provided, these shall be associated with necessary ON/OFF toggle switch. All the lamps shall have testing facility.

For instruments control MCB shall be used (Fuse with link not accepted)

2.4 Wiring

All wiring for relays and meters shall be with PVC insulated copper conductor wires. The wiring shall be coded and labelled with approved ferrules for identification. The minimum size of copper conductor control wires shall be 1.5 sq. mm. Runs of wires shall be neatly bunched and suitably

supported and clamped. Means shall be provided for easy identification of wires. Identification ferrules shall be used at both end of wires. All control wires meant for external connections are to be brought out on a terminal board. The cables shall be suitable for withstanding 105 deg C.

2.5 Space Heaters

Anti- condensation heaters shall be fitted in each cubicle together with an ON/OFF isolating switch suitable for electrical operation at 230 volts A.C 50 Hz single phase of sufficient capacity to raise the internal ambient temperature by 5° C. The electrical apparatus so protected shall be designed so that the maximum permitted rise in temperature is not exceeded if the heaters are energized while the switchboard is in operation. As a general rule, the heaters shall be placed at the bottom of the cubicle.

2.6 Ventilation Fans

The Switchboard shall be provided with panel mounting type ventilation fans in each panel with switchgear rated for 2000 amp and above or as required by engineer. The fan shall be interlocked with switchgear operation. The degree of enclosure protection to be maintained even with fans. The fans shall be fitted with temperature sensors for automatic operation.

2.7 Earthing

Continuous earth bus sized for prospective fault current to be provided with arrangement for connecting to station earth at two points. Hinged doors / frames to be connected to earth through adequately sized flexible braids. Calculations shall be provided for the earthing strip size as per the fault level of the panel. Min size of earth bus shall be 50 x 6 mm Al.

2.8 Sheet Steel Treatment And Painting

Sheet steel used in the fabrication of switchboards shall undergo a rigorous cleaning and surface treatment seven tank process comprising of alkaline degreasing, descaling in dilute sulphuric acid and a recognized phosphating process after which a coat of primer paint compactively with the final paint shall be applied over the treated surface. Final paint coat of oven baked powder coating, of minimum 75 micron thickness, of sheet approved by Engineer-in-Charge shall then be provided. Painting shade shall be Siemens Grey-RAL 7032.

2.9 Name Plates and Labels

Identification labels of Aluminium with black base and silver fonts shall be provided on all feeders / lamps / panel name plate / relays / contactors etc. These shall indicate the feeder number and feeder designation also along with rating of the switchgear. Sample for the same shall be first approved by engineer.

2.10 Installation

Splices shall be implemented to ensure the electrical continuity of the horizontal bus bars, auxiliary buses and the protective conductor between adjacent sections.

It shall be possible to secure the sections to a floor that is flat (max variation within 2 mm/m:)

- by anchoring directly to a concrete floor using anchor bolts;
- by securing to ordinary metal profiles.

Extensions to the low-voltage electrical switchboards shall be possible on either side (right or left).

2.11 Protection and Safety

The low-voltage electrical switchboards shall ensure the safety of life and property as well as provide a high level of continuity of service.

- Switching safety shall be ensured by a mechanical device preventing on-load withdrawal & on-load access to live parts, except by strictly following a defined procedure & using defined tools.
- Operating safety shall be ensured by the use of compartments in compliance with standard IEC 60439-1 and according to form types 3b.
- Current interruption shall be of the "visible break isolation" or "positive contact indication" type as defined by standard IS 13947: 1993.

In view of reducing the risk of electrical shock:

- Power and control circuits shall be separate and completely isolated;
- Auxiliary circuits shall be of the extra-low voltage type.
- Aux. contacts / Auxiliary contactor should be used for feeder (Relays are not preferred)

The low-voltage electrical switchboards shall be equipped with two types of mechanical locking compatible with the different positions of drawers. The locking system shall be partially mobile and implement three padlocks.

Optionally, the safety of persons shall be enhanced by a version complying with the requirements of standard IEC 61641 concerning the propagation of an arc inside electrical switchboards. Test certificates shall be available.

Provisions must be made, around the equipment critical zones, for visual/infrared inspection during equipment operation, with respect to operator safety.

Earthed metal or insulated shutters shall be provided between drawout and fixed portion of the switchgear such that no live parts are accessible with equipment drawn out. Degree of protection within compartments shall be at least IP 2X.

Overall IP rating of panel shall be IP 52 (except VFD starter).

IP rating for all PCC'S/MCCB in wet area like pump room shall be IP-65. (to be confirmed with engineer before quoting)

2.12 Internal Components:

The panels shall be equipped complete with all type of required number of air circuit breakers, switch fuse unit, contactor, relays, fuses, meters, instruments, indicating lamps, push buttons, equipment, fittings, busbar, cable boxes, cable glands etc. and all the necessary internal connections /wiring as required and as indicated on relevant drawings. Components necessary for proper complete functioning of the panels but not indicated on the drawings shall be supplied and installed on the panels.

All part of the panels carrying current including the components, connections, joints and instruments shall be capable of carrying their specified rated current continuously, without temperature rise exceeding the acceptable values of the relevant specifications at any part of the panels.

All units of the same rating and specifications shall be fully interchangeable.

2.13 L. T. Switchgears:

2.13.1 General:

The type, size, and rating of the components shall be as indicated on the relevant single line diagrams.

2.13.2 Miniature Circuit Breaker (MCB) / MPCB / ELCB:

MCB / MPCB shall be quick make and break and break type conform with IS: 8828 (1996). The housing shall be heat resistant and having high impact strength. The fault current of MCBs / MPCBs shall not be less than 10000 amps, at 230 volts. The MCBs shall be flush mounted and shall be provided with trip free manual operating mechanism with mechanical "ON" and "OFF" indications.

The circuit breaker dollies shall be of trip free pattern to prevent closing the breaker on a faulty current.

The MCB / MPCBs contact shall be silver nickel and silver graphite alloy and tip coated with silver. Proper arc chutes shall be provided to quench the arc immediately. MCB's / MPCBs shall be provided with magnetic fluid plunger relay for over current and short circuit protection. The over load or short circuit devices shall have a common trip bar in the case of DP and TPN miniature circuit breakers. All the MCB's / MPCBs shall be tested and certified as per Indian Standard, prior to Installation.

MPCB with extended support should be consider along with front operating mechanism. MPCB should be with all accessories like; auxiliary contacts, door rotary mechanism etc.

The RCCB should suffices all the requirements of IS as per code IS - 12640 - 1988. The RCA should be current operated and not on line voltage.

The RCCB should ensure mainly the following functions:

- i. Measurement of the fault current value.
- ii. Comparison of the fault current with a reference value.
- iii. The RCCB should have a torroidal transformer witch has the main conductors of primary (P - N) which check the sum of the current close to zero.
- iv. All metal parts should be inherently resistant to corrosion and treated to make them corrosion resistant.
- v. It should be truly current operated.
- vi. It should operate on core balance torroidal transformer.
- vii. Its accuracy should be $\pm 5 \%$.
- viii. It should operate even in case of neutral failure.
- ix. It should trip at a present leakage current within 100 mA
- x. Its enclosure should be as per IP 30.
- xi. Its mechanical operation life should be more than 20,000 operations.
- xii. It should provide full protection as envisaged by IE rules - 61-A, 71 - ee, 73 - ee, 1985 and also rule 50 of IE rule1956.

It should conform to all national and international standards like IS: 8828-1993, IS: 12640-1988, BS 4293 - 1983, CEE 27 (International commission Rules for the approved of electrical equipment).

2.13.3 Fuse:

Fuses shall be of high rupturing capacity (HRC) fuse links and shall be in accordance with IS : 2000-1962 and having rupturing capacity of not less than 35 MVA at 415 Volts.

Fuse link to be considered along with SFU.

2.13.4 Air Circuit Breaker:

The ACB shall meet with IS : 2516 part I, II and III. Each pole of the ACB's shall be equipped with over current, earth fault and short circuit release. The ACB's shall be equipped with under voltage trip only on those used as main incomer of all sources, bus coupler and inter connector. The trip devices shall be direct acting.

Disconnecting devices of approved type shall be provided to facilitate the removal of the circuit breakers from the housing for test and maintenance purpose.

The ACB's shall have an arc-quenching device on each pole. The ACB's shall have auxiliary contacts for signalling, interlocking etc. The ACB's shall have slow close facilities for checking contact operation and contact gap adjustment.

All contacts subject to arcing shall be tipped with arc resisting material. Main contacts shall be silver plated, multi-finger and spring-loaded type. Facilities shall be provided to isolate the circuit breaker for inspection purpose.

Interlocks shall be provided to:

Prevent the breaker from being isolated unless it is in the "OFF" position.

Prevent the breaker from being racked in to the service position unless it is in the "OFF" position.

Prevent the breaker from being accidentally pulled completely "OFF" the guide rail. Safety shutters of insulating material shall be provided to prevent access to all live contacts, when the breaker is in the inspection position or completely withdrawn.

Facilities shall be provided for earthing the circuit breaker.

Air circuit breaker shall be capable of clearing the maximum fault current, which can occur.

The breaker plates shall have an ON-OFF indicator, spring charge indicators, provision to padlock manual handle and provision to lock draw-out mechanism. Electrically operated breaker shall have provision for emergency manual closing by inserting a tool through the fuse plate. A control isolating switch shall be provided on the fuse plate to isolated the supply to the charging motor.

The breaker shall be having feature such as to indicate voltage status / trip / fault alarm indicators / remote operation from BMS – ON/OFF, shunt trip release and motorised reclosing / contacts for remote indication of open / close / trip wired to BMS, communication modules providing LAN interface with BMS and draw out pattern with test facility provision.

All ACB releases shall be with long time + short time + instantaneous + earth fault selective protection.

2.13.5 Moulded Case Circuit Breaker:

2.13.5.1 General

Moulded-Case Circuit Breakers (MCCB) shall comply with IS 13947: 1993 standards.

- they shall be of utilisation category A on all the operational voltage range – till 250A and category B on all the operational voltage range – for any rating with adjustable short time delay (if specified) with a rated service breaking capacity (Ics) equal to the ultimate breaking capacity (Icu) up to 500V for the greater ratings
- They shall have a rated operational voltage of 690 V AC (50/60 Hz),
- They shall have a rated insulation voltage of 800 V AC (50/60 Hz),
- They shall be suitable for isolation, as defined by IS 13947: 1993 for the Overvoltage Category IV for a rated insulation voltage up to 690 V .

MCCBs shall be designed according to Eco-design complying with ISO 14062 Especially MCCB's materials shall be of halogen free type. They shall be supplied in recyclable packing complying with European Directives.

The manufacturer shall implement nonpolluting production processes that do not make use of chlorofluorocarbons, chlorinated hydrocarbons, ink for cardboard markings, etc

MCCBs shall be mounted in panel as fixed type versions in 3-pole and 4-pole versions. A safety trip shall provide advanced opening to prevent connection and disconnection of a closed circuit breaker

MCCBs shall be designed for both vertical and horizontal mounting, without any adverse effect on electrical performance. It shall be possible to supply power either from the upstream or downstream side

MCCBs shall provide class II insulation between the front and internal power circuits.

2.13.5.2 Construction, Operation, Environment

For maximum safety, the power contacts shall be insulated in an enclosure made of a thermosetting material from other functions such as the operating mechanism, the case, the trip unit and auxiliaries

All poles shall operate simultaneously for circuit breaker opening, closing and tripping.

MCCBs shall be actuated by a toggle or handle that clearly indicates the three positions: ON, OFF and TRIPPED.

In order to ensure suitability for isolation complying with IS 13947: 1993:

- the operating mechanism shall be designed such that the toggle or handle can only be in OFF position (O) if the power contacts are all actually separated,
- In OFF position, the toggle or handle shall indicate the isolation position.

Isolation shall be provided by a double break on the main circuit.

MCCBs shall be able to receive a device for locking in the “isolated” position, with up to 3 padlocks, Ø8 maximum.

MCCBs shall be equipped with a “push to trip” button in front to test operation and the opening of the poles.

MCCB rating, “push to trip” button, performances and contact position indication must be clearly visible and accessible from the front, through the front panel or the door of the switchboard.

2.13.5.3 Current Limitation, Discrimination, Durability

MCCBs shall be capable of greatly limiting currents. For short-circuits, the maximum thermal stress I_t shall be as per IEC / IS.

These characteristics will allow high cascading performance with moulded-case or miniature circuit-breakers downstream

MCCBs shall be equipped with a tripping unit independent of the thermo-magnet or electronic one. This unit will trip the circuit-breaker for high value short-circuits currents. The breaking will be carried out in less than 10ms for short-circuit currents above $25I_n$.

MCCBs shall comprise a device, designed to trip the circuit-breaker in the event of high-value short-circuit currents. This device shall be independent of the thermal-magnetic or electronic trip unit.

MCCBs, the current ratings of which are identical with the ratings of their trip units, shall ensure discrimination for any fault current up to at least 35 kA rms, with any downstream circuit-breaker having a current rating less or equal to 0.4 times that of the upstream circuit-breaker.

The electrical durability of MCCBs, as defined by IS 13947: 1993 standard.

MCCBs shall be equipped with a self-test of the connection between the electronic trip unit, the current transformers and the actuator, that will not cause the circuit-breaker to trip. The self-test will be of positive logic and visible through the flashing of a green LED in case the self-test occurred correctly and the extinction of the LED in case the self-test failed.

The MCCB shall trip in case the environmental conditions of the circuit-breaker get out of their specified range. However, it will be possible to overrule this feature.

2.13.5.4 Auxiliaries and Accessories

It shall be possible to equip MCCBs with a motor mechanism for electrically controlled operation if specified in SLD. An “auto/manual” switch in front shall, when set to the “manual” position, lock out electrical control; when set to “auto”, lock out the manual control; remote indication of “manual” or “auto” mode shall be possible. It shall also be possible to seal the access to the “auto” control.

Closing shall take place in less than 80 ms.

Following tripping due to electrical faults (overload, short-circuit, earth fault if mentioned in SLD), remote reset shall be inhibited.

It shall however be possible if opening was initiated by a voltage release.

The operating mechanism shall be of the stored-energy type only

The addition of a motor mechanism or a rotary handle shall in no way affect circuit breaker characteristics:

- Only three stable tripping mechanism positions (ON, OFF and TRIPPED) shall be possible with the motor mechanism,
- Suitability for isolation shall be provided by positive contact indication (ON and OFF) in front of the motor mechanism module

MCCBs shall be designed to enable safe on-site installation of auxiliaries such as voltage releases (shunt and under voltage releases) and indication switches as follows:

- They shall be separated from power circuits,
- All electrical auxiliaries shall be of the snap-in type and fitted with terminal blocks,
- All auxiliaries shall be common for the entire range,
- Auxiliary function and terminals shall be permanently engraved on the case of the circuit breaker and the auxiliary itself,
- The addition of auxiliaries shall not increase the volume of the circuit breaker.
- MCCB should be with all accessories like; spreads links, shrouding terminals, auxiliary contacts, phase barrier, door rotary mechanism etc. Spreader links should be copper with Ni-Cr plated
- Outgoing terminal of MCCB should be 3Ph+N+E.

The addition of a motor mechanism module or a rotary handle, etc., shall not mask or block device settings

It shall be possible to assemble earth fault protection moulded-case circuit breakers by adding a residual current device (RCD) directly to the circuit breaker case. The resulting device shall:

- comply with IS 13947: 1993 standard,
- be immunised against nuisance tripping,
- be capable of working normally down to -25 °C ambient temperature,

- operate without an auxiliary power supply, i.e. it shall be capable of operating normally on any 2-phase or 3-phase power network with a voltage between 200 V and 440 V, and of tripping the circuit-breaker even in the event of voltage dips down to 80 V

It shall be possible to equip MCCBs with devices indicating faults without tripping the circuit breaker.

2.13.5.5 Protection Functions

General Recommendations

MCCBs with ratings up to & including 250 A shall be equipped with fully interchangeable trip units in order to ensure the protection against overcharge and short-circuit. The trip units shall be of thermal magnetic adjustable type.

MCCBs with ratings over 250 A shall be equipped with microprocessor based trip units with O/C / S/C & E/F.

2.13.5.6 Common Features

Electronic and thermal-magnetic trip units shall be adjustable and it shall be possible to fit lead seals to prevent unauthorized access to the settings

Electronic trip units shall comply with IS 13947: 1993 standard (measurement of rms current values, electromagnetic compatibility, etc.)

Protection settings shall apply to all circuit breaker poles

The trip units shall not augment overall circuit breaker volume

All electronic components shall withstand temperatures up to 125 °C.

2.13.5.7 Microprocessor Trip Units

Characteristics

- Long time protection (LT)
Selectable Ir threshold settings from 36% to 100 % of the trip unit rating
- Short time protection (ST)
Isd threshold shall be adjustable from 1,5 to 10 times the thermal setting Ir,
The time delay shall be either adjustable or fixed at 40 ms,

- Instantaneous protection

The threshold shall be either adjustable or fixed (starting from 1.5 times I_n and up to a value between 11 and 15 times I_n , depending on the rating)

Four-pole devices shall be equipped for neutral protection:

- as standard with a 3-position setting : - neutral not protected - neutral tripping threshold equal to half the phase value - neutral threshold equal to the phase value
- if required by harmonic 3 neutral current circulation with a specific 4-position setting - neutral not protected - neutral tripping threshold equal to half the phase value - neutral threshold equal to the phase value - neutral setting according to the rating of the phases in a ratio 1.6 (Oversized Neutral).

Load Monitoring Function

The following monitoring functions shall be integral parts of electronic trip units:

- 2 LED for load indication, one lighted above 90 % of I_r , and one lighted above 105 % of I_r
- a test connector shall be installed for checks on electronic and tripping mechanism operation using an external device.

Thermal Memory

In the event of repeated overloads, the electronic trip unit shall optimise protection of cables and downstream devices by memorising temperature variations.

Options:

It shall be possible to install all options for the electronic trip unit:

- High-threshold earth-fault protection,
- Auxiliary contact to indicate the cause of tripping (long time, short time, instantaneous, earth fault if requested),
- Data transmission via a BUS, in particular all the trip unit settings, current measurements for each phase, tripping causes, circuit breaker status.

transmission, in particular all the trip unit settings, all electrical parameters (current, energy, THD, voltage, etc.) measurements for each phase, tripping causes, circuit breaker status, control and alarms.

Software that allows these data to be analysed on PC shall be provided by the manufacturer.

2.13.6 Contactors / Relays / Starter:

- 2.13.6.1 The contactor shall meet with the requirements of IS: 2959.
- 2.13.6.2 Contactors shall be air break and electromagnetic type rated for uninterrupted duty as defined in relevant IS.
- 2.13.6.3 The main contacts shall be of silver or silver alloy.
- 2.13.6.4 The insulation for the coils shall be of class 'F'.
- 2.13.6.5 Each contactors shall be provided with 2 normally open and 2 normally closed auxiliary contacts.
- 2.13.6.6 The contactors shall be in accordance to type 2 co-ordinations for short circuit protection.
- 2.13.6.7 The contactor shall be suitable for uninterrupted duty (AC3) category.
- 2.13.6.8 All 3 Contactor sizes should be identical rating in Star-Delta feeders.
- 2.13.6.9 The electrical and mechanical endurance shall be as specified in IS code.
- 2.13.6.10 For all starters, component sizing shall be as per type-II co-ordination chart prescribed by switchgear manufacturer + Contactor shall be one rating higher than specified in type-2 coordination.
- 2.13.6.11 Remote start, stop, interlock wire should be wire up at terminals apart than PLC/BMS/SCADA signals/commands.
- 2.13.6.12 Outgoing terminal of Starter should be 3Ph+E.
- 2.13.6.13 Auto-Manual Status and ON-OFF-Trip potential free signal required for BMS/PCL wherever asked.
- 2.13.6.14 Thermal overload relays shall be of three elements positive acting ambient temperature compensated type with adjustable settings.
- 2.13.6.15 Thermal overload relays shall be of self/hand reset type as specified in the schedule.
- 2.13.6.16 All control terminals to OCS / PLC shall wired to single compartment. (marshalling box).
- 2.13.6.17 Separate control terminal blocks shall provide for control wiring.
- 2.13.6.18 From MCC to field in cable chamber.
 - From MCC to OCS / PLC in marshalling jb.
 - AI, AO, DI & DO shall be provided on separate terminal block.

2.13.6.19 Following control signal exchange between OCS / PLC & MCC panel shall be considered for AHU panel & package systems in process mcc —

From MCC panel to DES / PLC

- On, off & trip feedback — separate continuous potential free contacts.
- For VFD feeders — 4—2oma speed (rpm) feedback.
- Potential free contact for remote selection.

From DES / PLC to MOE panel

- Start & stop command — single latched contact.
- For VFD feeders only — 4—2oma reference current for speed control.
- Start permissive in local & remote mode.

2.13.6.20 Following control signal exchange between push button station & mcc panel shall be considered.

- a. On, off & trip feedback — separate continuous potential free contacts.
- b. Start & stop command — seperate continuous potential free contacts.

2.13.6.21 Control philosophy

- a. Under local mode selection start command will be executed from push button station near motor.
- b. Under remote mode selection start command will be executed from PLC panel.
- c. Stop command can be executed without selection.

2.13.6.22 Motor feeder shall have motor protection circuit breaker (MPCB) with S/C and O/C release.

2.13.6.23 Heavy duty bmr to be provided for blowers & fan application.

2.13.7 Multi Function Meter:

Flush mount 96 x 96 x 80 mm load manager type CONSERV EM 6400 or equivalent meter of accuracy class 1 as per IS 13779 shall be provided. The meter shall be accurate on distorted waveforms; simultaneous sampling of voltage and amperes shall be done. It shall have low burden on PT and CT shall have bright display, shall view 3 parameters together shall have auto scaling from kilo to mega to giga units, shall have programmable CT, PT ratios with built in phase analyser. Auto scrolling shall be programmable as per user choice and communication with PC; PLC DCS shall be possible through RS 485 serial port. It shall be dust proof, tamper proof with data import export option and 10 years back up of integrated data.

Parameters to be monitored shall be Frequency, Line to line and average and line to neutral and average voltage, phase wise and average current, phase wise and total KVA, KW and P.F. reading and KWH monitoring.

User programmable facility for delta 2e and star 3e measurement, C.T. and P.T. ratios, sliding window auto sync. And auto scrolling of parameters shall be available.

Sensing shall be 3 phase, 4 wire measuring True RMS with voltage input range of 110 to 415 V nominal and current input of 5 amps or 1 amps as per field configuration. Current range shall be from 50 mA to 7.5 A and burden on PT or CT shall be app 0.2 VA.

Accuracy for kW / kWh shall be as per IS 1377 / CBIP88 and for all other parameters shall be +/- 0.5% of full scale + 0.5% of reading + 1 digit. Digital readout shall be of 3 rows of 4 digits each (12.5 mm size) with 7 segments bright red LED. Input frequency shall be 50Hz / 60Hz +/- 5%. Power factor range shall be 0.5 lag – unit – 0.8 lead.

Resolution for power parameters shall be for 4 digits and energy parameters shall be 8 digits. Display update shall be at every 15 seconds for demand parameters and 1 sec for other parameters. Display sequence shall be parameter followed by value. Temperature range shall be 0-50oC and humidity <95% non-condensing.

Display pages shall be as follows:

Instantaneous –	VLL, A avg., F
	Ln, A avg., F
	KVA, kW, PF
Individual pages of above parameters.	
Integrated -	kVAh
	KWh
	Run hours
	On hours
	Interruption

2.13.8 ***Current Transformer:***

Where called for, CT's shall provide for current measuring. Each phase shall be provided with separate CT of class I accuracy and VA burden as shown in SLD for operation of associated metering and controls. Current transformer shall be in accordance with IS: 2705 - 1964 as amended up to date.

Separate CT for each protection devices and instrumentation device shall be provided.

The CT shall be able to withstand max short time withstands current indicated for the assembly.

The CT shall be cast resin type.

Test links at secondary – to facilities testing of instruments / meters and protection device.

2.13.9 Push Button & Indicating Lamp:

The push button unit shall comprise of the contact element, a fixing holder, and push button actuator. The push button shall be momentary contact type. The contacts shall be of silver alloy and rated at 10 Amps continuous current rating. The actuator shall be of stranded type and colour as per its usage for ON, OFF and Trip.

Indicating Lamp shall be LED type and shall supplied complete with translucent covers to diffuse the lamp light. Indicating lamps shall be part of push buttons where ever both are required and shall have testing facilities. Protection in form of MCB / HRC fuse shall be provided for the lamps.

Colour shade for the indicating lamps shall be as below:

ON indicating lamp	:	Green
OFF indicating lamp	:	Red
TRIP indicating lamp	:	Amber
PHASE indicating lamp	:	Red, Yellow, and Blue.

2.13.10 Selector Switches:

Selector Switches shall be of the heavy duty rotory type, with plates clearly marked to show the operating position. They shall be of the semi-flush mounted type with only the front plate and operating handle projecting.

Circuit breaker control switches shall be of the spring return to neutral type.

2.14 All panels short circuit integration:

The panel vendor / contractor shall be responsible for carrying out necessary study for type 2 co-ordination for complete system with fault discrimination. All the data considered for the study shall be discussed with the engineer.

2.15 415V Auto Transfer Switch - ATS

1.1 General

1.1.1 Scope

This specification covers performance, design, material, construction, manufacture, inspection, testing, packing forwarding, delivery at site, testing and commissioning of microprocessor controlled Auto transfer switches – with double throw power transfer switch mechanism as per single line diagrams, with all accessories complete in all respects as described in this specification.

Whether called for specifically or not, all accessories required for normal operation of equipment are deemed to be considered as a part of the contractor's scope of supply. Hardware / fabricated supports required for mounting and installation of the ATS is within the scope of work.

It is not the intent to specify completely herein, all details of design and construction of the equipment. However, the equipment shall conform in all respects to high standard of Engineering, design and workmanship and be capable of performing in continuous commercial operation up to the Manufacturer's guarantees in a manner acceptable to the Engineer, who will interpret the meaning of the drawings and specifications and shall be entitled to reject any work or material which is not full accordance therewith.

1.1.2 Codes and Standards

The automatic transfer switches and controls shall conform to the requirements of:

UL 1008	- Standard for Transfer Switch Equipment
IEC 947-6-1	- Low-voltage Switchgear and Control gear; Multifunction equipment; Automatic Transfer Switching Equipment
NFPA 70	- National Electrical Code
NFPA 99	- Essential Electrical Systems for Health Care Facilities
NFPA 110	- Emergency and Standby Power Systems

IEEE Standard 446 - IEEE Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications

NEMA Standard ICS10-1993 (formerly ICS2-447) - AC Automatic Transfer Switches

UL 508 - Industrial Control Equipment

1.2 Products

1.2.1 Mechanically Held Transfer Switch

The transfer switch shall be electrically operated and mechanically held. The electrical operator shall be a momentarily energized, single-solenoid mechanism. Main operators which include overcurrent disconnect devices, linear motors or gears shall not be acceptable. The switch shall be mechanically interlocked to ensure only two possible positions, normal or emergency. The switch shall be rated for AC-33A duty cycle for mixed load application as mentioned in IEC 60947-6-1.

All transfer switch sizes shall use only one type of main operator for ease of maintenance and commodity of parts.

The switch shall be positively locked and unaffected by momentary outages, so that contact pressure is maintained at a constant value and contact temperature rise is minimized for maximum reliability and operating life.

All main contacts shall be silver composition. Switches rated 600 amperes and above shall have segmented, blow-on construction for high withstand and close-on capability and be protected by separate arcing contacts.

Inspection of all contacts shall be possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors. Switches rated 600 amps and higher shall have front removable and replaceable contacts. All stationary and moveable contacts shall be replaceable without removing power conductors and/or bus bars.

Designs utilizing components of moulded-case circuit breakers, contactors, or parts thereof, which are not intended for continuous duty, repetitive switching or transfer between two active power sources are not acceptable.

Where neutral conductors must be switched as shown on the plans, the AS shall be provided with fully rated complete overlapping neutral transfer contacts. The neutrals of the normal and emergency power sources shall be connected together only during the transfer and retransfer operation and remain connected together until power source contacts close on the source to which the transfer is being made. The overlapping neutral contacts shall not overlap for a period greater than 100 milliseconds. Neutral switching contacts which do not overlap are not acceptable.

Where neutral conductors are to be solidly connected as shown on the plans, a neutral conductor plate with fully rated CU pressure connectors shall be provided.

1.2.2 Microprocessor Controller

The controller’s sensing and logic shall be provided by a single built-in microprocessor for maximum reliability, minimum maintenance, and the ability to communicate serially through an optional serial communication module.

A single controller shall provide twelve selectable nominal voltages for maximum application flexibility and minimal spare part requirements. Voltage sensing shall be true RMS type and shall be accurate to ± 1% of nominal voltage. Frequency sensing shall be accurate to ± 0.2%. The panel shall be capable of operating over a temperature range of -20 to +60 degrees C and storage from -55 to +85 degrees C.

The controller shall be connected to the transfer switch by an interconnecting wiring harness. The harness shall include a keyed disconnect plug to enable the controller to be disconnected from the transfer switch for routine maintenance. Sensing and control logic shall be provided on multi-layer printed circuit boards. Interfacing relays shall be industrial grade plug-in type with dust covers. The panel shall be enclosed with a protective cover and be mounted separately from the transfer switch unit for safety and ease of maintenance. The protective cover shall include a built-in pocket for storage of the operator’s manuals.

All customer connections shall be wired to a common terminal block to simplify field-wiring connections.

The controller shall meet or exceed the requirements for Electromagnetic Compatibility (EMC) as follows:

EN 55011:1991	Emission standard - Group 1, Class A
EN 50082-2:1995	Generic immunity standard, from which:
EN 61000-4-2:1995	Electrostatic discharge (ESD) immunity
ENV 50140:1993	Radiated Electro-Magnetic field immunity

EN 61000-4-4:1995	Electrical fast transient (EFT) immunity
EN 61000-4-5:1995	Surge transient immunity
EN 61000-4-6:1996	Conducted Radio-Frequency field immunity
IEEE472 (ANSI C37.90A)	Ring Wave Test.

1.3 Operation

1.3.1 Controller Display and Keypad

A four line, 20-character LCD display and keypad shall be an integral part of the controller for viewing all available data and setting desired operational parameters. Operational parameters shall also be available for viewing and limited control through the serial communications input port. The following parameters shall only be adjustable via DIP switches on the controller:

Nominal line voltage and frequency

Single or three phase sensing

Operating parameter protection

Transfer operating mode configuration

(Open transition, Closed transition or Delayed transition)

All instructions and controller settings shall be easily accessible, readable and accomplished without the use of codes, calculations, or instruction manuals.

1.3.2 Voltage, Frequency and Phase Rotation Sensing

Voltage and frequency on both the normal and emergency sources (as noted below) shall be continuously monitored, with the following pickup, dropout and trip setting capabilities (values shown as % of nominal unless otherwise specified):

Parameter	Sources	Dropout / Trip	Pickup / Reset
Undervoltage	N&E, 3 ϕ	70 to 98%	85 to 100%
Overvoltage	N&E, 3 ϕ	102 to 115%	2% below trip
Underfrequency	N&E	85 to 98%	90 to 100%
Overfrequency	N&E	102 to 110%	2% below trip
Voltage unbalance	N&E	5 to 20%	1% below dropout

Repetitive accuracy of all settings shall be within $\pm 0.5\%$ over an operating temperature range of -20°C to 60°C .

Voltage and frequency settings shall be field adjustable in 1% increments either locally with the display and keypad or remotely via serial communications port access.

The controller shall be capable (when activated by the keypad or through the serial port) of sensing the phase rotation of both the normal and emergency sources. The source shall be considered unacceptable if the phase rotation is not the preferred rotation selected (ABC or CBA).

Source status screens shall be provided for both normal & emergency to provide digital readout of voltage on all 3 phases, frequency, and phase rotation.

1.3.3 Time Delays

An adjustable time delay of 0 to 6 seconds shall be provided to override momentary normal source outages and delay all transfer and engine starting signals. Capability shall be provided to extend this time delay to 60 minutes by providing an external 24 VDC power supply.

A time delay shall be provided on transfer to emergency, adjustable from 0 to 60 minutes, for controlled timing of transfer of loads to emergency.

Two time delay modes (which are independently adjustable) shall be provided on re-transfer to normal. One time delay shall be for actual normal power failures and the other for the test mode function. The time delays shall be adjustable from 0 to 60 minutes. Time delay shall be automatically bypassed if the emergency source fails and the normal source is acceptable.

A time delay shall be provided on shut down of engine generator for cool down, adjustable from 0 to 60 minutes.

A time delay activated output signal shall also be provided to drive an external relay(s) for selective load disconnect control. The controller shall have the ability to activate an adjustable 0 to 5 minute time delay in any of the following modes:

Prior to transfer only.

Prior to and after transfer.

Normal to emergency only.

Emergency to normal only.

Normal to emergency and emergency to normal.

All transfer conditions or only when both sources are available.

The controller shall also include the following built-in time delays for optional Closed Transition and Delayed Transition operation:

1. 1 to 5-minute time delay on failure to synchronize normal and emergency sources prior to closed transition transfer.
2. 0.1 to 9.99 second time delay on an extended parallel condition of both power sources during closed transition operation.
3. 0 to 5-minute time delay for the load disconnect position for delayed transition operation.

All time delays shall be adjustable in 1 second increments, except the extended parallel time, which shall be adjustable in .01 second increments.

All time delays shall be adjustable by using the LCD display and keypad or with a remote device connected to the serial communications port.

1.3.4 Additional Features

A three position momentary-type test switch shall be provided for the test / automatic / reset modes. The test position will simulate a normal source failure. The reset position shall bypass the time delays on either transfer to emergency or retransfer to normal.

A SPDT contact, rated 5 amps at 30 VDC, shall be provided for a low-voltage engine start signal. The start signal shall prevent dry cranking of the engine by requiring the generator set to reach proper output, and run for the duration of the cool down setting, regardless of whether the normal source restores before the load is transferred.

Auxiliary contacts, rated 10 amps, 250 VAC shall be provided consisting of one contact, closed when the ATS is connected to the normal source and one contact closed, when the ATS is connected to the emergency source.

LED indicating lights (16 mm industrial grade, type 12) shall be provided; one to indicate when the ATS is connected to the normal source (green) and one to indicate when the ATS is connected to the emergency source (red).

LED indicating lights (16 mm industrial grade, type 12) shall be provided and energized by controller outputs. The lights shall provide true source availability of the normal and emergency sources, as determined by the voltage sensing trip and reset settings for each source.

The following features shall be built-in to the controller, but capable of being activated through keypad programming or the serial port only when required by the user:

Provide the ability to select “commit/no commit to transfer” to determine whether the load should be transferred to the emergency generator if the normal source restores before the generator is ready to accept the load.

Terminals shall be provided for a remote contact which opens to signal the ATS to transfer to emergency and for remote contacts which open to inhibit transfer to emergency and/or retransfer to normal. Both of these inhibit signals can be activated through the keypad or serial port.

An In phase monitor shall be provided in the controller. The monitor shall control transfer so that motor load inrush currents do not exceed normal starting currents, and shall not require external control of power sources. The in phase monitor shall be specifically designed for and be the product of the ATS manufacturer.

The controller shall be capable of accepting a normally open contact that will allow the transfer switch to function in a non-automatic mode using an external control device.

1.3.5 Engine Exerciser

The controller shall provide an internal engine exerciser. The engine exerciser shall allow the user to program up to seven different exercise routines. For each routine, the user shall be able to:

1. Enable or disable the routine.
2. Enable or disable transfer of the load during routine.
3. Set the start time
 - time of day
 - day of week
 - week of month (1st, 2nd, 3rd, 4th, alternate or every)
4. Set the duration of the run.

At the end of the specified duration the switch shall transfer the load back to normal and run the generator for the specified cool down period. A 10-year life battery that supplies power to the real time clock in the event of a power loss will maintain all time and date information.

1.3.6 System Status

The controller LCD display shall include a “System Status” screen which shall be readily accessible from any point in the menu by depressing the “ESC” key a maximum of two times. This screen shall display a clear description of the active operating sequence and switch position. For example,

Normal Failed

Load on Normal

TD Normal to Emerg

2min15s

Controllers that require multiple screens to determine system status or display “coded” system status messages, which must be explained by references in the operator’s manual, are not permissible.

1.3.7 Self Diagnostics

The controller shall contain a diagnostic screen for the purpose of detecting system errors. This screen shall provide information on the status input signals to the controller which may be preventing load transfer commands from being completed.

1.3.8 Communications Interface

The controller shall be capable of interfacing, through an optional serial communication module, with a network of transfer switches, locally (up to 4000 ft.) or remotely through modem serial communications. Standard software specific for transfer switch applications shall be available by the transfer switch manufacturer. This software shall allow for the monitoring, control and setup of parameters.

1.3.9 Data Logging

The controller shall have the ability to log data and to maintain the last 99 events, even in the event of total power loss. The following events shall be time and date stamped and maintained in a non-volatile memory:

1. Event Logging

1. Data and time and reason for transfer normal to emergency.
2. Data and time and reason for transfer emergency to normal.
3. Data and time and reason for engine start.
4. Data and time engine stopped.
5. Data and time emergency source available.

6. Data and time emergency source not available.

2. Statistical Data

1. Total number of transfers.
2. Total number of transfers due to source failure.
3. Total number of days controller is energized.
4. Total number of hours both normal and emergency sources are available.

1.3.10 Communications Module

A full duplex RS485 interface & Ethernet TCP/IP RJ45 socket shall be installed in the ATS controller to enable serial communications. The serial communications shall be capable of a direct connect or multi-drop configured network. This module shall allow for the seamless integration of existing or new communication transfer devices through Modbus open protocol. The proprietary protocols are not acceptable.

1.4 Additional Requirements

1.4.1 Withstand and Closing Ratings

The ATS/BPS shall be rated to close on and withstand the available RMS symmetrical short circuit current at the ATS/BPS terminals with the type of overcurrent protection shown on the plans.

The ATS/BPS shall be UL-1008 and IEC-60947-6-1 complied & in accordance with UL 1008 listing and be labeled in accordance with that standard's 1½ and 3 cycle, long-time ratings. ATS/BPS which are not tested and labeled with 1½ and 3 cycle (any breaker) ratings and have series, or specific breaker ratings only, are not acceptable.

The ATS rated 800A and above must be tested for 18/30 cycles short time withstand capacity matching breaker fault level to enable use of ACB as a back up protection device with short time delay setting for providing discrimination with the downstream breakers.

1.5 POWER FACTOR CORRECTION

1.0 Scope:

This specification covers design, manufacture, supply, installation, testing, commissioning of thyristorised zero crossing – Real Time Power Factor Correction (RTPFC) system with capacitor banks and harmonic filters suitable for continuous duty. The capacities given in SLD are for reference only and are to be verified by contractor after doing complete reactive load analysis and also necessary changes if required in the rating

of capacitors and harmonic filters is within scope of contractor. All necessary hardware / supports required for installation of the panel is scope of the works.

2.0 Standards:

The design, manufacture and performances of the power factor correction panel with capacitor banks shall comply with all currently applicable statutes, regulations and safety codes in the locations of installations. The capacitors used will also conform to the latest applicable Indian / British / IEC standards. In particular, the equipment shall conform to the latest revisions of the following.

IS: 13340 , 13341 & 12672 Capacitors for power system.

IS: 2208 , 13703 HRC cartridge fuse and links upto 600V

IS: 8828 MCB

IS: 13947 MCCBs

When the above standards are in conflict with these specifications, this specification shall prevail.

3.0 Capacitor Bank

Capacitor bank shall comprise of identical three phase capacitors in case of RTPFC. The individual capacitor unit shall be manufactured out of MPP design, comprising of bi-axially oriented metalised polypropylene film. Capacitor shall be tubular (Cylindrical) MPP self filling type. The capacitor shall consist of many such elements in series / parallel combinations for getting desired kVAr output. The dielectric losses of capacitor shall be restricted to 0.5 watts per kVAr. The phase terminal connections of the capacitor unit shall be brought out at the top, for suitable connections. The capacitor shall be provided with suitably rated discharge resistor. The capacitor shall be provided with over pressure interrupter mechanism, which will automatically disconnect faulty capacitor unit from the network without bursting, bulging or exploding the capacitor.

The rating of the step should be decided by due consideration of de-rating due to harmonic reactors, so as to ensure that each capacitor feeder delivers net output equivalent to the step rating. PF capacitors should be rated for minimum 480/525 VAC, 3-ph, 50 Hz and shall be suitable to operate continuously with the harmonic filters.

4.0 Harmonic Filter Reactors

Each feeder shall be provided with 7 % detuned harmonic filter reactor 440 V, 3-phase, 50 Hz of step rating. This reactor should be anti-resonance type, copper wound, low noise with high linearity-low loss core (CRGO lamination of 46/51 grade insulation class F). The linearity of the reactor should not be less than 1.5

In and suitable for continuous operation at system voltage without excess heating. One no temperature switch should be provided internally with terminals brought outside for control.

5.0 Capacitor Panel

The capacitor control panel shall operate in Automatic mode as specified in the data sheet. The panel for capacitor shall be fabricated from 2 mm thick sheet steel and shall be finished with 7tank process followed by powder coating.

Earthing terminal shall be provided as per clause No 4.0 of this specification. The panel shall be provided with suitably rated T.P. copper bus bar supported on epoxy insulator. Each capacitor unit shall be connected to main bus bar through thyristor of suitable rating with safety margin. Protective HRC/MCBs /MCCBs fuses of suitable rating shall be provided with base / holder as mentioned in the drawing. Connection shall be made with PVC insulated flexible copper cables having crimped copper lugs. All capacitor units shall be earthed; sufficient ventilation shall be provided to limit the temperature rise to maximum 85oC. Cooling fans shall be provided to each heat sink as per requirement. Suitable exhaust fans shall be provided in order to dissipate the internal heat of the panel and maintain the internal temperature rise of the panel within safe limits. The operation of fans shall be automatic with temperature sensor. Drawing pocket shall be provided at the door of each panel. A 15-amp switch & socket and the lamp holder shall also be provided for panel illumination at the suitable location.

The main Bus bar shall be terminated on suitably rated SFU /MCCB /SDU / ACB. Detachable gland plates shall be provided with suitable knockout for incoming cable connection from bottom/top as specified. Capacitor unit shall be mounted a frame of adequate strength construction.

The panel shall be mounted on MS channel section at the bottom for easy installation. The panel shall be provided with lifting hooks /eye bolts for handling. Automatic Power Factor Correction Relay shall be provided with all related circuits and three load CT's for each phase in order to control/ achieve target Power Factor OR unity as per setting.

The controller shall be capable of correcting Power Factor within 2 to 120 sec in case of RTPFC. The capacitor shall be switched ON and OFF using thyristors from APFC controller.

Average compensation required and compensation supplied shall be continuously monitored for all the three phase simultaneously and total low kVAr requirement shall be calculated accordingly. It would

automatically switch ON and OFF the capacitor bank so as to attain the set target power factor. The panel shall be provided as per respective drawing.

The thyristorised switching system shall have following minimum features.

1. Capacitor switching shall be at zero crossing and shall be smooth and surgeless, **as demonstrated at the test bench.**
2. No electromagnetic contactor/ relays/ moving parts shall be used in the switching circuit or parallel to the switching device;
3. Forced cooling system to thyristor shall be provided;
4. Diagnostic capability shall be provided to analyse and indicate type of fault;
5. Power factor controlling shall be on cycle-to-cycle basis. Proportionate correction or cutting A.C. waveform will not be allowed;
6. The controller shall be capable to work at phase to phase voltage between 200 to 440 volts;
7. Digital controller shall be provided which minimum indication of line voltage and current, capacitor current, Power factor, active power /reactive power/ apparent power, injected capacitive kVAr, uncompensated capacitive kVAr, CT ratio selected, switching time;
8. LED indication for capacitor bank step switch ON, power factor lag/lead shall be provided.

The thyristorised switching system shall inclusive of following facilities.

1. Over voltage protection.
2. Under voltage protection.
3. Over temperature protection.
4. Voltage imbalance protection in each phase.
5. Facility of manually operating capacitor bank on First-in-First out basis

6.0 EARTHING

The enclosure of capacitor unit shall be provided with 2 nos. 10 mm earth terminals or strip, each complete with two plain and one spring washer, nuts etc. These terminals shall be effectively bonded to the common sheet steel framework. Each bank in case of APFC will have two external terminals in the bus bar chambers complete with hardware.

7.0 VENDORS DATA: TO BE SUBMITTED WITH OFFER:**Approved Makes:**

Vendor shall provide information on the offered make and Cat nos. of items offered for respective Panels:

Sr. No.	Item Description	Specified Make	Vendor Confirmation
1.0	Air Circuit Breakers Ics=Icu=Icw(1sec)	Schneider Master Pack NW range with Micrologic 6.0E releases / L&T U power with UW MTX 3.5EC releases / Legrand DMX3 with MP4 - LSIG type.	
2.0	MCCB – Ics = 100% Icu FOR above 250Amps	Schneider CVS Microprocessor range / L & T Dsine range (Microprocessor MTX1.5 release)/ Legrand DPX3 with Micro Processor S1 Release)	
2.0A	MCCB till 250A, Ics=100% Icu	Schneider CVS Thermal Magnetic trip Unit / L & T Dsine Thermal Magnetic Release) Legrand DPX / DPX3 with Thermal Magnetic release)	
3.0	MCB	Legrand (DX3)/Schneider – Acti 9)/ Hager	
4.0	Capacitors – APP type – to be derated as per reactors.	EPCOS / L&T / Schneider	
5.0	Contactors	Schneider / Siemens / L&T	
6.0	Starters	As above	
7.0	CRCA sheet	Tata / SAIL	
8.0	Gaskets	Neoprene	

Sr. No.	Item Description	Specified Make	Vendor Confirmation
9.0	Meters	Schneider / L&T / Legrand	
10.0	Indicating lamps - LED	Schneider / Siemens / L & T - ESBEE	
11.0	Push Buttons	Schneider / Siemens / L & T - ESBEE	
12.0	Connectors	Wago / Connectwell / Elmex	
13.0	C.T.s – cast resin type.	Kappa / Ashmore / A.E.	
14.0	Reactors – 7% detuned	Copper winding	
15.0	Selector Switches	Schneider / L&T / Salzer	
16.0	SPD	Emerson / Legrand / Phoneix	

C) CABLE LAYING AND TRENCHES WITH TRAYS

1. SPECIFICATIONS

1.1.1 CABLE TRENCH

Cable trench shall be dug to the minimum depth of 1 mtr and the width shall dependent on the no of cables to be kept with the layer of brick in between two cables.

1.1.2 BRICKS

The bricks shall be hand or machine moulded and made from suitable soils and kiln burnt. They shall be free from cracks, flaws and modules of free lime. They shall have smooth rectangular faces with sharp corners and shall be uniform in colour. The bricks shall be moulded with a frog of size 100 mm. x 40 mm., and 10 mm. to 20 mm. deep on one of its flat sides. The bricks shall not break when thrown on the ground from a height of 6 m. B – grade locally available standard brick shall be used.

1.1.3 SAND

Sand shall be natural sand, clean, well graded, hard, strong, durable and gritty. Sand particles should be free from injurious amounts of dust, clay, kankar nodules, soft or flaky particles of shale, alkali, salts, organic matter loam, mica or other deleterious substances and shall be got approved from the CLIENT AND/OR

ITS ARCHITECT. The sand shall not contain more than 8% of silt as determined by field test, if necessary the sand shall be washed to make it clean. The sand used by civil agency shall be used.

1.1.4 CABLE TRAYS

Cable trays shall be fabricated from Hot Dip GI and channels of 14 gauge. The design shall be perforated / ladder type as per BOQ. Shall be fixed or suspended from the ceiling with the help of suspenders which shall have adequate diameter to sustain the weight of the cables and channels. Also if necessary anchor fasteners shall be used for grouting purpose.

1.1.5 WORKMANSHIP

The cable shall be laid side by side in trench with brick covering on all the three sides. The trench shall be such that sharp bends shall be avoided while laying the cable. The bedding of fine sand under the cable shall be not less than 6 mm. The trench shall be terminated in Manholes with specified size of R.C.C. hume pipes as shown in drawing. Cable markers shall be provided through out the route of cable at 10 mtrs distance. The trenches shall be refilled after the cable are laid and the Ground level shall be done as per original after pressing the same. The cables shall be checked for insulation resistance and continuity tests shall be carried out.

D) DISTRIBUTION BOARDS

1. Scope:

This specification covers performance, design, material, construction, manufacture, inspection, testing, packing forwarding, delivery at site, testing and commissioning of factory fabricated distribution boards with all accessories complete in all respects as described in this specification and single line diagrams.

Whether called for specifically or not, all accessories required for normal operation of equipment are deemed to be considered as a part of the contractor's scope of supply. Hardware / fabricated supports required for mounting and installation of the DB is within the scope of work.

It is not the intent to specify completely herein, all details of design and construction of the equipment. However, the equipment shall conform in all respects to high standard of Engineering, design and workmanship and be capable of performing in continuous commercial operation up to the Manufacturer's guarantees in a manner acceptable to the Engineer, who will interpret the meaning of the drawings and specifications and shall be entitled to reject any work or material which is not full accordance therewith.

2. Specifications

Distribution boards shall be fabricated from 14 gauge M.S. sheet or shall be readymade as specified in the make of material list. It shall be of double door type with hinged (lockable if required) door suitable for recessed mounting in wall. Distribution boards shall be powder coated with 7-tank process application.

The distribution boards shall be provided with phase barriers, wiring channels to accommodate wires and individual per phase neutral links with nos. of terminals (holes) equivalent to nos. of . circuit in D.B.. There shall be separate or individual earth link as per requirement. Proper arrangement shall be made for mounting of MCB's and other accessories.

Distribution boards shall meet with the requirements of IS 8623 and marking arrangement of bus bars shall be in accordance with I.S. standards.

Bus bars shall fully shrouded and shall be suitable for the incoming switch rating and sized for a temperature rise of 35° C over the ambient. Each board shall have two separate earthing terminals. Separate Neutral bars per phase with one terminal for each outgoing ckt shall be provided. Circuit diagram (laminated) indicating the load distribution shall be pasted on the inside of the DB as instructed. One earthing terminal for single phase and two terminals for 3 phase DB's shall be provided with an earth strip connecting the studs and the outgoing ECU earth bar.

The top and the bottom faces of the D.B. shall be provided for conduit entry of minimum 1" dia. The faces if asked shall be kept detachable.

All outgoing feeders shall terminate on a terminal strip which in turn is interconnected to the MCB by means of insulated single conductor rigid copper wires as follows

Up to 15 A	2.5 sq.mm.	40 A	10 sq.mm.
25 A	4.0 sq.mm.	63 A	16 sq.mm.
32 A	6.0 sq.mm.		

Each DB shall have indicating lamps preferably neon type denoting power availability in the board after the switch indicating lamps shall be complete with fuses.

3. Miniature Circuit Breakers (MCB) :

MCB's shall have quick make and break non-welding self-wiping silver alloy contacts for 10 KA short circuits both on the manual and automatic operation. Each pole of the breaker shall be provided with inverse

time thermal over load and instantaneous over current tripping elements, with trip-free mechanism. In case of multi-pole breakers, the tripping must be on all the poles and operating handle shall be common. Breakers must conform to IEC 60898 / IS 8828-1996. Pressure clamp terminals for stranded/solid conductor insertion are acceptable up to 4 sq. mm. aluminium or 2.5 sq.mm. copper and for higher ratings, the terminals shall be suitably shrouded. Wherever MCB isolators are specified they are without the tripping elements.

4. RCCB / ELCB

The RCCB should suffices all the requirements of IS as per code IS - 12640 - 2000. The RCA should be current operated and not on line voltage.

The RCCB should ensure mainly the following functions:

- i) Measurement of the fault current value.
- ii) Comparison of the fault current with a reference value.
- iii) The RCCB should have a torroidal transformer witch has the main conductors of primary (P - N) which check the sum of the current close to zero.
- iv) All metal parts should be inherently resistant to corrosion and treated to make them corrosion resistant.
- v) It should be truly current operated.
- vi) It should operate on core balance torroidal transformer.
- vii) Its accuracy should be $\pm 5 \%$.
- viii) It should operate even in case of neutral failure.
- ix) It should trip at a present leakage current within 100 mA
- x) Its enclosure should be as per IP 30.
- xi) Its mechanical operation life should be more than 20,000 operations.
- xii) It should provide full protection as envisaged by IE rules - 61-A, 71 - ee, 73 - ee, 1985 and also rule 50 of IE rule1956.
- xiii) It should conform to all national and international standards like IS: 8828-1993, IS: 12640-2000. The RCA should be current operated and not on line voltage.

5. Workmanship

The D.B. shall be properly grouted in the wall in concealed manner taking care that the powder coating is not scratched and dents are not formed on the D.B. The MCBs and ELCBs. In the distribution boards shall

be fixed as per the circuit details provided. All the wires terminating in the MCBs and the ELCBs shall be lugged for proper contact and ferrules depicting the circuit nos shall be provided. D.B.s mounted in concealed manner shall have a groove around it so as to save the finish of the plaster and colour during future opening of the door. The distribution boards shall have circuit chart tagged on the door for future maintenance. Danger notice plates shall be fitted to the distribution boards with screws and not stuck so as to assure its presence for a longer duration.

LT & HT CABLES AND CABLE TERMINATION

1.1 L. T. XLPE Cable:

1.1.1 Specifications:

The medium voltage cables shall be supplied, laid, connected, tested and commissioned in accordance with the drawings, specifications, relevant Indian Standards specifications, manufacturer's instructions. The cables shall be delivered at site in the original drums with manufacturer's name, size and type clearly written on the drums.

All cables shall be adequately protected against any risk of mechanical damage to which they may be liable in normal conditions of handling during transportation, loading, unloading etc.

The cable shall be supplied in single length i.e. without any intermediate joint or cut unless specifically approved by the Engineer.

The cable ends shall be suitably sealed against entry of moisture, dust, water etc. with cable compound as per standard practise.

1.1.2 Conductor:

Uncoated, annealed copper, of high conductivity, upto 4 mm² size the conductor shall be solid and above 4 mm² the conductors shall be concentrically stranded as per iec: 228. The conductor shall be of copper for all cables up to & including 100A. Above 100A all cable shall be with Al. conductors.

1.1.3 Insulation:

Cross link polyethylene (XLPE) extruded insulation rated at 70oc. Cables for all life safety equipments including lifts shall be of FRLS grade.

1.1.4 Core Identification:

Two core	:	Red and Black
Three core	:	Red, Yellow and Blue
Four core	:	Red, Yellow, Blue and Black
Single core	:	Green, Yellow for earthing.

Black shall always be used for neutral.

1.1.5 Assembly:

Two, three or four insulated conductors shall be laid up, filled with non-hygroscopic material and covered with an additional layer of thermoplastic material.

1.1.6 Armour:

Galvanised steel flat strip / round strips applied helically in single layers complete with covering the assembly of cores.

For cable size upto 10 sq mm	:	Armour of 1.4 mm dia G.I. round wire
For cable size above 10 sq mm	:	Armour of 4 mm wide 0.8 mm thick GI strip

1.1.7 Sheath:

ST -2 PVC along with polypropylene fillers to be provided.

Inner sheath shall be extruded type and shall be compatible with the insulation provided for the cables.

Outer sheath shall be of an extruded type layer of suitable PVC material compatible with the specified ambient temp. of 50oc and operating temperature of cables. The sheath shall be resistant to water, ultra violet radiation, fungus, termite and rodent attacks. The colour of outer sheath shall be black.

Sequential length marking along with size and other standard parameters shall be required at every 1.0 mtr on the outer sheath.

1.2 11kv Cable

11 kv cable shall have cross linked, polyethylene insulated (XLPE) conforming to IS : 7098 (Part-2) – 1985 & shall be with aluminium conductor.

1.2.1 Armouring and Serving

All multicore cables liable for mechanical damage and all HV cables (irrespective of the situation of installation) shall be armoured. Where armouring is unavoidable in single core cables, either the armour should be made of nonmagnetic material, or it should be ensured that, the armouring is not shorted at terminations, thus preventing the flow of circulating currents therein.

Short runs of cable laid in pipes, closed masonry trenches and similar protected or secured enclosures need not be armoured.

PVC and XLPE cables, when armoured, shall have galvanised steel wires (flat or round) for armouring.

1.3 11kv Joints

The connectors shall be insulated and sealed with thick walled, heat shrinkable tubings and mastics. The armour or copper tape shielding shall be rebuilt with wraparound metal case or with copper mesh. Solderless earth connection shall be provided to the armour or copper shielding. The outer protection and sealing shall be done with adhesive coated heat shrinkable tubing. Obtain prior approval of Engineers/Consultant before any such jointing.

1.4 11kv Termination

Shall be done using heat shrinkable kit. The kit shall be resistant to breakage, vandalism and moisture seal shall be applied. The kit shall have ceramic stress control, insulation tubing and screening.

1.5 Cable Marking:

The outer sheath shall be legibly embossed at every meter with following legend:

ELECTRIC CABLE: 1100 V, SIZE :__C X __ MM² with Manufacturers name, year of manufacturing and ISI symbol.

1.6 Sealing Drumming and Packing:

After tests at manufacturer's works, both ends of the cables shall be sealed to prevent the ingress of moisture during transportation and storage.

Cable shall be supplied in length of 500 mtrs or as required in non-returnable drums of sufficiently sturdy construction.

Cables of more than 250 meters shall also be supplied in non-returnable drums.

The spindle hole shall be minimum 110 mm in diameter.

Each drum shall bear on the outside flange, legibly and indelibly in the English literature, a distinguishing number, the manufacturer's name and particulars of the cable i.e. voltage grade, length, conductor size, cable type, insulation type, and gross weight shall also be clearly visible. The direction for rolling shall be indicated by an arrow. The drum flange shall also be marked with manufacturer's name and year of manufacturing etc.

1.7 Cable Termination:

Cable terminations shall be made with copper crimped type solder less lugs for all aluminium cables and stud type terminals. For copper cables copper crimped solder less lugs shall be used.

Crimping shall be done with the help of hydraulically operated crimping tool.

For joints where by cable is with aluminium conductor and busbars are aluminium, bimetallic lugs shall be used with compound. CUPAL type of washers shall be used.

Crimping tool shall be used for crimping any size of cable.

1.8 Cable Glands:

Glands shall be double compression type for all cables terminating in panels located in plant rooms / parking areas / external i.e. landscape / terrace & for all cables above 120 sq mm size.

All other cables shall be with single compression glands.

1.9 Ferrules:

Ferrules shall be of self-sticking type and shall be employed to designate the various cores of the control cable by the terminal numbers to which the cores are connected, for ease in identification and maintenance.

1.10 Workmanship

Cables shall be laid in the routes marked in the drawings. Where the route is not marked, the Contractor shall mark it out on the drawings and also on the site and obtain the approval of the Engineer and/or Its Consultant before laying the cable. Procurement of cables shall be on the basis of actual site measurements and the quantities shown in the schedule of work shall be regarded as a guide only.

Bending of cables shall be in accordance with standards given by manufacturer and also space between 2 cables equivalent to diameter of the cable shall be maintained.

In the case of cables buried directly in ground, the cable route shall be parallel or perpendicular to roadways, walls etc unless marked on drawing by consultant. Cables shall be laid on an excavated, graded trench, over a sand or soft earth cushion to provide protection against abrasion.

Contractor shall submit complete voltage drop calculation analysis with necessary derations as per the length at site prior to ordering of the cables.

Cable markers shall be used to identify external underground cables / cable route. The markers shall be installed at max distance of 10mtr. Nylon pull wires shall be left in all pipes / hume pipes for first time and future pulling of cables. At start / end of the cables and also in between at every 30 mtrs max, cable markers of Al type shall be used.

All cables shall be full runs from panel to panel without any joints or splices. Cables shall be identified at end termination indicating the feeder number and the Panel/Distribution board from where it is being laid. Cable termination for conductors up to 4 sq. mm may be insertion type and all higher sizes shall have compression type lugs. Cable termination shall have necessary brass glands. The end termination shall be insulated with a minimum of six half-lapped layers of PVC tape. Cable armouring shall be earthed at both ends.

In case of cables entering the buildings, the sleeves /cutouts shall be laid in slant position, so that no rainwater may enter the building. Once the cables are laid, sealing of the sleeves / cutouts for fire and water safety, shall be done by others as per architectural details.

E) INTERNAL WIRING**1. SPECIFICATIONS****RIGID PVC AND FLEXIBLE PVC FRLS LHSFT CONDUITS:**

All conduits shall be rigid PVC alloy low in halogens pipe having minimum wall thickness of medium gauge 1.6 to 1.8 (MMS grade) approved by F.I.A. & I.S.I. and shall confirm to IS 9537 part 3 and complying with fire safety standards classification V-0. The temperature stability shall be from –20oc - +80oc and also shall be uV stabilised.

Flexible conduits shall be formed from a continuous length of spirally wound interlocked steel strip with a fused zinc coating on both sides. The conduit shall be terminated in brass adapters.

ACCESSORIES:

PVC conduit fittings such as bends, elbows, reducers, chase nipples, split couplings, plugs etc. shall be specifically designed and manufactured for their particular application. All conduit fittings shall conform to IS: 2667-1964 and IS: 3857-1966. All fitting associated with galvanized conduit shall also be galvanized.

WIRES:

All wires shall be single core multi-strand/ flexible copper or single strand Copper (if specified in BOQ), PVC insulated FR grade as per IS: 694 and shall be 660 V\1100 V.

All wires shall be colour coded as follows:

Phase	Colour of wire
R	Red
Y	Yellow
B	Blue
N	Black
Earth	Green (insulated)
Control (If any)	Grey
All off wires	Same as Phase wire

SWITCHES & SOCKETS:

Switches shall be modular type with silver-coated contacts. Sockets shall be 5 pins with switch and plate type cover. Combination of multiple switch units and sockets should be used to minimize the switch boxes.

For heavy duty, metal clad sockets with M.C.B / Isolator mounted in a galvanized steel box shall be provided.

SWITCH PLATE AND BOX:

Plates of the same make, as that of switches shall be used with the modular range. Also M.S. boxes shall be taken as switch boxes.

2. B. WORKMANSHIP

The size of conduit shall be selected in accordance with the number of wires permitted under table given below. The minimum size of the conduit shall be 25 mm diameter unless otherwise indicated or approved. Size of wires shall not be less than 1.0 sq.mm. Copper or 2.5 sq.mm. Aluminium.

Nominal Dia of wires	Nominal Cross sec. Area	20 mm		25 mm		32 mm		38 mm	
(mm)	(mm ²)	S	B	S	B	S	B	S	B
1/2.40	1.50	4	3	8	6	15	9	--	--
1/1.80	2.50	4	2	6	4	10	8	--	--
1/2.24	4.00	2	2	4	3	8	6	--	--
1/2.80	6.00	1	--	4	3	6	6	--	--
1/3.55	10.00	1	--	3	2	5	4	6	5

S - runs of conduits which have distance not exceeding 4.25 m. between draw boxes & which do not deflect from the straight by an angle more than 15 degree.

B - runs of conduits, which deflect, from the straight by more than 15°.

Conduits shall be kept at a minimum distance of 100 mm. from the pipes of other non-electrical services. And maintain minimum 300 mm distance between telephones, TV & Computer piping.

Separate conduits/raceways shall be used for:

Normal lights and 5 A 3 pin sockets on lighting circuit.

Separate conduit shall be laid from D.B. to switch board.

Power outlets - 15 A 3 pin 20 A/30 A, 2 pin scraping earth metal clad sockets.

Emergency lighting.

Telephones.

Fire alarm system.

Public address system & Music system.

For all other voltages higher or lower than 230 V.

T.V. Antenna.

Water level guard.

Computer Wiring

Wiring for short extensions to outlets in hung ceiling or to vibrating equipments, motors etc., shall be installed in flexible conduits. Otherwise rigid conduits shall be used. No flexible extension shall exceed 1.25 m.

Conduits run on surfaces shall be supported on metal 12 mm. thick G.I. pressure saddles which in turn are properly screwed to the wall or ceiling. Saddles shall be at intervals of not more than 500 mm. Fixing screws shall be with round or cheese head and of rust-proof materials. Exposed conduits shall be neatly run parallel or at right angles to the walls of the building. Unseemly conduit bends and offsets shall be avoided by using fabricated mild steel junction/pull through boxes for better appearances. No cross-over of conduits shall be allowed unless it is necessary and entire conduit installation shall be clean and neat in appearance.

Conduits embedded into the walls shall be fixed by means of staples at not more than 500 mm. intervals. Chases in the walls shall be neatly made and refilled after laying the conduit and brought to the finish of the wall but the building Contractor will do final finish.

Conduits buried in concrete structure shall be put in position and securely fastened to the reinforcement and got approved by the CLIENT AND/OR ITS ARCHITECT, before the concrete is poured. Proper care shall be taken to ensure that the conduits are neither dislocated nor choked at the time of pouring the concrete suitable fish wires shall be drawn in all conduits before they are embedded.

Where conduit passes through expansion joints in the building, adequate expansion fittings shall be used to take care of any relative movement.

Inspection boxes shall be provided for periodical inspection to facilitate withdrawal and removal of wires. Such inspection boxes shall be flush with the wall or ceiling in the case of concealed conduits. Inspection

boxes shall be spaced at not more than 12 meters apart or two 90° solid bends or equal. All junction and switch boxes shall be covered by 6 mm clear plate. These junction boxes shall form part of point wiring or conduit wiring as the case may be including the cost of removing the cover for painting and re-fixing. No separate charges shall be allowed except where specially mentioned.

Conduits shall be free from sharp edges and burrs and the threading free from grease or oil. The entire system of conduits must be completely installed and rendered electrically continuous before the conductors are pulled in. Conduits should terminate in junction boxes of not less than 32 mm. deep.

An insulated earth wire of copper rated capacity shall be run in each conduit.

Lighting & Power Wiring:

All final branch circuits for lighting and appliances shall be single conductor/ stranded/ flexible wires run inside conduits. The conduit shall be properly connected or jointed into sockets, bends, and junction boxes.

Branch circuit conductor sizes shall be as shown in the schedule of quantities and or drawings.

All circuits shall preferably be kept in a separate conduit up to the Distribution Board. No other wiring shall be bunched in the same conduit except those belonging to the same phase. Each lighting branch circuit shall not have more than ten outlets or 800 watts whichever is lower. Each conduit shall not hold more than three branch circuits.

Flexible cords for connection to appliances, fans and pendants shall be 650/1100 V grade (three or four cores i.e. with insulated neutral wire of same size) with tinned stranded copper wires, insulated, twisted and sheathed with strengthening cord. Colour of sheath shall be subject to the CLIENT AND/OR ITS ARCHITECT'S approval.

Looping system of wiring shall be used. Wires shall not be jointed. Where joints are unavoidable, they shall be made through approved mechanical connectors. No such joints shall be made unless the length of the sub-circuit, sub-main or main is more than the length of the standard coil.

Control switches shall be connected in the phase conductors only and shall be 'ON' when knob is down. Switches shall be fixed in 3 mm. thick painted or galvanized steel boxes with cover plates as specified. Cadmium plated brass screws shall be used.

Power wiring shall be distinctly separate from lighting wiring. Conduits not less than 25 mm. and wires not less than 2.5 sq.mm. copper shall be used.

Every conductor shall be provided with identification ferrules at both ends matching the drawings.

Testing: the entire installation shall be tested for:

Insulation resistance.

Earth continuity.

Polarity of single pole switches.

General: All the wiring switch board, outlet points shall be done in a concealed manner in wall & slab in PVC conduit of minimum 25 mm dia. (medium gauge) & with 650v / 1100v grade PVC insulated flexible copper conductor wire. The switches should be modular with moulded cover plates, blank plates for outlet boxes. The accessories, connectors, sockets, should be fixed with brass chrome / cadmium plated machine screw. For fan points the rates should be with hum -free type 300 W regulators as required to complete the point wiring. The wiring shall be as per IS: 732 and IS: 4648. The wiring shall be done in a looping manner so as to avoid junction boxes at any place. All the looping shall be done only in the switchboard and outlet points. The size of the wire shall be as per the specification. Colour code shall be strictly followed.

The size of wires shall as follow:

25-32 Amp. metal clad points:

Phase / Neutral	6.0 mm ²
Earth	4.0 mm ²

20 Amp. outlet points:

Phase / Neutral	4.0 mm ²
Earth	2.5 mm ²

Two nos. of 15 Amps. socket outlet connected in parallel
from DB to first outlet

Phase / Neutral	4.0 mm ²
Earth	2.5 mm ²

from first outlet to second outlet.

Phase / Neutral	2.5 mm ²

Earth 2.5 m m²

Light, fans, exhaust fan, 5 Amp. On board plug point, two way light points, bell point etc from switch to outlet.

Phase / Neutral 1 m m²

Earth 1 m m²

From D.B. to switch board – lighting / 5 A socket etc – i.e. circuit mains part of point wiring

Phase / Neutral 1.5 m m²

Earth 1 m m²

15/20 Amps. Socket outlet for AC / Geyser

Phase / Neutral 2.5 m m²

Earth 1.5 m m²

15/20 Amps. Socket outlet for appliances or looped from sockets with 4 sq mm ckt.

Phase / Neutral 2.5 m m²

Earth 1.5 m m²

Circuit mains of same phase shall be drawn in one pipe with prior permission/discussion with the consultant.

Separate phase, neutral and earthing wire of sizes recommended by consultant shall be drawn for each and every circuit main.

Mains for lighting and on board plug points shall be of one-size higher wires than those used in off.

The point definition shall be conducting and wiring from D.B. to S.B. and there from to final outlet point including switches and accessories, junction boxes, fan boxes, zarri work with cement –sand etc of approved make.

F) LIGHT FIXTURE AND FANS

1. Specifications

Light fixtures as per specs in the drawing of approved makes shall be installed. The fixtures shall be complete with ballast and shall be prewired by the manufacturer.

2. Workmanship

The fixture shall be installed on wall / ceiling as directed and as per manufacturer's instruction, with necessary accessories for surface, concealed, suspended from ceiling, bracket mounting etc. The job also includes connection of fixture with respective outlet point with heat resistant wires through heat resistance sleeve and PVC connector. Earthing shall be provided to the fixtures.

3. External Light Poles

4. Specifications

Street light poles, M.S. poles shall be as per the drawing given. The sections for the pipe shall be as shown in the drawing. The poles shall be welded properly and grinding shall be perfect to show smooth surface and stability shall be maintained. The light fixtures to be mounted above the poles shall be as specified in the BOQ. All the poles shall be treated with 2 coats of red oxide and after the putty and other works shall be spray painted with automotive category paints only. In case of powder coating 7 tank processes shall be adopted. The painting or the powder coating option shall be as per the BOQ.

5. Workmanship

All the light poles shall be brought to site and shall be stored in such a place so as to avoid rusting and brazing of the poles. The poles shall be erected as per the drawing and the top level of all the poles shall be similar. The poles shall be at right angle with the ground. Necessary civil works and spiral earthing shall be done as shown in drawing. No additional holes shall be drilled in poles at site for enabling the cable works. Poles with damage in colour or indentations shall be rejected and if Engineering in charge approves for damage in colour the same shall be finished at the site.

6. Mode of Measurement

The poles shall be measured in nos and the cabling for the same shall be measured in rmt.

Poles or external light fixtures shall be free from dents or flaking of powder coating until hand over. Damaged material shall be rejected / replaced as per consultants / EIC instructions.

G) CHEMICAL EARTHING

1. Earth Rod

The Earth Rod shall be mentioned in earthing schematic. Length of copper bonded steel rod shall be 10 feet of 32 mm dia.

The minimum copper bonding thickness is 250 microns.

Copper bonding on the steel rod is through Nickel interface.

Gives lowest possible resistance to ground also resist to corrosion.

It shall be molecularly bonded with copper to high strength steel cores.

The life of the earth rod shall be minimum 20 years.

Earth resistance of $< 3\Omega$ shall be achieved at farthest point for normal earthing & $< 1\Omega$ shall be achieved at farthest point for clean earthing.

2. Ground enhancing material

Necessary amount of GEM shall be used as soil tests as per site requirement & approval engineers.

3. Earth strips / wires

The earthing conductor (protective conductor from earth electrode up to the main earthing terminal/earth bus, as the case may be) shall be of copper / Al. of at least 98% conductivity confirming to I.S. 3043, and in the form of wire or strip as specified.

The size & material of earthing conductor and nos. of earth pits are as specified in drg. Though contractor shall confirm the same as per local CEIG dept. requirements & any changes required for the same is within scope of contractor.

4. Shop drawings / execution

The contractor shall be responsible to prepare shop drawings for routes of complete system along with necessary calculations before execution for approvals along with location of pits as per site condition. The drawings given by consultant are indicative and it shall be contractor's responsibility to achieve the necessary values for earthing. Contractor shall also incorporate necessary requirements as per local codes / approving authorities.

Following activities shall be carried out for the earthing station

Minimum 2 mt. center to center distance between two earth pits.

The bore should be minimum 10ft deep.

All earth pits of same category shall be interlinked with insulated cable.

The earth conductors (Cu. / Al.) inside the building shall be properly clamped / supported on the wall with Galvanized Iron clamps and Mild Steel Zinc Passivated screws / bolts. The conductors outside the building shall be laid at least 600 mm. below the finished ground level or as per site condition as approved by engineer.

The earth conductors shall either terminate on earthing socket provided on the equipment or shall be fastened to the foundation bolt and / or on frames of the equipment. The earthing connection to equipment body shall be done after removing paint and other oily substances from the body and then properly be finished.

For termination / connectors for the earth strip / wires; factory fabricated connectors shall be used. Braising and other local means for joining shall be not carried out. The connectors shall be tested as per BS EN 50164 : 2000.

H) LIGHTING ARRESTOR SYSTEM

GENERAL

The lightning protection system shall be of the enhanced type which is designed to attract lightning to a preferred point and safely convey the lightning energy to ground with minimal risk of side flashing via a predetermined route.

The complete lightning protection system will comprise the following key components.

- (a) Advanced lightning rod
- (b) Mounting support
- (c) High voltage shielded cable
- (d) Lightning Strike Recorder
- (e) Dedicated earthing system

THE LIGHTNING ROD

The advanced lightning rod shall be of a “Controlled Advanced Triggering” type and will respond dynamically upon leader activity in the near area.

The advanced lightning rod shall be configured as a spheroid which is comprised of separate electrically isolated panels surrounding an earthed central finial.

The insulation material used to electrically isolate the panels shall be comprised of a base polymer which provides high ozone and UV resistance with a dielectric strength of 24 – 38 KV/mm.

The external shape of the advanced lightning rod shall be such that it will limit the development of sharp point corona discharge under static thunderstorm conditions.

The upper section of the central finial shall be rounded to provide a blunt surface.

The upper section of the central finial shall be rated to withstand 200KA.

An air gap shall be provided between the individual electrically isolated panels (4 panels) and the blunt configured tip of the central rod. Dome shapes and pointed central rods will not be acceptable.

Arcing shall occur between the panel sections of the spheroid and the blunt configured finial tip only upon the progression of a lightning leader.

The advanced lightning rod shall have no moving parts and will have no dependence on external power supply or batteries. There should be no high impedance static drain unit between the central rod and the panels.

Under a normal atmosphere all components of the advanced lightning terminal shall be non-corroding.

The advanced lightning rod shall be installed at a minimum of 10 metres from the ground.

The advanced lightning rod shall be insulated from all surrounding points and features of the structure being protected.

The advanced lightning rod shall not be installed in a corrosive environment unless the manufacturers written approval has first been granted.

The advanced lightning rod shall be installed as per the manufacturer's instructions.

The advanced lightning rod shall not be of the ESE type and all lightning terminals claiming compliance to NF C17-102 shall not be considered suitable.

The advanced lightning rod shall have been tested to the following standard IEC 601:1989.

The lightning rod shall be shown to have withstood a minimum current impulse of a 180kA 8/20 μ s waveform as per the test standard IEC 60-1:1989.

MOUNTING SUPPORT OF LIGHTNING ROD

The mounting pole used to support the lightning rod shall be a circular insulating 170mm diameter tube at a minimum height of 2 metres. The pole will have an outside diameter of 68mm.

The mounting pole and supports shall be securely fixed with brackets and guy wires where required.

The down conductor shall pass through the centre of the insulating pole for the entire length of the pole.

HIGH VOLTAGE SHIELDED CABLE

4.1 The high voltage shielded cable shall consist of a core filler, stranded copper conductor, insulation material, outer copper conductor with external conductive sheath.

4.2 The main copper conductor within the high voltage shielded cable shall have a minimum cross sectional area of 50mm².

4.3 The outer diameter of the high voltage shielded cable shall be less than 38mm.

4.4 The high voltage shielded cable shall have a maximum inductance of 25 nH/m.

4.5 The main copper conductor shall allow for direct connection to the lightning rod through the use of a compression lug.

4.6 The high voltage shielded cable shall be fixed to the structure through the use of suitable saddles every two metres for the length of the cable route.

4.7 The high voltage shielded cable shall be installed as per manufacturer's instructions and shall not be subject to bends of less than 0.6 metres radius.

4.8 The high voltage shielded cable shall have been tested to the following standard IEC 60-1:1989.

- 4.9 The high voltage shielded cable shall have been subjected and successfully withstood a maximum voltage of 280kV in compliance to IEC test standard, IEC 600601, 2nd edition, 1989-11.

5.0 EVENT RECORDING DEVICE

- 5.1 All systems shall be installed complete with the lightning strike recorder.
- 5.2 The lightning strike recorder shall contain a mechanical 6 digit display which will register all lightning discharges with a sensitivity of 1500A 8/20 us peak current impulse.
- 5.3 The lightning strike recorder shall be housed in a IP 67 rated enclosure and will operate without reliance on batteries or an external power source.
- 5.4 The lightning strike recorder shall be installed as per the manufacturer's instructions.
- 5.5 It shall be shown that the event recording device has been successfully tested under test standard IEC 60-1:1989.

6.0 EARTHING

- 6.1 The earthing system shall incorporate the following individual components or a combination of the following – 25 x 1mm flat copper tape buried to a depth of not more than 800mm or by deep driven copper bonded steel core earth rods. All components of the earthing system shall be electrically connected to the central injection rod which is securely connected to the lower end of the high voltage shielded cable.
- 6.2 The earthing system shall be installed so that the final impedance reading does not exceed 10 Ohms unless otherwise stipulated by the lightning protection manufacturer or consulting engineer.
- 6.3 It is recommended that the earthing system is bonded to all structural reinforcing steel of the building, along with all connecting services.
- 6.4 The use of ground resistance improvement material shall be applied in order to reduce the resistivity levels of the earthing system.

I) TELEPHONE AND COMPUTER SYSTEM**2. SPECIFICATIONS****TELEPHONE CABLES AND WIRES:**

The type of cables and the services shall be as follows:

Indoor – Multipair PVC sheath armoured / un-armoured as specified 0.6 mm tin Cu. Cable.

Outside – Multipair PVC sheath armoured / jelly filled as specified 0.6 mm tin Cu. Cable.

All multi core cables and wires shall be of tinned copper conductor of not less than 0.6 mm dia and shall be colour coded twisted pairs with rip cord.

The conductor resistance shall be less than 150 ohms per KM and the insulation resistance between the conductors not less than 50 mega ohms and the nominal capacitance of about 0.1 microfarad per kilometre.

Cables laid underground or locations subject to dampness and flooding shall be filled with polyethylene compound and shall have sufficient protection against moisture and water ingress.

All armouring shall be of galvanized steel wires and protected against corrosion by an outer sheath of PVC in the case of indoor cables and polyethylene in the case of outdoor cables. Outer sheathing must be fire retarding and anti-termite.

All un-armoured single core cables and inner sheath of armoured cables shall be provided with ripcord.

TELEPHONE TAG BLOCKS:

The telephone tag blocks shall be suitable for the multi core telephone cables and shall have two terminal blocks, cross connect type. All incoming and outgoing cables shall be terminated on separate terminal blocks and termination shall be silver soldered. The cross connecting jumpers shall be insulated wires of same diameter and screw connected.

The tag blocks shall be mounted inside fabricated sheet steel boxes with removable hinged covers and shall be fully accessible. The enclosure shall be painted with 2 coats of red oxide and stove 172ntercoo.

TELEPHONE OUTLET SOCKET:

Telephone outlet socket shall be of the same make as that of the switches and accessories. The outlet sockets shall consist of 2 A 2 Pair polyethene connector in M.S.I / PVC boxes with switch plate of the same make as that of switches and telephone socket. The telephone outlet socket unless and otherwise specified shall be jack type and not pin type.

COMPUTER WIRES:

The computer wires shall be of 4 pair enhanced Cat 6 category and shall be of the makes as specified in the tender.

Characteristic	Min. Required Specification
Features	Category 6 Unshielded Twisted Pair 4 pair 100Ω cable shall be compliant with ANSI/TIA/EIA-568-C.2 Additional Transmission Performance Specifications for 4-pair 100Ω Category 6Cabling.
	Category 6 UTP cables shall extend between the work area location and its associated telecommunications closet and consist of 4 pair, 23 AWG, UTP.
	The 4 pair Unshielded Twisted Pair cable shall be UL® Listed
	ETL Verified 4-Connector Channel to ANSI/TIA-568-C.2 Category 6 and ISO/IEC 11801 Class E, along with channel illustration, and parts numbers.
Mechanical Characteristics	Construction: 4 twisted pairs separated by internal X shaped, 4 channel, polymer spine / full separator. Half shall not be accepted.
	Conductor Solid bar Copper
	Conductor Diameter 0.56±0.005mm (23 AWG)
	Insulation: High Density Polyethylene
	Jacket FR PVC
	Outer Diameter 6.1 mm nominal
	Temperature Range -20° to +70°C

COMPUTER DATA OUTLET SOCKETS:

The computer sockets shall be of e Cat 6 category and of the make specified in the tender. The sockets shall be installed in the plates of the modular switches range to be used. The sockets shall be crimped using crimping tool with the Cat 6 wire.

FLOOR RACEWAY:

Floor raceway of hot dip 174 intercoole / aluminium sheet of 14 g / 2.0 mm shall be used and the dimensions for the same shall be as per the BOQ. The raceways shall be as per the make specified in the tender. The raceways shall be free of any sort of welding edges or other sharp edges to protect cutting of wires during pulling. The raceways shall be laid with use of junction boxes fabricated from 14 g hot dip GI as per drawing.

B. WORKMANSHIP

All cables shall be on cable racks and neatly stitched together.

The connection at the tag blocks shall be silver soldered so as to achieve minimum contact resistance.

The final branch connections with single pair cables in conduits and the maximum number of cables in each conduit shall be as follows:

Conduit	diameter	Max. No. of cables
Inch	mm.	
¾"	20	2 Nos. single pair
1 »	25	6 Nos. Single pair
1¼ »	32	12 Nos. Single pair
1½"	40	18 Nos. single pair

The tag blocks shall be mounted inside fabricated sheet steel boxes with removable hinged covers and shall be fully accessible. The enclosure shall be painted with 2 coats of red oxide and stove 174ntercoo.

J) UPS**Scope**

The present special contract specifications constitute a call for best offers for the supply of:

Uninterruptible Power System(s) (hereinafter referred to as UPS) rated at 3 X 40kVA, 3 X 20KVA and 2 x 15KVA featuring NiCad batteries housed in one or more external racks/cubicles and providing a minimum autonomy as defined under "Batteries" herein.

The present specifications contain minimum requirements. All offers must be completed strictly in accordance therewith, either by confirming data or by filling in the spaces provided, where requirements are not met.

Any deviations or exceptions to the minimum requirements must appear in the offer.

Where no exceptions are shown, the requirements of the present specifications will be considered as accepted.

RELEVANT REFERENCE STANDARDS

The choice of materials and components, engineering developments and the construction of the equipment must comply with current directives and standards.

The UPS will have a CE mark as specified by Directives 73/23, 93/68, 89/336, 92/31 and 93/68.

The UPS will be designed and produced according to the following specifications:

- IEC/EN 62040-1-1 “General and safety requirements for UPS used in operator access areas.”
- EN 62040-2 “Electromagnetic compatibility (EMC) requirements”
- IEC/EN 62040-3 “Performance requirements and test methods”

Design Specifications

The Uninterruptible Power System (UPS) will include the following operational components:

- Full IGBT Rectifier/battery charger
- IGBT Inverter
- Maintenance bypass switch
- Static switch
- Batteries.

IGBT Rectifier/Battery charger

The IGBT Rectifier/Battery charger will have an input isolating switch and a PWM digital vector control system (DSP based) which, in addition to normal functions (AC/DC conversion), will automatically correct the input power factor to a value > 0.99 and limit the harmonic rejection to the mains at a THDI value $< 3\%$ at full output load, and a THDi value $< 7\%$ for any other condition.

For the battery charger function, this converter will include built-in fuses and a control circuit for the voltage and battery recharging current. The ripple current to the batteries will be less than 0.05 C10. A microprocessor control function will perform the following operations:

- Test the battery by automatically performing a partial battery discharge at weekly intervals or at intervals defined by the user
- Adjust battery float voltage as a function of ambient temperature
- Calculate the remaining battery autonomy time during discharge
- Automatically compensate battery shutdown voltage as a function of the time for prolonged discharges.

IGBT Inverter

The IGBT inverter will have a PWM digital vector control system (DSP based), capable of converting DC voltage from the IGBT rectifier or battery into AC voltage. A rated output filter will create an output voltage sinusoidal envelope.

The control circuit, in addition to normal functions, will automatically adjust nominal output power in accordance with ambient temperature.

Inverter should be able to deliver full active power at Unity power factor (KVA=KW)

4.1 UPS compatibility to Load Power factor

UPS should support the full Power factor range (Lagging & leading) of load without any deration in power rating

5.0 Static bypass switch

The static bypass switch will feature a separate power input and will consist of the following:

- Static switches (SCR type), which can support overloads and short circuits downstream of the UPS
- A back feed detection circuit as specified by IEC/EN 62040-1-1, clause 5.1.4
- A bypass and maintenance bypass input isolating switch with auxiliary indicator contact
- An output load switch.

The control logic will be handled by digital algorithms (using vector control techniques), similar to those used for the rectifier and the inverter. The static bypass shall be equipped with a back feed protection device compliant with clause 5.1.4 of IEC/EN 62040-1-1; and a relay signal contact for the control of the external back feed isolator to be installed on the bypass line upstream from the UPS.

6.0 Batteries

The VRLA, WET or NiCad batteries will feature an enclosure made of self-extinguishing material.

The batteries will be housed in one or more racks/ cubicles and will be protected by fuses located on each pole and via a dedicated switch.

OPERATING MODES

This section describes the different operating modes of the Uninterruptible Power System.

The UPS, using the above-mentioned digital vectorial control (DSP system), will be able to operate both in double conversion and digital interactive modes.

The operating mode may be factory set by the manufacturer during testing or by the customer using the appropriate diagnostic and control software.

The IGBT inverter will be synchronized with the bypass line so that the load can be transferred from the inverter (conditioned line) to the bypass supply (direct line) and vice versa without any break in the supply to the load.

In all operating modes, the battery charger will provide the power necessary to keep the battery fully charged.

Double conversion operation

In this operating mode, under normal service conditions, the load will always be supplied from the inverter, guaranteeing maximum protection for the load.

Upon failure or reduction of the primary AC source, the load will be supplied by the battery through the inverter. During this phase, power will be drawn from the battery. Visible and audible signals will alert the user to this operating state. The remaining autonomy time will be calculated by a diagnostic algorithm.

Upon return of the primary AC source to within tolerance limits, the Uninterruptible Power System will recommence operating in normal mode.

In the event of an inverter overload, manual stop or failure or temporary overload downstream of the UPS, the load will be automatically transferred to the bypass supply source without interruption.

In the event of an overload with an unsuitable supply, the Uninterruptible Power System will not transfer the load but will continue to supply it from the inverter for a period of time dependent upon the extent of the overload and the characteristics of the UPS.

The user will be alerted of these anomalous operating conditions via the alarm.

Digital interactive mode

In this operating mode, under normal service conditions, the load will always be supplied from the direct line through the bypass static switch. The quality of the direct line will be monitored constantly using algorithms operated in real time by the DSP control system.

If the direct line is outside the permitted tolerances, the load will be automatically transferred to the conditioned line (inverter) without interruption.

In the absence of power supply to the direct and conditioned lines, the battery will supply power to the loads through the inverter. During this phase, power will be drawn from the battery and the battery charge will be reduced. Visible and audible signals will alert the user to this operating state. The remaining autonomy time will be calculated by a diagnostic algorithm.

When the quality and reliability of the direct line return within permitted limits, the UPS will automatically start supplying the load from the direct line.

Maintenance bypass switch

The UPS will be equipped with a bypass switch capable of transferring the load to the bypass supply without interruption so as to enable the UPS to be switched off and isolated for maintenance operations. The supply to the load will be maintained.

Controls and diagnostics

The controls for the electronic power supply modules will guarantee the following:

- A three-phase power supply which is ideal for the load
- Controlled battery recharging

Minimum harmonic rejection to the upstream mains power supply (THDi<3% at full load, THDi<7% in any other condition).

The UPS will feature a digital vector control based on a DSP (Digital Signal Processor).

The special DSP algorithms must be designed to ensure rapid and flexible processing of the detected data, allowing rapid generation of controlled variables. It must also be possible to run the control for the electronic inverter devices in real time to:

- Improve short-circuit behavior (300% In for 10 ms, 150% In up to 5 s)
- Have a 179ntercooler179 (precise phase) angle between UPS output and bypass network, in the event of mains voltage distortion
- Highly flexible parallel operation.

Microprocessor control and diagnostics

Operation and control of the UPS should be provided through the use of microprocessor-controlled logic. Indications, measurements and alarms, together with battery autonomy, will be shown on a graphic liquid crystal display (LCD). The procedures for start up, shutdown and manual transfer of the load to and from bypass will be explained in clear step-by-step sequences on the LCD display.

Warning/fault: this page contains information regarding various anomalies concerning power converters such as the bypass, rectifier, inverter and booster/charger. In addition to this there is also warning and fault information relating to the battery and the load.

Events log: displays the date and time of important UPS events, alarms and other warnings.

Measurements: this page holds the full set of measurements for each functional block (rectifier, bypass, booster/charger, batteries, inverter and load).

Battery: displays the battery status/values including temperature, cell voltage, capacity and run time as well as commands for allowing the user to configure battery testing.

Tools: this page allows users to customize the settings of the LCD display and to select the desired language, choosing between 15 languages.

Controls

The UPS will be provided with the following controls:

- Inverter start
- Inverter stop

- Reset faults
- Buzzer/mute alarm

Measurements

The UPS will provide the measurements (voltage, current and frequency) for every single internal functional block and this information will be directly accessible on the display, via the measurements button.

Signals and alarms

The UPS must provide signals and alarms for every single functional block. These signals must be directly accessible via the display, by clicking the warning and fault button.

The UPS will also:

- Clearly display, upon mains failure, the remaining battery autonomy which will be a function of battery status and charge (discharge curve, degradation, operating temperature, etc)
- Have three serial RS232 ports for compatibility and communications with special peripheral units and for remote connections
- Be able to support remote graphic measurement and 180ntercool software
- Be able to interface with a network monitoring system using SNMP slot-in cards
- Provide a Tele-monitoring function (see description under section 6.0 “Tele-monitoring”)

A voltage-free input will also be provided to disable the static switches and all power converters (EPO) in case of emergency.

Programmable I/O contacts (at least 4 voltage-free outputs and 2 inputs).

TELEMONITORING

This section defines the requirements of the system for remote monitoring and control from the Service Centre.

Monitoring and control from service centre

The system will be capable of analysing UPS operation and electrical supply in order to identify faults and thus prevent the occurrence of conditions likely to damage the equipment protected by the UPS.

The system will guarantee single or parallel UPS surveillance, 24 hours a day for 365 days a year by 181ntercoole technical personnel operating remotely. The system will provide a detailed, preventive analysis of connected UPS, without any of the disruption associated with an on-site visit.

The Tele-monitoring system will offer the following main features:

- Continuous monitoring and control of the performance of end-user UPS
- Bi-directional communications between end-user UPS, Authorised Service Centre and its 181ntercoole field service engineers
- Automatic location of Service Engineers in the event of anomalous UPS functioning (even at night and during public holidays)
- Possibility of using graphic software for remote in-depth analysis and control
- Periodic reports on UPS performance with advice from Service Centre engineers.

7.0 UNINTERRUPTIBLE POWER SYSTEM**TECHNICAL DATA SHEET**

PARAMETERS	UNIT	SPECIFICATION	VENDOR CONFIRMATION
Inverter input characteristics			
Nominal voltage	(V)	400 V 4wire	
Tolerance on voltage	(%)	-15%,+20% @100% load	
Nominal frequency (60 Hz selectable)	(Hz)	50	
Tolerance on frequency	(%)	± 10	
Input power factor @ 100% load		>0.99	
Total harmonic distortion (THDi) @ full load	(%)	< 3	
Walk in /Soft start	(Sec)	10 (1 to 90 selectable)	
Rectifier Hold OFF (Sec)	(Sec)	10 (1 to 180 selectable)	
Inverter output characteristics			
Nominal voltage (380/415 selectable)	(V)	400 V 4wire	
Nominal frequency (60 Hz selectable)	(Hz)	50	
Nominal power @ 40°C	(kVA)	200	
Nominal Power @ 40°C	(kW)	200	
Automatic adjustment of nominal output power as a function of temperature	(%)	@25 °c = 110%	
	(%)	@30 °c = 110%	
	(%)	@40° c = 110%	
Output voltage stability in steady-state condition for input within permitted limits and load variations from 0 to 100%	(%)	±1%	

PARAMETERS	UNIT	SPECIFICATION	VENDOR CONFIRMATION
Stability in dynamic conditions for 100% load step variations	(%)	±5%	
Load crest factor without derating		3:1	
Output voltage distortion with 100% linear load	(%)	<1	
Output voltage distortion with non-linear load as specified by IEC/EN 62040-3	(%)	<3	
Output frequency stability in synchronization with mains ($\pm 2 \pm 3 \pm 4$ selectable)	(%)	±1	
Output frequency stability with internal clock	(%)	±0.1	
Frequency slew rate	(Hz/sec)	<1	
Permitted overload:			
for 10 minutes	(%)	125	
for 60 seconds	(%)	150	
Short circuit current:			
300% In	(ms)	10	
150% In	(s)	5	
Characteristics of electronic static changeover switch			
Nominal voltage (380/415 selectable)	(V)	400	
Tolerance on voltage (± 5 , ± 15 selectable)	(%)	±10	
Nominal frequency (60 Hz selectable)	(Hz)	50	
Tolerance on frequency ($\pm 2 \pm 3 \pm 4$ selectable)	(%)	±1	
UPS characteristics			
Maximum UPS cabinet dimensions WxHxD	(mm)		
Noise level measured @ 1 meter and @ 100% load according to ISO 3746	(dBA)	70 dba	
AC/AC efficiency – double conversion mode @ 100% load (inbuilt K13 iso. Transformer)	(%)	94.5	
Efficiency in digital interactive mode @ 100% load	(%)	98	
EMC compatibility as per EN 62040-2		Class C3	
Degree of protection		IP 20	
Frame colour		RAL 7021	

The constructional and functional characteristics of UPS must be in line with the state-of-the-art technology in this field.

The supplying company must be able to provide proof that it is ISO 9001-2000 and ISO 14001 certified for design and manufacturing and for the provision of services.

The UPS will be guaranteed for one year during which time the Supplier will provide technical assistance.

The offer must include:

- a draft maintenance contract providing for 24 hour service with guaranteed minimum service call response time of 4 hours (references are required)
- the addresses of all Service Centres, divided according to geographical areas, and the number of engineers working for each centre
- Indication of main Tele-monitoring installations in operation.

K) DIESEL GENERATOR SET WITH ACOUSTIC CANOPY

GENERAL:

SCOPE:

- 1.1 This general specification together with the equipment sheets and attachments defines the minimum requirements the design, performance, inspection, testing and supply diesel engines for general industrial purposes.
- 1.2 The construction, design and rating of the diesel engine shall meet fully, the requirements of the specified driven machine and the Vendor shall select and provide the requisite ancillaries and controls with the diesel engine for its safe and satisfactory operation.
- 1.3 No deviations or exceptions from this specification shall be permitted without the written approval of the purchaser. Intended deviations supported by reasons there of shall be separately listed by the vendor and submitted with the bid for the consideration of the Purchaser.
- 1.4 Compliance with this specification shall not relieve the vendor of the responsibility of furnishing equipment and accessories of proper design, materials and workmanship to meet the specified operating conditions.
- 1.5 This general specification supplements the specific requirements contained in the attached equipment data sheets. In the event of any contradiction between the two, the information contained in the latter shall govern.
- 1.6 Other attachments of the Material Requisition from a part of this specification.
- 1.7 TERMS AND DEFINITIONS:**
 - 1.7.1 The Net Calorific value of fuel is defined as the heat resulting from the complete combustion of a unit quantity of fuel oil and air, without condensation of the water vapor. A net calorific value of 9,720 Kcal/Kg (As per IS: 1460 Rev.2) shall be considered while declaring the fuel consumption and for testing purposes.

- 1.7.2 The unit of horse power as defined in this specification is the metric horse power equivalent to 4,500 n-Kg/Min. The horse power in F.P.S. system is equal to 1.014 metric horse powers.
- 1.7.3 Other terms used in this specification or in the equipment data sheets are as defined in the latest edition of British Standard-5514.

STANDARD OPERATING CONDITIONS:

The standard operating conditions shall be defined in the latest edition of B.S.-5514 unless otherwise mentioned specifically in the equipment data sheet.

RATED POWER OUTPUT AND SPEED:

- 3.1 The diesel engine rating shall be the net output in brake horse power, which the engine is capable of delivering continuously at the stated crank shaft speed under the conditions specified under Clause 2.0 above, provided the engine is maintained in good operating condition and is serviced / overhauled regularly as per the schedules laid down by the Manufacturer.
- 3.2 No negative tolerance shall be allowed on the diesel engine rating specified by the Vendor in the equipment data sheets.

The engine shall be capable of satisfactorily providing an output 10 percent in excess of the continuous rating defined above, at the same speed for one hour in any period of 12 hours consecutive running.

The normal power requirement of the engine driven radiator fan or the coolant pump and the battery charging dynamo shall be clearly stated for the engine which is so equipped.

Unless otherwise specified in the equipment data sheets, the site rating of the engine shall be worked out considering the duration's specified under the latest edition of B.S.-5514 and the power absorb by all the engine driven ancillaries shall also be deducted.

DESIGN & CONSTRUCTION:

4.1 GENERAL:

- 4.1.1 The Diesel engine offered shall be of the regular production models of the manufacturer for industrial applications and already type tested either at the manufacturer's works or outside. The type test report shall be furnished to the purchaser for his review if so desired.

In case the proposed engine model has not been type tested, vendor shall furnish with the offer, a reference list of its existing industrial installation and at least three of these engines, should have completed, 5,000 hours of running at site.

- 4.1.2 Unless otherwise specified in the equipment data sheets, the diesel engine shall be provided with class A2 governing as per the latest edition of B.S. 5514.
- 4.1.3 The “Cyclic irregularity” of the diesel engine for direct coupling to an electric generator, “angular deviation of p_{73} A.C. generators “ driven by diesel engine for parallel operation, and the “engine governor speed droop characteristics “, shall be restricted to the values specified under the latest edition of B.S.-5514.
- 4.1.4 In case diesel engines are required to drive generators in parallel, the governor fuel injection pumps provided should have identical characteristics and the speed-load curves shall be made available to the purchaser’s inspector for his scrutiny and approval prior to load testing. The vendor shall maintain proper record for such curves to ensure additional diesel engines if required in future with identical characteristics, could be made available to the purchaser. A set of the said curves shall also be furnished to the purchaser.
- 4.1.5 The vendor shall be responsible for carrying out torsion analysis of the dynamic system as specified in the latest edition of British Standard-5514. The results in the form of a report shall be submitted to the purchaser for scrutiny and reference, if desired.
- 4.1.6 Vendor shall provide the flexible exhaust connection /s to connect the engine exhaust to the exhaust piping. The required size of the exhaust piping should be clearly specified by the Vendor.
- 4.1.7 If specified, the common base plate for mounting the diesel engine and the driven equipment as well as the flexible coupling, shall be supplied by the vendor.
- 4.1.8 Vendor shall indicate in the bid, the ISO Noise Level rating of the diesel engine with the offered exhaust silencer/s.

4.2 ENGINE STARTING:

- 4.2.1 Diesel engines shall be capable of starting without the use of cold starting aids so long the ambient temperature at the site is not below 4 oC. The vendor shall provide suitable cold starting

aids with diesel engine for quick starting below 40C of ambient and such aids shall be clearly detailed out along with the offer.

- 4.2.2 Where the diesel engine is specified / offered with battery starting arrangement, the starter motor shall be capable of starting the engine without having to disengage the driven machine with the help of a clutch. Where the diesel engine is equipped with a dual starter the synchronizing switch and the corresponding wiring / connection with the starter motor shall be provided by the vendor.

In case of diesel engines driving fire water pumps, besides the engine mounted dynamo and voltage regulator, the Vendor shall also provide automatic battery charging equipment suitable for taking power from an alternating current power source and mounted on a free standing type of a panel.

The battery charger if specified in the equipment data sheet, shall be capable of delivering a current equal to 100 percent of the 20 hour discharge rate of the battery and also equipped with charging rate selector device.

- 4.2.3 Where the diesel engine is specified / offered with compressed air starting, the Vendor shall also provide the air compressor driven by a diesel engine / electric motor and equipped with necessary instruments and controls as specified in the equipment data sheets.

The air receiver supplied by the vendor shall provide batteries and battery charging equipment (see clause B. above) for operating the electrical controls of the diesel engine.

- 4.2.4 If as specified in the data sheets, the diesel engine is required to start / stop automatically, the vendor shall provide the necessary controls (automatic-cum-manual) in the engine panel and the interconnecting wiring and piping from the panel to the engine and starting equipment. A pilot lamp shall be provided in the line side of the starting equipment circuit to indicate that the controller is in the automatic position. In the event the engine does not start after three attempts have been made, the controller shall stop all further cranking and operate the audiovisual alarm. A.D.C. motor driven per lubrication pump with timer suitably interlocked with the starting system shall be provided by the vendor. Whenever the unit is arranged for automatic shut down, a running period time set for a specific time interval, and shall be provided.

4.3 ENGINE COOLING:

- 4.3.1 When radiator cooled engines are offered, the diesel engine shall be provided with a radiator for mounting on the common base plate, complete with the suction / blower fan, temperature control valve and a radiator guard.
- 4.3.2 Where the engine cooling is achieved by closed circuit cooling water system, the vendor shall provide the complete jacket water (primary water) circuit, heat exchanger with the make-up tank and its piping, as well as the raw water (secondary water) circuit including but not limited to the following:
 - 4.3.2.1 Raw water pump with driver, unless the raw water is required to be obtained from the discharge of the pump driven by the diesel engine.
 - 4.3.2.2 Raw water piping (prefabricated) and fittings, as specified in the equipment data sheets.
 - 4.3.2.3 Instruments and controls as specified in the equipment data sheets.

4.4 ENGINE FUEL SYSTEM:

- 4.4.1 A fuel float (surge) tank if recommended by the manufacturer, shall be supplied with the diesel engine along with its interconnecting piping / hoses.
- 4.4.2 The daily service fuel tank shall be equipped with as air breather, shielded level gauge, strainer and a hand hole of not less than 150 mm diameter, besides the required fuel connections and a drain plug. The capacity of tank shall be as specified in the equipment data sheets.
- 4.4.3 The inside surfaces of the fuel tank and the float tank shall be coated with Enamel Red or Black of I.C.I. or its equivalent and the outside surface to be given two coats of the oil resistant primer paint. Both the fuel tank and the float tank, shall be hydrostatic tested at a pressure not less than 0.35 kg /Cm².

5.0 INSPECTION & TESTING:

- 5.1 The inspector representing Purchaser shall have entry to the plant while and wherever work for the equipment is being performed.
- 5.2 The vendor shall have the responsibility of providing purchaser's inspector with all requisite facilities / equipment for carrying out satisfactory testing.

- 5.3 The diesel engines shall be tested in the presence of purchaser's inspector in accordance with the latest edition of B.S. -5514 or any other equivalent standard as agreed to with the purchaser before the finalization of order.
- 5.4 The routine load and fuel consumption test shall be of the following duration :
- 5.5 Unless otherwise specified, 10% overload provision shall be kept while setting the fuel stop for the site running.
- 5.6 The hydrostatic test certificates for the heat exchanger / Intercooler , fuel tanks and other pressure vessels shall be furnished to the purchaser's inspector for his review and approval at the time of load testing of the diesel engine.
- 5.7 The engine control panel/s after assembly and wiring, shall be functionally tested in the presence of the purchaser's inspector.

6.0 PREPARATION FOR SHIPMENT:

- 6.1 Immediately upon completion of all tests and inspections, all exposed machined surfaces shall be cleaned and coated with a suitable rust preventive by the vendor and the un-machined surface shall be painted by at least two coats of red oxide primer.
- 6.2 Diesel engines shall be transported assembled as far as possible.
- 6.3 All untapped opening shall be provided with 4mm thick metal closures with full rubber gaskets and bolted by not less than 4 bolts. All connections including those for instruments, instrument leads, lubricating oil and the like shall be identified with securely attached tags indicating the type of connection, the instrument or the line description as applicable.
- 6.4 The equipment shall be crated for domestic / export shipment as specified in the data sheets considering for storage at job site for at least 6 months. Lifting load-out, and handling instructions shall be securely attached to the exterior of the largest packing in a well marked weather proof container. Upright position lifting points, weight (including packing and dimensions shall be clearly identified with item no., serial no., package no., and the names of the equipment.)

7.0 PROPOSAL:

- 7.1 Proposals shall be accompanied with completely filled in Data Sheets. The vendor shall not use his own data sheets.
- 7.2 The proposals must include either a specified statement that all equipment is in accordance with the purchaser's specifications or exceptions, if any, to this general specification including attachments shall be clearly brought out by the vendor on separate sheets, supported with suitable reasons thereof for the consideration of the purchaser.
- 7.3 Additions or exclusions from the scope of supply shall be clearly brought out on separate sheets giving reasons for such deviations for the purchaser's approval.
- 7.4 Rating (HP) curves for the diesel engine for different duties and their interpretation as per the applicable standard, shall accompany the proposal.
- 7.5 The drawings and data as listed under "prints with Quote" on the vendor data requirement sheet attached with this specification shall be provided.
- 7.6 The vendor shall also submit a separate proposal for carrying out supervision of the installation and commissioning of diesel engine/s offered indicating per item rates, no. of specialists proposed to be deputed, completion time and a list indicating nature and quantity of consumable/ tools required and any other terms.

8.0 SCOPE:

- 8.1 This specification define the requirements of design, manufacture, testing and supply of self excited emergency generator complete with automatic voltage regulator, control panel, generator breaker and other accessories as specified in the material requisition.
- 8.2 Unless otherwise specified the emergency generator shall be supplied complete with
 - a) Brush less excitation system complete with AVR.
 - b) Electric panel including control cubicle and associated auxiliary devices, relay panel and generator breaker battery and charger (unless otherwise specified).
 - c) Air inlet and outlet for generator cooling (inlet shall be oriented to suit local plant layout).
 - d) Lifting arrangement for the machine.
 - e) Foundation frame complete with foundation bolts and base frame.
 - f) Lube oil system integral with the prime mover lube oil system.
 - g) Spares for commissioning
 - h) Spares for two years of operation and maintenance.

Any other part / accessories not specifically mentioned above but considered necessary for safe and reliable operation.

9.0 CODES AND STANDARDS:

Unless they are in variance with the clause of this specification the diesel engine driven generator and their components shall comply with the latest edition of the applicable standards listed below:

IS : 22534 Designation for type of construction and mounting arrangement of rotating electrical machines.

IS: 46914 Degree of protection providing by enclosures of rotating electrical machinery.

IS: 47284 Terminal marking of rotating electrical machines.

IS: 71324 Guide for testing 3 Ph. Synch. Machines.

IS: 54224 Turbine type generators.

IS: 48894 Methods of determination of efficiency of rotating electrical machines.

IS: 12714 Insulating materials for Electric machinery and apparatus in relation to their thermal stability service, classification of

IS: 47224 Specification for rotating electrical machines.

IS: 25164 A.C. Circuit breakers.

Other codes shall be: AS2789, BS4999, BS5000, DIN6271, EGSA101P, IEC34/1, IS4722, ISO3046/1, ISO8528, NEMAMG1-22, SAEJ1349.

10.0 PERFORMANCE REQUIREMENTS:

10.1 Operative Conditions:

Generators shall be suitable for operating satisfactorily in humid and corrosive atmosphere found in pump house. Service conditions shall be as specified in the data sheet. The generator shall operate satisfactorily under sudden load application. Generator rating indicated in the data sheet shall be the net output of the set after accounting for all auxiliaries for the prime mover and generator.

10.2 Transient Voltage performance

The dip or rise in system voltage load variations is dependent on the leakage voltage drop of the machine which shall be kept to the minimum.

In case of sudden application of full load at rated power factor the voltage drop shall not exceed 15% of the rated voltage. The rated voltage shall be restored within 0.5 to 0.8 second depending on the size of the machine.

10.3 Voltage Regulation

The voltage regulation of the machine shall be within $\pm 2\%$ of the nominal voltage under following conditions:

- a). Between no load and nominal load with p.f. of 0.8 lag to unity.
- b). With the machine cold or warm.
- c). At a speed drop of approximately 3% of the nominal speed.

10.4 Voltage setting range:

The generator terminal voltage shall be adjustable with a continuously variable potentiometer. The adjustment range shall be $\pm 5\%$ of the nominal voltage with a possible extension to $\pm 10\%$.

10.5 Harmonic Content

The maximum permissible deviation from the sine wave shall be 5%. The harmonic content of the voltage shall be less than 3% measured between phases off load and up to nominal rating for a power factor of 0.8 lag to unity and with symmetrical distortion free consumers in circuit.

10.6 Frequency limits

The Generator shall be suitable for continuous operation at rated load for frequency variation of $\pm 3\%$ of rated value in addition the vendor shall furnish the short time under-frequency operating limits.

10.7 Overloads:

The generator shall be capable of withstanding without injury the effect of a 10% overload for one hour and 50% overload for one minute.

10.8 Short Circuit Conditions:

The generator shall be capable of withstanding without damage, a three phase, a line to line, line to earth or two line to earth short circuit for a period of 3 seconds when operating at rated speed and with an excitation corresponding to 5% over voltage at no load.

10.9 Parallel operation:

Generator sets shall be suitable for parallel operation amongst themselves, or with other generating sets or with other sources (Grid supply) at operating voltage and under load conditions up to rated value. The set shall be provided with Electronic governor system.

10.10 Excitation support system

Excitation system shall be provided with short circuit support equipment (Series compounding) to maintain three times the rated current for three seconds in case of short circuit to ensure proper fault clearance in outgoing feeders.

11.0 DESIGN AND CONSTRUCTION:

- 11.1 The generator design shall meet the requirement specified in data sheet and shall be suitable for the site conditions specified therein.
- 11.2 The generator shall be mounted on a common base frame together with the prime mover unless otherwise agreed. The generator shall be provided with necessary lifting hooks and two earth terminals for connection to main earth grid.
- 11.3 The generator winding shall be class “F” insulation with temperature limitation for class “B” the windings and overhangs shall be braced to withstand the short circuit forces. For machines rated 1000 KW and above shall have six no. RTDs suitably distributed in stators winding.
- 11.4 The stators windings shall be brought out to six insulated terminals in two separate terminal boxes. The alternator shall, therefore, be provided with three separate terminal boxes i.e. for the line and neutral stators connections and for control connections. The terminal box for the line terminals shall have sufficient space for the termination of cable size specified in data sheet. The neutral box shall in addition to space for neutral earthing cable have sufficient room for current transformers used for protection of generator. Star connection shall be formed in the neutral side terminal box. The terminal box for control cables shall contain properly marked terminals for all internal equipment e.g. embedded temperature detectors etc. All terminals shall be stud type. The terminal boxes shall be complete with lugs and double compression cable glands. Current transformers shall be as specified in data sheet.

- 11.5 All parts and accessories shall be suitable to withstand stresses due to over speed / overload / short circuit conditions specified.
- 11.6 Bearings shall be double shielded and relubricated. Grease in the bearing enclosure shall provide additional lubrication to bearing as well as provide sealing against dust and moisture.
- 11.7 The generator shall be air cooled unless otherwise agreed generator enclosure shall be as specified in data sheet.
- 11.8 The direction of rotation of the rotor of the machine shall be compatible with that of the prime mover. A clear indication of the direction of rotation shall be given on either end of the machine.
- 11.9 Space heaters shall be installed within the enclosure, location and max. surface temperature of the heaters shall be such that no damage can be caused to any insulation. Heaters shall suitable for operation on a single phase 240V AC supply unless otherwise specified.
- A suitable double pole switch shall be mounted on or adjacent to the stators frame or enclosure for the manual switching off of the heaters.
- 11.10 Field winding shall have class “F” insulation with excellent electrical and mechanical properties. The field winding shall be capable of operating at a field voltage of 125% of rated load field voltage for at least one minute starting from stabilized temperatures at rated conditions.
- 11.11 All cabling on the generator set skid shall be in GI cable trays/ conduits. All cables shall be identified close to their termination point. Double compression type cable glands shall be used for cable termination.
- 11.12 A rating plate of corrosion resistant material shall be fixed on the generator frame and shall give the following information:
- Manufacturer’s name.
 - Serial Number, Type and frame reference
 - Rated output in MVA & MW
 - Rated power factor, frequency and voltage
 - Rated stators current and speed in Rev. / Min.
 - Class of insulation
 - Phase rotation (CW or CCW)
 - Customer’s indent no.
 - Year of manufacture
 - Weight rotor and stators in KG.

12.0 EXCITATION SYSTEM:

The generator shall be provided with brush less type solid state excitation system with automatic voltage regulator. The excitation system shall include the automatic voltage regulator, AC exciter and rotary rectifier. The field of the exciter shall be fed from the stators winding through a suitable transformer and AVR. AC Voltage generated in the AC exciter shall be rectified by the rotary rectifier assembly and fed to the main field circuits. The rotor windings of the AC exciter, the rectifier assemble, main field winding of the generator and other accessories on rotor part shall be rigidly fastened to the shaft and the connection with different items shall be anti-loosening type.

The exciter capacity shall be at least 20% more than the maximum requirement at any time. The exciter winding shall be insulated with class “F” insulation.

Automatic solid state voltage shall be provided with the following features as a minimum.

- Under frequency protection.
- short circuit protection.
- Manual voltage control switch with adjuster.
- Cross current compensation for parallel operation.
- Voltage build up circuitry.
- Stators current limited.
- Field current limited.

The Current and potential transformers required to feed the AVR from the generator terminal shall be adequately rated.

13.0 SYSTEM OPERATION

The emergency generator set shall normally be in an unattended area. The Control system shall operate in fail safe mode and shall include all controls and protection necessary for the safe operation of the package. The generator set shall function as per one of the following schemes:

- Auto main failure scheme (AMF).
- Manual start in service mode.
- Manual test mode.

14.0 GENERATOR CONTROL PANEL:

14.1 The Local generator control panel for the generator set shall comprise of the following unless otherwise specified in the attached data sheet.

- a) Automatic Voltage Regulator.
- b) Protection and metering equipment's.
- c) Indicating instruments.
- d) Local breaker for DG set (Siemens / Schneider)
- e) Control gear for generator set auxiliaries.

Any other accessory require to make the generator set operational as a package shall be included in scope of supply. If required the generator control panel shall be split into various functional sections viz. protection, metering and control, regulation etc.

The generator break shall also be part of the control panel unless otherwise specified. The breaker rating shall be as specified in the drawing. The protective relays in the Gen. Control panel shall act to trip this breaker on fault conditions unless otherwise specified. This breaker also serves the purpose of local isolation.

All motor starters for generator set auxiliaries shall be DOL type.

Unless otherwise specified, the DC control supply required for relays, controls, closing/tripping of generator breaker, annunciation circuit and for any other purpose shall be met by a DC system consisting of battery and battery charger of suitable capacity to be supplied by the generator set manufacturer. The battery shall be sized for two hours' load cycle a maximum. Battery charger shall be of the constant voltage type with current limiting feature and facilities for automatic and manual, normal and quick charging of batteries. Charger shall be sized for boost charging of batteries with 10 to 14 hours.

14.2 The panel shall be free standing, metal enclosed, dust and vermin proof type with a hinged door and having a degree of protection IP 51 as per IS:51 as per IS:2147 unless otherwise specified. Power and control equipment shall be segregated inside the panel as far as practicable. The maximum light of the operation handle/switches shall not exceed 1000 mm. and the minimum height not below 300 mm. All hardware shall be corrosion resistant and bolts, nuts and washers shall be made of galvanized zinc passivated or cadmium plated high quality steel. Unless otherwise specified the panel shall be suitable for bottom cable entry. Necessary glands shall be provided with the panel.

All auxiliary devices for control, indication, measurement and alarm such as push buttons control-selector switches, indicating lamps, metering instruments, annunciation's etc. shall be mounted on the front door of the panel. Adequate number of potential free contacts shall be provided in the control panel for any remote control, monitoring of the generator set.

- 14.3 All switches shall be load – break, heavy duty type. All fuses shall be non-deteriorating HRC cartridge pressure filled, link type. The contractor shall be air-break type having AC-3 duty rating. Thermal overload relays shall be three element, positive acting, ambient temperature compensated type with adjustable setting range and built in protection feature against single phasing. All indicating instruments shall be moving iron, flush mounting type and of 96 mm x 96 mm square pattern. All control / selector switches shall be rotary back connected type having a cam-operated contact mechanism with knob type handle. “STOP” push buttons shall be stay put type.
- 14.4 Wiring for power, control and signaling circuits shall be done with PVC insulated copper conductors having 660 / 1100 V grade insulation. Minimum size of control wires shall be 2.5 mm “ELEMEX” type terminals shall be acceptable for wires up to 10mm² size and for conductors larger than 10 mm² bolted type terminals with crimping lugs shall be provided. A minimum of 10% spare terminals shall be provided on each terminal block.
- 14.5 An adequately sized earth bus shall be provided in the panel for connection to the main earth grid. All non current carrying metallic parts of the mounted equipment's shall be earthed. Doors and movable parts shall be earthed using flexible copper connections.
- 14.6 Engraved nameplates shall be provided for all devices mounted on the front of the panel. Nameplate or polyester adhesive stickers shall be provided for each equipment mounted inside the panel.

15.0 PAINTING, PACKING AND TRANSPORT:

- 15.1 All metal surfaces shall be thoroughly cleaned of scale, rust and grease etc. prior to painting. Cleaned surfaces shall be given two coats of primer and prepared for final painting. Final finish shall be free from all sorts of blemishes.
- 15.2 The equipment shall be shipped to site suitably packed to prevent any damage. Each package shall have labels to show purchaser's name, purchase order and equipment no. suitable lifting lugs etc.

shall be provided and lifting points shall be clearly marked on the package. Packing shall be suitable for storage at site for a minimum period of 6 months.

17. SPECIFICATIONS FOR UNDER GROUND DIESEL TANK WORKS

1 HSD STORAGE TANK:

Scope:

The contractor shall design, supply, install test and commission the HSD tank, fittings and accessories as per requirements of the following BIS codes:

IS 10987 / IS 823 / IS 1239

Rules and regulation of the chief inspector / Controller of Explosives India.

Petroleum rules 1936

All site welding shall be carried out by fusion welding as per IS 823. For all butt welds, the roof run and final run shall be carried out.

The HSD tank shall be MS construction, horizontal cylindrical in shape with dished ends.

The tank shall be all welded construction and shall be suitable for storage of HSD up to maximum temperature of 40 deg. C at atmospheric pressure. Shell thickness of tank shall be 6 mm and thickness of dished ends 8 mm.

Tanks shall be painted externally and internally to prevent corrosion. The internal surface of the storage tanks shall be thoroughly cleaned with wires brush / emery paper to remove rust, scale etc and treated with coat of suitable oil resistant paint. The external surface of the tank shall be thoroughly cleaned with wire brush / emery paper to remove rust, scale etc. and painted with one coat of zinc chromate primer followed by two coats of finishing paint (Bitumen based).

All the oil supply pip shall be MS heavy class as per IS 1239 Part 1. All fittings shall be of heavy duty. Flanges shall be conforming to ASA class 150 weld necks and material to IS 226.

All valves shall be ball type and of body bonnet, gland nut of bronze material with brass or SS ball only.

The strainers shall be of cast iron body with FM or bronze mesh for fine filtration of the oil.

The HSD supply pipes from HSD yard to respective day oil storage tank shall be laid underground. These pipes shall be provided with corrosion proof and weather proof treatment.

CLEANLINESS

The area around the vessels shall be kept free from readily ignitable materials, such as weeds and long dry grass by providing stone pitching.

EARTHING

HSD tank and pipe lines shall be provided with copper earthing and earthed in efficient manner.

NO SMOKING

A permanent notice with letters minimum 5 cms high prohibiting smoking and naked lights shall be fixed to the fence surrounding the area.

FIRE PROTECTION

The area where tanks, pumping equipment, loading and unloading facilities are provided; shall be well protected from fire by providing fire hydrants and fire extinguishers. (Shall be part of FFTG tender)

INSPECTIONS, APPROVALS AND LICENCE

The contractor shall arrange the inspection, approval and license for the proposed HSD oil installation by the Chief Inspector / Controller of Explosives as given below:

Pre – Installation Approval

The contractor shall upon the award of the work shall prepare working drawings for the HSD installation and submit the drawings to the consultants for their provisional approval. The drawings so approved by the consultants shall be submitted to the Chief inspector / Controller of Explosives for his scrutiny and approval.

Procedures if required to be followed from local CFO office shall be followed.

Test & Safety Certificates.

It shall be the responsibility of the contractor to arrange test and safety certificates under rules 126 after the installation is commissioned.

Inspection / Storage License

It shall be the responsibility of the Contractor to arrange for inspection of the installation by the Chief inspector / Controller of Explosives and carry out any modifications / additions if required by the chief inspector / controller of explosives and obtain storage license and submit the same to owners.

FUEL OIL PIPING**Scope**

The scope of this section comprises the supply and laying of pipes, pipe fittings and valves. Testing and balancing of all HSD piping required for the complete installation as shown on the drawings. All piping inclusive of fittings and valves shall follow the applicable BIS codes.

1. Pipes shall be MS class “B” and fittings shall be welded type fittings conforming to relevant BIS codes. All jointing in the pipe system shall generally be by welding flanges, unless otherwise mentioned or directed at site. All welding shall be done by qualified welders and shall strictly conform to BIS code of procedure for manual metal arc welding of mild steel.
2. All pipes and their steel supports shall be thoroughly cleaned and given on primary coat of red oxide paint before being installed. All welded piping shall be subject to the approval at site.
3. Threaded joint fittings shall be malleable casting of pressure rating suitable for the piping system. Fittings used on welded piping shall be of the weldable type.
4. Tee-off connections shall be through equal or reducing tees otherwise ferrules welded to the main pipe shall be used. Drilling and tapping of the walls of the main pipes shall not be resorted to.

MOTORS AND PUMPS**SCOPE**

This specification covers the design, manufacture and testing of three phase medium voltage squirrel cage induction motors.

2. STANDARDS

Unless they are at variance with the clauses of this specification, the squirrel cage induction motors and their components shall comply with the latest applicable Indian standards listed below. Where Indian standards do not exist, the relevant IEC, British or German (VDE) standards shall apply.

2.1 IS – 325 Three phase induction motors.

2.2 IS – 1076 Preferred numbers.

2.3	IS – 1231	Dimensions of three phase, foot mounted induction motors.
2.4	IS – 1271	Insulating materials for electric machinery and apparatus in relation to their terminal stability in service, classification of.
2.5	IS – 2148	Flame proof enclosures of electrical apparatus.
2.6	IS – 2223	Dimensions of flange mounted AC Induction motors.
2.7	IS – 2253	Types of construction and mounting of motors.
2.8	IS – 2254	Dimensions of vertical shaft motors for pumps.
2.9	IS – 2968	Slide rails for electric motors, dimensions of.
2.10	IS – 4029	Guide for testing three phase induction motors.
2.11	IS – 4691	Degrees of protection provided by enclosures for routing electrical machinery.
2.12	IS – 4722	Specification for rotating electrical machines.
2.13	IS – 4728	Terminal marking for rotating electrical machinery.
2.14	IS – 4889	Methods if determination of efficiency of rotating electrical machines.
2.15	IS – 6362	Methods of cooling for rotating electrical machines.
2.16	IS – 6381	Constructions and testing of electric apparatus with type of protection ‘e’.
2.17	IS – 7389	Pressurized enclosure of electrical equipment for use in hazardous area.
2.18	IS – 7816	Guide for testing insulation resistance of rotating machines.
2.19	IS – 8223	Dimensions and output ratings for foot mounted rotating electrical machines with frame numbers 355 to 1000.

2.20	IS – 8289	Specification for electrical equipment with type of protection ‘n’.
2.21	IS – 8789	Values of performance characteristics for three phase induction motors,
2.22	IS – 9283	Motors for submersible pump sets.
2.23	IS – 9628	Specification for three phase induction motors with type of protection ‘n’.
2.24	IS – 12075	Mechanical vibrations of rotating Electrical Machines.
2.25	IS – 12065	Permissible limits of noise level for rotating electrical machines.
2.26	IS – 12802	Temperature rise measurement of rotating electrical machines.
2.27	IS – 13529	Guide on effects of unbalanced voltages on the performance of three phase cage induction motors.
2.28	IS – 13555	Guide for selection and application of three induction motors for different types driven equipment.

3. OPERATING CONDITIONS

3.1 Ambient Conditions - Aurangabad

3.2 Frequency and Voltage Variations

Motors shall be suitable for operating satisfactorily in humid and corrosive atmosphere found in Refineries, Petrochemical complex, fertilizer and metallurgical plants. Service conditions shall be as specified in the data sheets. If not specifically mentioned therein, a maximum ambient temperature of 40°C and an altitude not exceeding 1000 meters above mean sea level, shall be taken into consideration.

Unless otherwise agreed motors shall be designed for continuous, satisfactory operation at rated output under the following conditions:

- a) The terminal voltage differing from its rated value by not more than $\pm 6\%$, or
- b) The frequency differing from its rated value by not more than $\pm 3\%$ or
- c) Any combination of (a) and (b).

Unless otherwise specified motors shall be designed for direct –on-line starting. Motors shall be designed for re-acceleration under full load after a momentary loss of voltage with the residual voltage being 100% out of phase.

Minimum locked rotor thermal withstand time at rated voltage shall be 10 seconds under cold conditions and 8 seconds under hot conditions. The starting time of the motor shall be less than the hot thermal withstand time (time tE in case of increased safety motors) to permit application of conventional bimetal relays or thermal release against locked rotor and overload conditions.

Unless otherwise specified, all motors shall be suitable for starting under specified load conditions with 75 percent of the rated voltage at the terminals.

Motors shall be designed to allow the minimum number of consecutive starts indicated below:

3.3 Starting

TABLE – I

Starts	Min no. of consecutive starts
No of consecutive start-ups with initial temp. of the motor at ambient level (cold)	3
No of consecutive start-ups with initial temp of the motor at full load operating level (hot).	2

3.4 Direction of Rotation

Motors shall be suitable for their direction of location. In case unidirectional fan is provided for motors, direction of rotation for which the motor is designed shall be permanently indicated by means of an arrow. A painted arrow shall not be acceptable. directional arrow should be manufactured from corrosion resistant material. When a motor is provided with bi-directional fans, a double headed arrow should be provided.

4. PERFORMANCE

4.1 Motors shall be rated for continuous duty (SI) unless otherwise specified.

4.2 The starting current (as % rated current) shall not 600% for motors upto and including 75 KW and 550% for motors above 75 KW subject to tolerance.

- 4.3 Starting torque and minimum torque of the motor shall be compatible with speed torque curve of the driven equipment under specified operating conditions. For heavy duty drives such as blowers, crushers etc. high starting torque motors shall be provided. In case where characteristics of driven equipment are not available while selecting the motor, minimum starting torque shall be 110% of rated value for motors up to 75KW and shall be 90% of rated value for motors above 75 KW.
- 4.4 The pull out torque at the rated voltage shall be not less than 175 percent of the rated load torque with no negative tolerance. Unless otherwise agreed, the pull out torque shall not exceed 300 percent of the rated load torque.
- In case of motors driving equipment with pulsating loads (e.g. reciprocating compressors) the minimum value of pull out torque at 75 percent of the rated voltage shall be more than the peak value of pulsating torque and the current pulsation shall be limited to 40%.
- 4.5 The minimum value for product of efficiency and power factors for motors rated upto and including 37 KW shall be as per IS – 8789.
- The minimum value for product of efficiency and power factors of 2 pol, 4-pole, and 6-pole motors rated above 37 KW shall be as given below.

Product of efficiency and power factor at rated load (minimum)

	2-POLE	4-POLE	6-POLE
45 KW	0.82	0.80	0.79
55 KW	0.82	0.80	0.79
75 KW	0.82	0.80	0.80
90 KW	0.82	0.80	0.80
110 KW	0.86	0.80	0.80
125 KW	0.86	0.80	0.80
160 KW	0.86	0.81	0.80
180 KW	0.86	0.83	0.80
200 KW	0.86	0.83	0.80

Efficiency and power-factor figures for motors having synchronous speeds of 750 r.p.m. and below shall be as agreed between the purchaser and manufacturer.

5. GENERAL REQUIRMENTS AND CONSTRUCTIONAL DETAILS

5.1 Windings

a) Insulations and bracing

Unless otherwise specified in the data sheet motors shall be provided with class 'B' insulation as a minimum. In case of motors with class 'F' insulation the permissible temperature rise as measured by resistance method above the specified ambient temperature shall be limited to those specified in the applicable Indian standards for class 'B' insulation.

The winding shall be tropicalized. The windings shall preferably be vacuum impregnated. Alternately the windings shall be suitably varnished, baked and treated with epoxy gel for operating satisfactorily in humid and corrosive atmospheres.

Windings shall be adequately braced to prevent any relative movement during operation and in this respect, particular care shall be taken for the stator windings of direct-on-line starting squirrel cage motors. Insulation shall be provided between coils of different phases which lie together. Core laminations must be capable of withstanding burnout for rewind at 400oC without damage or loosening.

In case of motors driving equipment with pulsating loads, special attention shall be paid to the joints of rotor bars and end rings to avoid premature failure due to induced fatigue stresses.

b) Phase Connections

The windings shall be connected in delta. However, for motors rated 2.2 KW and below, star connection may be accepted.

If star- delta starting is required, this will be specified in the data sheet and the motor windings shall be fully insulated for delta connection.

c) Winding Terminations

The ends of the windings shall be brought out into a terminal box. They shall be terminated by means of terminals mounted on an insulating base made of no-hygroscopic and non-flammable material.

All motors shall be with six terminals and suitable links to connect them in star or in delta except for motors rated up to and including 202 KW which may be accepted with three terminals.

All terminals shall be adequately designed. Line terminals shall be thoroughly insulated from the frame with material resistant to tracking.

Anti-loosening, anti-vibration type of terminals shall be provided in case of increased safety (Type 'e') and non-sparking (Type 'n') type of motors.

d) Terminal Box and Cable Entries

Unless otherwise specified, the terminal box shall be located on the right hand side as viewed from the driving (coupling) end. It shall be rotatable in steps of 90o to allow cable entry from any direction.

The terminal box shall be of sturdy construction and large enough to facilities easy connection of the cables. Terminal box cover shall be provided with handles to facilitate easy removal.

An adequately sized earth terminal shall be provided in the motor terminal box for termination of the forth core of specified cables.

The terminal box shall be provided with cables lugs and entries for suitable cables glands corresponding to the number and size of specified cable. Nickel glands shall be supplied along with the motor for mentioned cable sizes.

Equipment and accessories provided shall confirm to the hazardous area classification and the environmental conditions wherever required as specified in the motor data sheet.

Unless otherwise specified the terminals, cable lugs, terminal box, cable entries and cable glands shall be suitable for the cable sizes as specified below for 2 pole, 4 pole or 6 pole motors:

<u>Motor rating upto and including</u>	<u>Sizes of phase conductor (mm²)</u>
2.2 KW and below	4 Al./2.5 cu
3.7 KW	6 Al./4.0 cu
5.5 KW	10 Al./6.0 cu
7.5 KW	10 Al./6.0 cu
9.3 KW	16 Al./10.0 cu
11.0 KW	16 Al./10.0 cu

NOTE : Cable sizes motors having synchronous speeds 750 rpm and below shall be as agreed between the purchase and manufacturer.

Cable Type

Cables used are of 650/1100 V grade aluminium conductor, XLPE insulated, PVC extruded inner sheath, armoured with overall PVC sheath for conductor cross- sections of 35 mm² & above. However, for cables upto & including 16 mm² cross-section cables used may be with copper or aluminium conductor as indicated in the data sheet.

The terminal box shall be capable of withstanding internal short circuit conditions without danger to personnel or plane from the emission if hot gases or flame or due to excessive disortion or damage of the terminal enclosure.

Phase Marking

appropriate phase markings as per IS : 4728 shall be provided inside the terminal box. The marking shall be non-removable and indelible.

Motor Casting and Type of Enclosure

Motors for use in safe areas shall be normal industrial degree of motor enclosures including terminal boxes and bearing housing shall be IP 55 as per IS : 4691.

Motors for use in hazardous areas (Zone 1 or Zone 2) shall have type of protection Ex(d) Or Ex(e) or Ex (n) as specified in the data sheet and shall meet the requirements of applicable Indian standards. Ex(d) type of motors shall have a BIS marking on the name plate.

Motors for outdoor use shall be suitable for installation and satisfactory operation without any protective shelter or canopy. Motor casing shall be provided with a suitable drain for removal of condensed moisture except in case of flameproof motors.

Vertical motors with downward shaft shall be provided with fully covering rain canopies. Vertical motors with upward shaft e.g. on fin-fan coolers, shall be adequately protected, (such as cowls/canopies) against ingress of water into the enclosure or the bearing housing even when standing still for long periods of time. Motors designed to handle external thrust from the pump shall be supplied with a thrust bearing at the non-driving end.

All internal and external metallic parts which may come into contact with cooling air, shall be of corrosion resistant material or appropriately treated to resist the corrosive agents which may be present in the atmosphere. Screws and bolts shall be hot dip galvanized or zing passivated to protect against corrosion.

Unless otherwise agreed, motors shall have standard frame size for various output ratings as stipulated in IS : 1231.

5.3 Bearing and Lubrication

Motors shall have grease lubricated ball or roller bearings. In all cases, the bearings shall be chosen to provide a minimum L-10 rating life of 5 years, (40 000 hours) at rated operating conditions. (The L-10 rating life is the number of hours at constant speed that 90% of a group of identical bearings will complete or exceed before the first evidence of failure). Unless otherwise specified the bearing shall be adequate to absorb axial thrust produced by the motor itself or due to shaft expansion. Vertical motors shall be provided with thrust hot liquids where the driven machine operates at high temperatures, bearings shall be cooled by a shaft mounted fan. This shall ensure efficient ventilation of the bearing and disperse the heat transmitted from the driven object by conduction or convection. For motors operating in hazardous areas fans shall be of an anti-static non-sparking material.

Bearing shall be capable of grease injection from outside without removal of covers with motors in the running conditions. The bearing boxes shall be provided with necessary features to prevent loss of grease or entry of dust or moisture e.g. labyrinth seal. Where grease nipples are provided, these shall be associated, where necessary, with appropriately located relief devices which ensure passage of grease through the bearing. Pre-lubricated sealed bearings may be considered provided a full guarantee is given for 4 to 5 years of trouble-free service without the necessity of re-lubrication.

5.4 Cooling System

All motors shall be self ventilated, fan cooled. Fans shall be corrosion resistant or appropriately protected. They shall be suitable for motors rotation in either direction without affecting the performance of the motor. If this is not possible for large outputs, it shall be possible to reverse the fan without affecting the balancing of the motor.

5.5 Rotor

The rotor shall be of squirrel cage type, dynamically balanced to provide a low vibration level and long service life for the bearings. The accepted values of peak to peak vibration amplitudes for a motor at rated voltage and speed on a machined surface bedplate with the motor leveled and with a half-key or coupling fitted shall not exceed those given in IS-12075. Die cast aluminium rotors for motors in hazardous areas may be accepted provided the same are type tested and approved by competent authorities.

5.6 Shaft Extension

Motors shall be provided with a single shaft extension with key-way and full key. Motor shaft shall be sized to withstand 10 times the rated design torque.

5.7 Lifting Hook

All motors except for fractional horse power motors shall be provided with lifting hooks of adequate capacity

5.8 Earth Terminals

Two earth terminals located preferably on diametrically opposite points shall be provided for each motors. Unless otherwise specified, the size of each earth stud shall be as given below :

Motor Rating	Stud size
Upto and including 3.7KW	6 mm
5.5KW to 30 KW	10 mm
Above 37KW	12 mm

Necessary nuts and spring washers shall be provided for earth connection.

An additional earth terminal shall be provided inside the terminal box as stated in 5.1

6 MISCELLANEOUS ACCESSORIES

6.1 Anti-Condensation Heaters

All motors rated above 30KW shall be provided with 240 V anti-condensation heaters, sized and located so as to prevent condensation of moisture during shut-down periods. Motors rated 30 KW and below shall be provided with anti-condensation heaters if specified in the requisition. Motors meant for humid location such as cooling tower fans, sump pump motors etc. shall be provided with space heaters irrespective of the motor rating in the motor data sheet. The heaters shall

permanently remain 'ON' when the motor is not in service and as such shall not cause damage to the windings.

The heater leads shall be brought out to separate terminal box of the same specification and grade of protection as the main power terminal box excepting that the cable glands provided shall be suitable for two core 4 sq. mm aluminum conductor, armored cable or 3 x 2.5 sq. mm. copper conductor armored cable.

A warning label with indelible red inscription shall be provided on the motor to indicate that the power line and the heater supply shall be isolated before carrying out any work on the motor.

6.2 Name Plates

A stainless steel name plate manufactured from series 300 stainless steel and as required under specification IS-325 shall be provided on each motor. In addition to the motor rating plate a separate motor plant equipment number plate shall be fixed in a readily visible position. This number shall be indicated in the data sheets attached with purchase requisition.

Additional information as stipulated in applicable Indian standards shall be included in the name plate for motors meant for use in hazardous atmospheres as per IS:13408

7. NOISE LEVEL

The permissible noise level shall not exceed the stipulations laid down in IS – 12065.

8. MOTOR VIBRATIONS

Motor vibrations shall be within the limits of IS – 12075 unless otherwise specified for the driven equipment.

9. CRITICAL SPEEDS

The first actual critical speed of stiff rotors shall not be lower than 125% of the synchronous speed. For flexible rotors this shall be between 60% and 80% of the synchronous speed; the second actual critical speed shall be above 125% of the synchronous speed.

Internal and external parts of the casing and all metal parts likely to come in contact with the surrounding air shall be protected with anti-acid paint that will resist the particular ambient condition.

All external surfaces shall be given a coat of epoxy based paint.

10. PAINTING

11. INSPECTION AND TESTING

The vendor shall allow purchaser or his authorized representative to visit the works during manufacture of motors to assess the progress of work as well as to ascertain that only quality raw material is used for the same. He shall be given all assistance to carry out the inspection.

The vendor shall give at least 4 weeks advance notice to the purchaser, regarding the date of testing to enable him or his representative to witness the tests.

The motors shall be tested in accordance with IS: 325 and IS: 4029. Type test including any specific test to ascertain compliance with these specifications shall be carried out on one sample from each KW rating and frame size. Routine tests shall be carried out on all motors. In addition, measurement of vibration and noise level (if desired) shall form a part of route tests.

Test on completely assembled motor shall be carried out in the presence of purchaser or his representative. The result shall be tabulated and signed by both vendor and purchaser or their representatives. Though the motors shall be accepted on the basis of the satisfactory result of the test at the works, it shall not absolve the vendor from liability regarding the proper functioning of the motor coupled to the driven equipment at site.

12. DRAWING AND DATA

12.1 Following minimum information shall be furnished along with Bid:

- a) KW rating, make, frame size, full load speed, mounting, enclosure type and specific type of construction {Ex(d), Ex(n) etc.}.
- b) For heavy duty drives starting torque, starting time and lock rotor withstand time of the motor shall also be furnished.

12.2 After placement of order, vendor shall furnish all necessary data / drawings / documents including but not limited to the following:

- a) Completed motor data sheet.
- b) GA, Dimension and mounting details.
- c) Details of terminal box and auxiliaries.

- d) Performance characteristics viz. speed v/s current and speed v/s torque.
- e) Thermal withstand curves under hot and cold conditions.

Subsequent to completion of satisfactory inspection and testing, duly signed test certificates, installation, operation and maintenance manual shall be furnished by the vendor to complete the contractual obligations.

13.0 TECHNICAL DATA FOR EQUIPMENTS :

A. PRIME MOVER FOR D.G. SET

1.	Prime mover	Diesel Engine
2.	Qty, required	One No. for each alternator.
3.	Service	Prime mover for generating set.
4.	Horse power	
5.	RPM	1500 RPM
6.	Type	Radiator cooled set.
7.	Flywheel	Require
8.	Vibration damper	Require
9.	Fuel pump air cleaner	Require
10.	Fuel pump	Require
11.	Radiator	Require
12.	Oil filter, fuel filter etc.	Require
13.	Lub oil pump	Require
14.	110 V DC V electrical system	Require
15.	Safety controls	Require
16.	Silencer	Require
17.	Coupling	Require
18.	Instrument panel consist of :	
	a) Starter switch	Require
	b) Lub. oil temp. gauge	Require
	c) Water temp. gauge	Require
	d) Oil pressure gauge	Require
	e) Meter	Require
	f) Tachometer	Require
19.	Fuel tank	Require

20.	Battery charger	Require
21.	Engine testing	Require
	a) At shop	
	b) At site	
22.	Tool kits	Require
23.	Literature	Require
	a) Operation & maintenance manual	
	b) Parts catalogue/list	

Note :

1. The engine HP. should be selected so as to achieve required KW rating to be generated considering derating of engine due to altitude, temp. Humidity etc.
2. The engine test shall be witnessed by the client's representative.

ALTERNATOR**DATA SHEET - B**

1. Make :
2. Rating : 2 x500KVA
3. Power factor : 0.8
4. Rated voltage : 415 V
5. Voltage regulation : As required
6. Rated current :
7. Speed : 1500 RPM.
8. Frequency : 50 Hz.
9. Field current at rated
output and power factor : to be specified by tenderer
10. Field voltage at rated
output and power factor : to be specified by tenderer
11. Method of excitation and
Regulation : Self
12. Class of insulation : A) Starter - F with temp.rise of Cl.B
B) Rotor - F --- do -----
13. Degree of protection : Screen protected, drip proof.
14. Base plate : The Engine & alternator shall be
mounted and aligned on a common
base plate fabricated from steel.
15. Control Panel AMF : Consist of
 - i. ACB / MCCB with O/L, E/F and shunt trip releases
 - ii. On/off indicator.
 - iii. Auxiliary switch.
 - iv. Ammeter & Voltmeter with assessors
 - v. KWH meters with CTs.
 - vi. Over voltage relay
 - vii. Under Voltage relay
 - viii. Reverse & Forward Power relay.
 - ix. Over & Under frequency Relay
 - x. KVA meter
 - xi. Frequency meter.

- xii. Annunciation windows.
- xiii. LED Lamp indicator.
- xiv. Auto load sharing and synchronizing relay for 3 sets

16. Change over switch : Auto synchronizing with load sharing.

2. LIST OF APPROVED MAKE / MANUFACTURERS

1)	Rigid PVC Conduit	Precision plastic industries, Polycab, AKG
2)	Accessories for conduit	Same make as of pipe
3)	Flexible Wires – Cu – multistrand	Finolex, RR kable, Havells, Polycab, Avocab
4)	Switches / Back box / Plates	Legrand (Arteor), MK Blenze, Norisys
5)	DB / MCBs / ELCB /Ind plug socket	Schneidder Acti 9, Legrand – DX3, Hager
6)	Data and Voice wires – Cat 6	Systimax, Tyco, Legrand, Digilink
7)	Tele / TV wires – Cat 3 / RG11 / RG6	Delton / Finolex / Havells / Polycab / RR kable
8)	Cables	Finolex, Havells, Polycab, KEI, RR kabel, Avocab
9)	Glands	Comet, Standard Metal Industries
10)	Cable Lugs	Dowells, 3-D
11)	M.S. Conduit – ISI marked	BEC, Steel Craft, Vimco
12)	ACB / MCCB / etc all switchgears for panels	As per list given in panel specs
13)	Telephone tag block	Krone, ITL
14)	Ceiling Fans	Crompton – High Speed
15)	Exhaust Fan with gravity louvers Indoor	Usha Lexus or equi of crompton / orient
16)	Cable Tray	Profab, MM engineering, KEW, Legrand

- 17) GI / AL Floor raceways and floor junction boxes MK, Legrand
- 18) PVC wall raceway MK, Legrand.
- 19) Inverter Sukam, microtek, Luminous
- 20) ESE arrestor / Chemical earthing Nimbus - Jeff, Eritech, Indellec , MAP.
- 21) Transformers Kirloskar, CG, Voltamp, Ames
- 22) DG OEM of Caterpillar, Cummins, Super nova
- 23) LT Panel vendors Arrow Engineers, Vivid, Listen lights, Peaton, Adelec, Marine, JJ industries
- 24) Light Fixtures Philips, Wipro, CG, NTL lemins
- 25) UPS Emerson, Numeric, Delta, Eaton, APC
- 26) HT VCB Schneider / ABB / Siemens

The successful tenderer shall have to use the makes from above in consultation with the ARCHITECT and / or their consultant.

For at par comparison tenderer shall consider 1st listed make as long as possible.

3. SAFETY CODE

1. Suitable scaffolds shall be provided for workmen for all work that cannot safely be done from the ground, or from the ground, or from solid construction except such short period work as can be done safely from ladders. When a ladder is used an extra labour shall be engaged for holding the ladder and if the ladder is used for carrying materials as well suitable footholds and handhold shall be provided on the Ladder and the ladder shall be given an inclination not steeper than 1/4 to 1 (1/4 horizontal and 1 vertical).

2. Safe means of access shall be provided to all working platform and other working places. Every ladder shall be securely fixed. No portable single ladder shall be over 9 meters in length. Width between side rails in a rung ladder shall in no case be less than 30 cm. for ladders upto and including 3 meters in length. For longer ladders this width shall be increased atleast 6 mm. for each additional 30 cm. of length. Uniform step spacing shall not exceed 30 cm.
Adequate precautions shall be taken to prevent danger from electrical equipment. No materials on any of the sites shall so stacked or placed as to cause danger or inconvenience to any person or the public. The contractor shall provide all necessary fencing and lightest to protect public from accidents and shall be bound to bear expenses of defines of every suit, action or other proceedings at law that may be brought by any person for injury sustained owing to neglect of the above precautions and to pay any damages and costs which may be awarded in any such suit, action or proceedings to any such person or which may with the consent of the contractor be paid to compromise any claim by any such person.
3. Demolition : Before any demolition work is commenced and also during the process of the work:-
 - a) All roads and open areas adjacent to the work site shall either be closed or suitably protected.
 - b) No electric cable or apparatus, which is liable to be a source of danger over a cable or apparatus used by operator, shall remain electrically charged.
 - c) All practical steps shall be taken to prevent danger to persons employed, from risk or fire or explosion or flooding. No floor, roof, or other part of a building shall be so overloaded with debris or any materials as to render it unsafe.
4. All necessary personal safety equipment as considered adequate by the Engineer-in-charge shall be available for use of persons employed on the site and maintained in a condition suitable for immediate use; and the contractor shall take adequate steps to ensure proper use of equipment by those concerned.
 - a) Those engaged in handling any material, which is injurious to eyes, shall be provided with protective goggles.
 - b) Those engaged in welding works shall be provided with welder's protective-shields.
 - c) Stone breakers shall be provided with protective goggles and protective clothing and seated at sufficiently safe intervals.
 - d) The contractor shall not employ male or female labour below the age of 18 years.
5. When work is done near any place where there is risk of drowning, all necessary equipment shall be provided and kept ready for use and all necessary steps taken for prompt rescue of any person in danger and adequate provision made for prompt first aid treatment of all injuries likely to be sustained during the course of the work.

6. Use of hoisting machines and tackle including their attachments, anchorage and supports shall confirm to the following:
 - a) i. These shall be of good mechanical construction, sound material and adequate strength and free from patent defects and shall be kept in good repair and in good working order.
ii. Every rope used in hoisting or lowering materials or as a means suspension shall be of durable quality and adequate strength, and free from patent defects.
 - b) Every crane driver or hoisting appliance operator shall be properly qualified and no person under the age of 21 years shall be in charge of any hoisting machine including any scaffold winch or give signals to operator.
 - c) In case of every hoisting machine and of every chain ring hook, shackle swivel and pulley block used in hoisting or lowering or as means of suspension, safe working load shall be ascertained by adequate means. Every hoisting machine and all rear referred to above shall be plainly marked with safe working load. In case of a hoisting machine having a variable safe working load, each safe working load and the conditions under which it is applicable shall be clearly indicated. No part of any machine or of any gear referred to above in this paragraph shall be loaded beyond safe working load except for the purpose of testing.
 - d) In case of a departmental machine, safe working load shall be notified by the Engineer-in-charge. As regards contractor's machines the contractor shall notify safe working load of each machine to the Engineer-in-charge whenever he brings it to site work and get it verified by the Engineer-in-charge.
7. Motors gearing, transmission, electric wiring and other dangerous parts of hoisting appliances shall be provided with efficient safeguards; hoisting appliances shall be provided with such means as will reduce to the minimum risk of accidental decent of load adequate precautions shall be taken to reduce to the minimum risk of any part of a suspended load becoming accidentally displaced. When workers are employed on electrical installations, which are already energized, insulating mats working apparel such as gloves, sleeves and boots as may be necessary, shall be provided. Workers shall not wear any rings, watches and carry keys or other materials, which are good conductors of electricity.
8. All scaffolds, ladders and other safety devices mentioned or described herein shall be maintained in a safe condition and no scaffold, ladder or equipment shall be altered or removed while it is in use. Adequate washing facilities shall be provided at or near places of work.
9. These safety provisions shall be brought to the notice of all concerned by display on a notice board at a prominent place at the work spot. Persons responsible for ensuring compliance with the safety code shall be named therein by the contractor.

10. To ensure effective enforcement of the rules and regulations relating to safety precautions, arrangements made by the contractor shall be open to inspection by the Engineer-in-charge or his representatives and the Inspecting Officers.
11. Notwithstanding the above conditions 1 to 14 the contractor is not exempted from the operation of any other Act or Rule in force.
12. If the height at which the contractor is working is more than 12 feet then the staff should wear safety helmet and tie himself with softy belt, client/ architect have all right to ask the contractor to stop wire if the safety condition are not fulfilled.

SR.NO	DESCRIPTION	AREA IN SQ.MT	AREA IN SQ.FT	Lighting Load in KW	Power Load in KW	Equipment Load in KW	Connected load in KW	Load factor	Actual Load in KW	Load on DG set in KW	Load on DG set in KW in case of fire
COMMON AREA LTG & POW. LOAD											
1	Lobby & corridor	2,207.00	23,747.32	19.00	5.94		24.93	0.70	17.45	17.45	17.45
2	Atrium	1,300.00	13,988.00	20.98	6.99		27.98	0.70	19.58	19.58	19.58
3	Stair case	1,232.00	13,256.32	6.63			6.63	0.80	5.30	5.30	5.30
4	Store & Utility Area	2,325.00	25,017.00	12.51	12.51		25.02	0.60	15.01	15.01	15.01
5	Toilet & fresh room area	910.00	9,791.60	7.83	4.90		12.73	0.60	7.64	7.64	7.64
6	Open parking	1,062.00	11,427.12	1.14			1.14	0.80	0.91	0.91	0.91
7	Parking	5,750.00	61,870.00	12.37	6.19		18.56	0.70	12.99	12.99	12.99
	Total for common area Load			80.47	36.52	-	116.99		78.89	78.89	78.89
DAV OFFICE AREA											
Gr. floor plan											
1	DAB Office	1,464.26	15,755.44	15.76	63.02		78.78	0.70	55.14		
2	HVAC Low Side					18.27	18.27	0.85	15.53		
	Total			15.76	63.02	18.27	97.05		70.67		-
5th floor plan											
1	DAB Office	1,335.20	14,366.75	14.37	57.47		71.83	0.70	50.28		
2	HVAC Low Side					14.92	14.92	0.85	12.68		
	Total			14.37	57.47	14.92	86.75		62.97		-
	Total DAV Office Load			30.12	120.49	33.19	183.80		133.64	-	-
COMMON LOAD											
1	Lift	6.00				7.50	45.00	0.60	27.00	15.00	15.00
2	HVAC LOAD										
2.1	Ventilation Load (NC)						158.53		158.53	158.53	158.53
2.2	Ventilation Load (FC)						158.53			158.53	
2.3	AC Load High side						916.49	0.80	733.19		
2.3	AC Load Low side						74.23	0.80	59.38		
2.4	Fresh Air Load						27.60	0.80	22.08		
3	Landscape/Facade Lighting			15.00			15.00	0.80	12.00	12.00	
4	Plumbing System										
4.1	Flushing	2.00				5.63	11.26	0.60	6.76	6.76	
4.2	Domestic	2.00				7.50	15.00	0.60	9.00	9.00	
4.3	Water Transfer pump	1.00				3.75	3.75	0.60	2.25	2.25	
4.4	STP	1.00				22.50	22.50	0.60	13.50	13.50	
4.5	Sump Pump For Pump Room	1.00				5.63	5.63	0.60	3.38	3.38	
4.6	Sump Pump For Parking	4.00				5.63	22.52	0.60	13.51	13.51	
4.7	Boiler for Kitchen	1.00				10.00	10.00	0.60	6.00	6.00	
5	Stack parking						138.00	0.30	41.40		
6	BMU Unit						10.00	0.60	6.00		
7	Fire Sysytem										
7.1	Fire Hydrant	1.00				75.00	75.00	0.90	67.50		67.50
7.2	Fire Sprinkler	1.00				75.00	75.00	0.90	67.50		67.50
7.3	Fire Drencher	1.00				75.00	75.00	0.90	67.50		67.50
7.4	Hydrant Jockey	1.00				11.25	11.25	0.90	10.13	10.13	
7.5	Sprinkler Jockey	1.00				11.25	11.25	0.90	10.13	10.13	
7.6	Booster	4.00				11.25	45.00	0.90	40.50	40.50	40.50
	Total		-	15.00	-	326.89	1,926.54		1,152.65	459.21	416.53
	COMMON TO ALL FLOOR TOTAL			125.59	157.01	360.08	2,227.33	-	1,365.19	538.10	495.42
COMMON HT SERVICE TRANSFORMER RATING											
	Maximum Demand in KW (Excl. fire load)			=		1,365.19					
	Overall Diversity - 90%			=		1,228.67					
	Maximum Demand in KVA @ 0.90 P.F.			=		1,365.19					
	Equipment Loading @ 85%			=		1,606.10					
	Transformer Rating			=		1 x 2000 KVA					
DG SET RATING											
	Maximum Demand in KW			=		538.10	495.42				
	Overall Diversity - 90%			=		484.29	445.88				
	Maximum Demand in KVA @ 0.80 P.F.			=		605.36	557.35				
	Equipment Loading @ 85%			=		712.19	655.71				
	DG Set Rating			=		2 x 500 KVA					
UPS RATING (EXCLUDING OFFICE)											
	Maximum Demand in KW			=		8.05					
	Maximum Demand in KVA @ 0.80 P.F.			=		10.06					
	Equipment Loading @ 85%			=		11.83					
	UPS Rating			=		2X15 KVA					

SOLAR POWER

SCOPE OF WORK, SPECIAL CONDITON AND TECHNICAL SPECIFICATION

This work includes supply, erection testing and commissioning of grid connect solar generating panels, connecting them with existing electrical distribution system with “on GRID TYPE“ inverters. This work has to be carried out as per the conditions and technical specifications given below:-

- I. The solar panels shall be fitted on the roof top of building. Rates given in schedule of quantity are inclusive of cost of cables, M.S angles and brackets required for fabrication of the stands of solar panels.
- II. Rates in the quantity schedule for each item are also inclusive of all the incidental material required for satisfactory completion and commissioning of work.
- III. All switch gears should L&T, Siemens, Legrand make only
- IV. Complete wiring and cable laying out from solar panels output to main distribution board of the building should be done by the firm
- V. All wiring materials should be fire retardant/ halogen free and low smoke with ISI mark and as per IS 694 latest version
- VI. Apart from attending the break-down calls, the firm shall inspect the system quarterly preventive maintenance of solar panels and electrical equipment till guarantee period is completed.
- VII. Minimum 02 numbers of maintenance free earthing kit as per IS 3043-1987 or latest shall be provided for each panels i.e. total 05 numbers of earthing kit and its connection to the panels shall be made without any extra charges.

TECHNICAL SPECIFICATION

1.0 This specification provides the generic requirement for required capacity module, Number of cells in the module will however depend on the capacity of solar panels.

2.0 This specification covers the general and technical requirements for design, manufacture, testing, supply, installation & commissioning of Grid connect solar generating system to be provided at the premises for meeting the lighting and other Electrical load requirements.

3.0 REFERENCE STANDARDS

IS: 2834:1989 reaffirmed 2000)	Solar Photovoltaic Energy Systems – Terminology
IEC : 61215 Ed 2 or latest	Crystalline silicon terrestrial photovoltaic (PV) modules – Design qualification and type approval

IEC:60904-1(2006)	Photovoltaic Devices- Part-I: Measurement of Photovoltaic current-Voltage Characteristic

IS: 9000	Basic environmental testing procedure for electronic and electrical items
IEC 61723 Ed1.0	Safety Guidelines for grid connected photovoltaic Systems mounted on the buildings
IEC 60364-7-712 (1997)	Electrical Installations of Buildings Part 7: requirements for special installations or locations Section,712: Photovoltaic power supply systems.

Note : Latest version of the specification shall be referred to.

4.0 SYSTEM DESCRIPTION

Solar Photo Voltaic (SPV) grid connect system shall consist of mainly the following: -

- 4.1 Solar panels
- 4.2 Module mounting structure
- 4.3 Junction boxes
- 4.4 Power conditioning unit (PCU)
- 4.5 Cable and other accessories

The PV array converts the light energy of the sun to DC power. The module mounting structure shall be used to hold module in position. The DC power shall be converted to AC to supply the AC loads connected like lights within the premises. Solar panels shall be integrated with the premises power supply from electricity authority.

DC distribution board shall be provided in between solar array and PCU. It shall have MCCB of suitable rating for connection and disconnection of array section.

No electrical storage batteries shall be required.

5.0 GENERAL REQUIREMENTS

- 5.1 Solar generating system shall support peak electrical load during day time

- 5.2 Solar panels shall be installed on the shade free roof while the PCU and distribution boards etc. shall be housed inside the room provided by client
- 5.3 The statutory approval of local authorities/state electricity distribution company etc. shall be obtained by Client, if required.
- 5.4 Client shall provide a shadow free area @ 125 - 150 sq. ft. / KWp of solar array
- 5.5 Array structure of PV yard and all electrical equipment such as PCU, inverters etc. shall be grounded properly using adequate number of earthing kits.
- 5.6 Suitable marking shall be provided on the bus for easy identification.

6.0 TECHNICAL REQUIREMENT

- 6.1 The DC output from the modules shall be fed to array junction box & the strings are paralleled at sub Main & Main junction boxes. Then PCU shall convert DC energy produced by the solar array to AC energy. The AC power output of the inverter shall be fed to the AC distribution board (metering panel & isolation panel), which also houses energy meter. The ACDB should be capable of interfacing solar power with grid power and DG power and to dedicated load also, if desired.
- 6.2 The system shall automatically wake-up in the morning
- 6.3 When the grid voltage and/or frequency goes out of preset range, the inverter shall be immediately disconnected from the grid. The inverter will reconnect after a pre-determined time when the grid is back in the range.
- 6.4 Array to inverter voltage drop shall be less than 5% at the maximum current output of the array.
- 6.5 Adequate space & ventilation shall be provided to inverter.
- 6.6 For safety reasons, PV inverter system shall be disconnected from the network following the fault or loss of supply on the power network.
- 6.7 System Load requirement / power consumption shall vary from place to place. 7.5/6.3/5.3/5.4/8.1KWp capacity arrays shall be installed & Component equipment of the system shall be sized as per load requirement at the site location.
- 6.8 SPV Module

6.8.1 Individual Solar PV Module should be of capacity 300 Wp (or higher) conforming to IEC:61215 Ed 2 or latest – Edition II, IEC : 61730 – I:2007, IEC : 61730 – II : 2007, manufactured in India in a plant certified under ISO 9001 : 2008 & ISO 14001 and also type tested by any one of the three accredited test laboratories under Ministry of New & Renewable Energy, Govt. of India. The Solar PV Module should be made from not more than 60 Nos. 156X156 mm poly crystalline Silicon Solar Cell connected in series.

6.8.2 SPV modules of similar output with +/- 2% tolerance in single string shall be employed to avoid array mismatch losses.

6.8.3 SPV module shall contain crystalline high power silicon solar cells. The solar cell shall have surface anti-reflective coating to help to absorb more light in all weather conditions.

6.8.4 Photo/electrical conversion efficiency of SPV module shall not be less than 14%.

6.8.5 Fill factor of the module shall not be less than 72%.

6.8.6 Each module shall have low iron tempered glass front for strength & superior light transmission. It shall also have tough multi-layered polymer back sheet for environmental protection against moisture & provide high voltage electrical insulation. Transmittivity of glass shall be not less than 91%.

6.8.7 Module junction box (weather resistant) shall be designed for long life outdoor operation in harsh environment.

6.8.8 SPV module shall be highly reliable, light weight and shall have a service life of more than 20 years. SPV modules shall have a limited power loss of not more than 10% of nominal output at the end of 10 years and of not more than 20 % of nominal output at the end of 25 years.

6.8.9 The rated output of any supplied module shall not vary by more than 3-5% from the average power rating of all ratings.

Each modules, therefore, has to be tested and rating displayed.

6.8.10 Whenever more than one module is required, identical modules shall be used.

6.8.11 It shall perform satisfactorily in relative humidity upto 100% and temperature between -10°C and $+85^{\circ}\text{C}$.

6.8.12 The solar modules shall have suitable encapsulation & sealing arrangements to protect the silicon cells from the environment. The encapsulation arrangement shall ensure complete moisture proofing (IP 65) for the entire life of solar modules. The terminal block shall be of Nylon 6 material.

6.8.13 The array structure shall be grounded properly using maintenance free earthing kit as per IS: 3043-1987

6.8.14 Marking:

Each module shall carry the following clear and indelible markings:-

- Name, monogram or symbol of manufacturer;
- Type or model number;
- Serial number;
- Polarity of terminals or leads (colour coding is permissible);
- Open – circuit voltage
- Operating voltage.
- Maximum system voltage for which the module is suitable;
- Operating current
- Short circuit current
- Date & place of manufacture;.
- Weight of the module

Module shall be tested as per Annexure-A.

6.9 Module Mounting Structure:

6.9.1 The array structure shall be so designed that it will occupy minimum space without scarifying the output from SPV panels.

6.9.2 The structure shall be designed to allow easy replacement of any module & shall be in line with the site requirements.

6.9.3 The array structure shall be made of hot dipped galvanized MS angles of suitable size.

- 6.9.4 The foundation for module mounting structure shall be preferably 1:2:4: PCC construction or any other combination based on the local site condition requirement for which design details shall be submitted.
- 6.9.5 The support structure design & foundation shall be designed to withstand wind speed upto 200 kmph.
- 6.9.6 The clearance of the lowest part of the module structure & the developed ground level shall not be less than 500mm.
- 6.9.7 The module alignment & tilt angle shall be calculated to provide the maximum annual energy output. This shall be decided based on the location of array installation.
- 6.9.8 All fasteners shall be of stainless steel of grade SS 304.
- 6.9.9 JUNCTION BOXES:
The array junction boxes shall be dust, vermin & waterproof & made of FRP/ABS plastic.
- 6.9.10 MOVs shall be used at the terminals of array junction boxes for external over voltage protection.
- 6.9.11 The junction boxes shall have suitable cable entry points fitted with cable glands of appropriate sizes for both incoming & outgoing cables.
- 6.9.12 Suitable markings are provided on the bus bar for easy identification & cable ferrules shall be fitted at the cable termination points for identification.
- 6.9.13 The Array Junction Box should be preferably have maximum 08 input and 01 output with MOV and Terminal block.

6.10 POWER CONDITIONING UNIT (PCU)

PCU shall supply the DC energy produced by array to DC bus for inverting to AC voltage using its MPPT (Maximum Power Point Tracking) control to extract maximum energy from solar array and produce 415V AC, 3 phase, 50 Hz to synchronize with the local grid.

- 6.10.1 MPPT Solar charge controller, inverter and associated control and protection devices etc. all shall be integrated into PCU.
- 6.10.2 PCU shall provide 3 phase, $415 \pm 10\%$ V, 50 ± 0.5 Hz supply on AC side with THD < 3%.
- 6.10.3 DC voltage ripple content shall not be more than 3%.
- 6.10.4 Efficiency of PCU shall not be less than 92%
- 6.10.5 Degree of protection: IP-21
- 6.10.6 It shall have protection features such as over voltage, short circuit, over temperature etc.
- 6.10.7 The inverter shall be efficient based on PWM with IGBT/MOSFET reliable power based design.
- 6.10.8 The PCU shall be capable of complete automatic operation, including wake-up, synchronization & shut down.
- 6.10.9 PCU shall have facility to display its basic parameters of the system.
- 6.10.10 PCU shall be capable to synchronize independently & automatically/to be phase locked with POWER SUPPLY AUTHORITY grid power line frequency to attain synchronization & export power generated by the solar panel to POWER SUPPLY AUTHORITY grid in addition to supply power to the loads.
- 6.10.11 Built-in with data logging to monitor plant performance through external PC shall be provided.
- 6.10.12 Inverter shall be tested for islanding protection performance.
- 6.10.13 Only isolated inverters shall be grounded on DC side.
- 6.10.14 Indications (through LEDs & LCD display)
- Inverter ON
 - Grid ON
 - Inverter under voltage/over voltage

Inverter over load

Inverter over temperature.

6.10.15 Protections:

Over voltage both at input & output

Over current both at input & output

Over/under grid frequency

Over temperature

Short circuit

Protection against lightening

Surge voltage induced at output due to external source.

6.11 Cables and Hardware

Cables of appropriate size to be used in the system shall have the following characteristics:

- i) Temp. Range -10°C to $+120^{\circ}\text{C}$.
- ii) Voltage rating 600/1000V
- iii) Excellent resistance to heat, cold, water, oil, abrasion, UV radiation, ozone & weathering
- iv) Halogen-free, low smoke, low toxicity.
- v) Flame retardant
- vi) Flexible
- vii) Fulfills IEC 60332-1 requirements
- viii) Conductor class IEC 60228 class 5

6.11.1 Cabling on DC side of the system shall be as short as possible to minimize the voltage drop in the wiring.

6.11.2 Components and hardware shall be vandal and theft resistant. All parts shall be corrosion resistant.

6.12 The system description, general/technical requirements etc. are given for general guidance only. The supplier/manufacturer shall submit the detail design of the complete solar generating system by using their software to optimize the combination of modules considering the specific location, isolation, nature of load etc.

6.13 AC Distribution board (ACDB):

The ACDB must have the following features:

6.13.1 Bus Bar minimum 3 times capacity of Solar Power plant.

- 6.13.2 Input Grid Line should come from such Distribution Board of client so that Solar Power can feed the load or feed power to the grid even when grid fails (DG Runs) in day time and Solar Isolation is available.
- 6.13.3 The Solar Power should be exported to the bus bar inside ACDB through a LCD Energy Meter.
- 6.13.4 The Designated Load should be routed through ACDB and an Energy Meter to register the Load Energy Consumption from Solar & Grid during Week Days and Holiday.
- 6.13.5 This feature will enable Railways to highlight GREEN POWERED ZONE in a building which will help them in long Run to Get IGBC NC Rating for that building.

6.14 Maintenance System –

The Array Yard should have permanent Water Line with Butterfly valve and rubber hose so that cleaning can be done by vendor during warranty period and later on by Railway people.

7.0 INSTALLATION & COMMISSIONING:

- 7.1 The installation shall be done by the supplier/manufacture who is responsible for its performance and direction of installation & ensures structural stability. The supplier shall conduct a detailed site assessment. The PV installer shall obtain data specific to the site, rather than relying on general data. While making foundation design, due consideration shall be given to weight of the module assembly, maximum wind speed at the site etc.
- 7.2. The SPV panel shall have a provision for directional and angular adjustment of the mounting structure to get maximum utilization of incident sunlight. It shall be mounted facing south& tilted to an angle equal to the latitude where being used for optimum performance
- 7.3 Solar panel supporting structure shall be hot dip galvanized MS frame.
- 7.4 The supporting structure incorporates corrosion resistant hardware's for all external connections.

8.0 DOCUMENTATION:

The supplier shall provide easy-to-use illustrated installation and operation manual in English and local language for easy installation and trouble-free usage. Manual shall contain complete system details such

as array lay out, schematic of the system, working principle etc., clear instruction on regular maintenance, trouble shooting of the solar generating system & emergency shutdown procedure.

9.0 AFTER SALES SERVICE:

The details of service centers in India shall be provided along with offer. All essential materials & manpower shall be placed at the service centers to ensure quick & efficient after sales service.

One set of essential spares for the system being offered shall be included in the offer & details of the offered spares shall be included with the technical bid.

Annexure-A

Quality Testing of PV-Module

Modules used in solar panels shall have IEC 61215 Ed 2 or latest compliance certificate. The qualification testing procedure is defined in IEC 61215 Ed 2 or latest to examine the impact of mechanical, thermal & electrical stress on power output. The bidder shall submit appropriate type approval certificate for the offered solar modules from IEC approved laboratories.

Method of Testing

10 Visual Inspection:

Each module shall be carefully inspected under an illumination of not less than 1000 lux for the following conditions:

- 1.1 Racked, bent, misaligned or torn external surfaces.
- 1.2 Broken / cracked cells
- 1.3 Faulty interconnections or joints
- 1.4 Cells touching one another or the frame
- 1.5 Failure of adhesive bonds; bubbles or de-laminations forming a continuous path
- 1.6 Between a cell & edge of the module
- 1.7 Faulty terminations, exposed live electrical parts
- 1.8 Junction box should have common terminals with suitable bypass diode for preventing hot spot problem.

2.0 Performance at STC: (Clause 10.1 of IEC 61215 Ed 2 or latest)

The current-voltage characteristics of the module shall be determined in accordance with IEC 60904-1 at a specific set of irradiance & temp conditions Performance of PV-Module shall be generally evaluated at Standard-Test-Conditions (STC) as defined in IEC 60904 standards:

- i) Cell temp. of 25° C,
- ii) Incident solar irradiance of 1000W/m²,
- iii) Spectral distribution of light spectrum with an air mass AM=1.5

3.0 All PV modules supplied shall be accompanied with I-V curves (tested in the manufacturing unit clearly indicating the serial number, batch number, date and country of origin).

4.0 ENVIRONMENTAL TESTING

Following environmental test shall be conducted on offered module for initial clearance of the offered system once in 2 years.

Test	Test Details	Actual test to be carried out at Govt. Recognized Lab or manufacturer premises as per standard
Cold Test	Temp. (-) 40°C Duration: 16 hrs.	IEC-68-2-1
Rapid change of temp.	Low Temp.: (-) 40°C High Temp. : (+) 85°C No. of Cycles : 10 Duration Exposure: 30 min Rise / Fall of temp : 1°C/ Minute	IEC-68-2-14
Dry Heat	Temp. (+) 85°C Duration: 16 hrs	IEC-68-2-2
Salt spray	Temp. (+) 35°C, RH 95% Duration: 2 hrs spray and 22 hrs conditioning No. of Cycle : 01	IEC-68-2-11 Test Ka
Wind	Pressure equivalent to an air velocity of 200 km/hr	
Rain	Test as required in the mentioned standards	JSS: 55555 (Test No. 12)
Dust	Temp : 40°C, RH < 50% Duration – 1 hr	JSS: 55555 (Test No. 14)
Composite Temp and humidity Test	Temp between 25°C, 65°C and -10°C, RH: 95% Dwell time : At 65°C with 95% RH : 05+05 Hrs At 25°C with 95% RH: 30+30 min. At 10°C : 2 hrs	IEC –68-2-38
	Duration – 240 hrs. No. of Cycles – 10	
Others	Electrical Isolation Test Routine test	Shall be done at manufacturers place for every modules offered

5.0 Acceptance Criteria:

The Module is deemed to have passed the tests if the sample meets the following criteria:

- 5.1 There is no evidence of a major visual defect such as a cracked or broken window, bubbles or de-lamination in the encapsulant etc.
- 5.2 There is no cell breakages & no water infiltration into terminal boxes.

- 5.3 No sample exhibits any open circuit or ground fault.
- 5.4 No visible evidence of major defects that may affect the performance of the module.
- 5.6 Insulation Resistance not less than 50M-ohm at 500 V DC.
- 5.7 Degradation of performance may not exceed 5% after each single test or 8% after the whole sequence.

4.0 HVAC WORKS

Design Parameters

a. Air cooled chillers:

Chilled water entering temperature at chiller	- 54°F (12.22°C)
Chilled water leaving temperature at chiller	- 44°F (6.67°C)
Fouling factor for chiller in FPS unit	- 0.0005
Refrigerant (HCFC free)	- HFC134a
Max. IKW/TR at design conditions (100% load)-	1.3
Min. COP at ARI conditions (100% load)	- 3.1
Min. IPLV	- 3.45

b. Air Handling Units (AHU):

Maximum face velocity across pre-filters	- 500 fpm
Maximum face velocity across MERV-13	- 500 fpm
Maximum face velocity across cooling coils	- 500 fpm
Maximum fan outlet velocity	- 1800 fpm
Maximum fan speed	
Impeller dia above 450mm	- 900 rpm
Impeller dia 450mm and below	- 1500 rpm

c. Air Distribution System:

Maximum flow velocity in AC ducts	- 1500 fpm
Maximum flow velocity in ventilation ducts	- 1500 to 2200 fpm
Maximum friction in AC & ventilation ducts	- 0.1 inches per 100 feet

d. Piping shall be sized for the following design parameters: Maximum velocity 1.2 m/Sec (4 fps) for piping 50 mm & under 2.5 m/Sec (8.2 fps) for piping over 50 MM dia Maximum friction 15 k Pa per 30 M Run (5 ft per 100 ft Run)

CODES AND STANDARDS

The system, design, materials, equipment and installation shall comply with all other applicable codes & standards and issued by:-

Table 5: Codes for HVAC Works

Codes	Description
	National Building Code 2005
	Energy Conservation Building Code 2008
ASHRAE 90.1-2014	ANSI/ ASHRAE/ IESNA standard 90.1-2014: Energy standard for buildings except low rise residential buildings.
	AMCA : Air Movement and Control Association
	ARI - American Refrigeration Institute
AHRI 410-2001 with Addenda 1, 2 and 3	Forced-Circulation Air-Cooling and Air-Heating Coils
ANSI/AHRI 430-2009	Central Station Air Handling Units
ANSI/AHRI 440-2008	Performance Rating of Room Fan-Coils
AHRI 550	Standard for centrifugal or rotary screw water chilling packages.
AHRI 575	Standard for method of measuring machinery sound within equipment room.
ASME: Section VIII Div.1	Code for Unfired Pressure Vessels Section VIII (Design; construction, testing and certification of pressure vessels) with 'U' stamping
ANSI B31.5	Code for Refrigeration piping
ASME B31.1	Code for Process piping
ISO 2858, 5199	Specifications for pumps
ASHRAE 52.1-1992	Air Filters
ASHRAE 62-1-2010	Indoor Air Quality
	Duct Fabrication as per SMACNA
IS : 277 – 1977	GI Sheets
IS : 737	Aluminum Sheets
IS : 325	Three-phase induction motors

IS : 659	Safety code for air conditioning,
IS : 660	Safety code for mechanical refrigeration
IS : 4671	Expanded polystyrene for thermal insulation purposes
IS : 4894	Centrifugal Fans
IS : 1239 & IS 3589	Pipe & Pipe Fitting
	Fire Damper UL555, CBRI approved
IS : 659 – 1964 (Reaffirmed 1991)	Air conditioning (Safety Code)
IS : 660 – 1963 (Reaffirmed 1991)	Mechanical Refrigeration (Safety Code)
BS : EN:779 – 1993	Filters
ASHRAE Hand Books	American Society of Heating, Refrigeration & Airconditioning Application 2007. Fundamentals 2005. Refrigeration 2006. Systems & Equipment 2008.
NFPA	National Fire protection code
	ASHRAE Indoor air quality Standard 62.1-2007. ASHRAE 90.1-2007 ASHRAE 55-2004 ASHRAE 52.1 and 52.2
IEC	Relevant Sections.

1.1 AIR COOLED SCREW CHILLER

System Description

Microprocessor-controlled air-cooled chiller utilizing a mono / twin rotor, 2960 rpm (50 HZ), direct drive, hermetic / semi-hermetic / open, screw compressor using refrigerant HFC-134a or any other ecofriendly alternative refrigerant.

Chillers using CFC refrigerants such as CFC-11, 12 or 500 shall not be acceptable.

Quality assurance

Unit shall be certified with Eurovent / AHRI standard. AHRI 550/590 or EUROVENTANSI / CE PED Directive

Unit shall be designed, manufactured and tested in a facility with a quality assurance system certified ISO 9001.

Unit shall be manufactured in a facility with an environment management system certified ISO 14001. Unit shall be tested at the factory.

Delivery, storage and handling-

Unit controls shall be capable of withstanding 55°C storage temperatures in the control compartment.

General (Products / Equipment) -

Factory assembled, single-piece, air-cooled liquid chiller contained within the unit cabinet shall be all factory wiring, piping, controls, refrigerant charge (HFC – 134a), required prior to field start-up.

Unit Cabinet-

- Frame shall be made of U steel beam and protected by three layers of paint.
- The control box plates shall be steel with an oven-baked polyester-paint finish, and be capable of withstanding a 500-hour salt spray test in accordance with the ASTM B-117 standard (U. S. A.)/ EN (Europe)

Fans-

- Condenser fans shall be direct-driven, die cast aluminium blades, shrouded-axial type, shall be statically and dynamically balanced, and made of recyclable material with inherent corrosion resistance. Air shall be discharged vertically upward.
- Fan shall be protected by coated steel wire safety guards.

Compressors-

- Unit shall have semi-hermetic twin-screw, gear-driven compressors with internal muffler and check valve.
- Each compressor shall be equipped with a discharge shut-off valve.
- Capacity control shall be provided by pilot-operated solenoid valve, capable of reducing unit capacity to 25% of full load. Compressor shall start in unloaded condition.
- Motor cooling shall be provided by direct liquid injection and protected by internal overload thermistor.
- Lube oil system shall include pre-filter and internal filter capable of filtration to 3 microns.

Evaporator-

Unit shall be equipped with a single evaporator-

- Evaporator shall be tested and stamped in accordance with applicable European/American pressure code PED / ASME for a refrigerant side operating pressure of 1700 kPa (service des Mines units) and for a maximum water-side pressure of 1000 kPa.
- Shall be mechanically cleanable shell-and-tube type with removable heads.
- Tubes shall be internally-enhanced, seamless-copper type, and shall be rolled into tube sheets.
- Shall be equipped with Victaulic water connections (accessory flanges on request).
- Shell shall be insulated with 19 mm closed-cell, polyvinyl-chloride foam with a maximum K factor of 0.28.
- Shall incorporate two independent refrigerant circuits.
- Shall have an evaporator drain and vent.

Shall incorporate a refrigerant level control system.

Condenser-

- Coil shall be air-cooled with integral subcooler and shall be constructed of aluminium fins mechanically bonded to internally finned cu tubes. The tubes are then cleaned, dehydrated & sealed.
- Condenser coils shall be leak tested and shall be pressure tested at 3400 kPa.
- Condenser fan motors shall be 3-phase type with permanently lubricated bearings and Class F (minimum) insulation. Variable Speed low-temperature Device to control condensation adjusting the rotational speed with voltage steps (auto-transformer).
- The fins shall have anti-corrosive coating (Acrylic/ Eco coat/ Bly Gold).

Evaporative Cooling Kit :

The Kit should automatically start when ambient temperature rises above 30°C (or any other re-settable set point). Plastic pipes and nozzles to be provided on condenser face to spray water on the plastic net. It should use ON/OFF solenoid valves & a controller to ON/OFF the Solenoid valve. It should comprise of sensor input, control set point, temperature & timer control, Display, push buttons, pressurising pump etc.

Alternatively, celdek pads are acceptable provided that they are mounted on SS sump on all sides of air intake and are sized adequately to ensure that air quantity does not come down during operation. The condenser fan should be oversized in this alternative to overcome the pressure drop through the celdek pads so that efficiency of the chiller does not come down below its specified limit.

Refrigeration Circuits-

Refrigeration circuit components shall include oil separators, high and low side pressure relief devices (according to applicable standards), discharge and liquid line shutoff valves, filter driers, moisture indicating sight glasses, electronic expansion devices, refrigerant economizers and complete operating charges of both refrigerant and compressor oil.

Controls, Safeties and Diagnostics-

1. Controls-

- a. Unit controls shall include as a minimum; the microprocessor board, and a 6-digit diagnostic display with keypad.
- b. Shall be capable of performing the following functions -
 - Automatic changeover between compressors.
 - Capacity control based on leaving chilled fluid temperature with return fluid temperature sensing.
 - Limiting the chilled fluid temperature pull-down rate at start-up an adjustable range of 0.1°C to 1.1°C per minute to prevent excessive demand spikes at start-up.
 - Enable adjustment of leaving chilled water temperature according to the return water temperature or by means of a 0 – 10 V signal to the outdoor temperature.
 - Provide a dual set point for the leaving chilled water temperature activated by a remote contact closure signal.
 - Enable a 2-level demand limit control (between 0 and 100%), activated by a remote contact closure signal.
 - Control water pump(s) operation.
 - Enable automatic lead-lag of two chillers in a single system.

2. Diagnostics-

- a. Display module shall be capable of displaying set points, system status (including temperatures, pressures, run time and percent loading), and any alarm or alert conditions.
- b. Control Module, in conjunction with the microprocessor, shall be capable of displaying the output of a full load run test to verify operation of every switch, sensor, fan and compressor before the chiller is started, & carrying out a diagnosis & preventive maintenance (incorrect water loop, oil filter dirty etc.)

3. Safeties-

- a. Unit shall be equipped with all necessary components and in conjunction with the control system shall provide the unit with protection against the following -

- Loss of refrigerant charge.
 - Reverse rotation.
 - Low chilled water temperature.
 - Low oil pressure (per compressor).
 - Current imbalance.
 - Thermal overload.
 - High pressure.
 - Electrical overload.
 - Loss of phase.
- b. Fan motors shall be individually protected by a circuit breaker.

Control shall provide general alarm remote indication for each refrigerant circuit. Control system shall have a RS485 serial output port (option and accessory).

Operating characteristics-

- Unit shall be capable of starting and running at full load at outdoor ambient temperatures from 0°C to 46°C.
- Unit shall be capable of starting up with 25°C entering fluid temperature to the evaporator.

Electrical characteristics-

- Unit electrical power supply shall enter the unit at one or two locations.
- Unit shall operate on 3-phase power supply without neutral.
- Unit with two compressors shall have a factory-installed, star-delta starter to limit electrical inrush current.
- Control voltage shall be supplied by a factory-installed transformer.
- Unit shall be supplied with factory-installed electrical disconnect switch / circuit breaker.

Finishing -

Electrical Cabinet Color - as per HVAC Consultant/Project Consultant/ Client. Compressor / Heat Exchanger Color - as per HVAC Consultant / Project Consultant / Client

Low-voltage unit mounted starter

A reducer voltage wye-delta or double / solid-state starter shall be supplied. The compressor motor starter shall be factory mounted, wired, and tested prior to shipment by the chiller manufacturer. Customer electrical connection for compressor motor power shall be limited to main starter power connection only.

Solid-state starter shall provide stepless compressor motor accelerating and limit motor in rush current to 150-300% of compressor motor RLA. The starter shall include 6 Silicon Control Rectifiers (SCR) with integrally mounted bypass contactors to provide SCR by pass once the motor has achieved full voltage and speed. The starter shall also include automatic acceleration kick circuitry which monitors motor current subsides and automatically ramps voltage up at a faster rate to eliminate the instability that occurs at the break away torque point.

Starter shall be UL and CSA approved and shall include-

- NEMA 1 enclosure with integral fan cooling and lockable hinged doors.
- Main power disconnect (non-fused type)
- Solid-state 3-phase over load relay with manual reset.
- 2 KVA control / oil heater transformer
- Branch circuit breaker for control power and oil heater
- 5 pilot relays for control of chilled water pump. Condenser water pump, tower fan, customer remote alarm, shunt trip, and main power disconnect. The shut trip shall be energized by the SMM during unauthorized operation (such as loss of communication) between the SSM (Starter Management Module) and PSIO (Processor Sensor Input / Output Module).

Solid-state starters also include the following standard features-

- Current imbalance detector which monitors 3 phase motor current to provide the following protection-
 - Phase loss
 - Phase reversal
 - Phase imbalance
 - Ground fault
 - Shorted SCR
 - Current flow while stopped protection
- Diagnostic LED's shall be provided to indicate :
 - Starter on
 - Run (up to voltage)
 - Phase correct
 - Over temperature fault
 - SCR gates energized

- Ground fault
- Current imbalance fault
- Shorted SCR.

I²T fuses the solid-state circuitry at 200,000 amp interrupting capacity.

Electrical requirements

The contractor shall supply and install main electrical power line, disconnect switches, circuit breakers, electrical protection devices per local code requirements and as indicated necessary by the chiller manufacturer.

The contractor shall wire the water flow switches to the chiller control circuit to ensure that chiller will not operate until flows are established & maintained as per contractors / consultant's specifications.

The contractor shall supply and install electrical wiring and devices required to interface the chiller controls.

Piping requirements – instrumentation and safeties

The contractor shall supply and install pressure gages in readily accessible locations in piping adjacent to the chiller such that they can be easily read from a standing position on the floor. Gages shall be very accurate. Scale range shall be such that design valves shall be indicated at approximately mid-scale.

Gauges shall be installed in the entering and leaving water lines of the cooler and condenser.

HVAC contractor shall supply & install flow detection devices in chilled water and condenser water piping. Switches shall make contact when flow is established. Flow switches shall be installed in horizontal runs at least 5 pipe diameters down-stream from any bend or tee.

4. Insulation

1. Chilled water piping and cooler water boxes shall be installed by the HVAC contractor.
2. Chiller shall be insulated at factory. Final layer of insulation shall be installed at the job site by the HVAC contractor along with cladding.
3. Chiller insulation shall confirm to UL standard 94, classification 94 HBF and should be suitable for positive temperature operation.

5. Vibration isolation

Chiller manufacturer shall furnish neoprene isolator pads for mounting equipment on a level concrete surface.

Start-up

1. The manufacturer shall provide a factory trained representative, employed by the chiller manufacturer, to perform the start-up, operation and maintenance manual provided by the chiller manufacturer.
2. After the above services have been performed, the same factory trained, representative shall be available for a period of class room instruction (not to exceed 4 hours) to instruct the chiller owner's personnel in the proper operation and maintenance of the chiller.
3. Manufacturer shall supply the following literature-
 - a. Start-up, operation and Maintenance Instructions.
 - b. Installation Instructions
 - c. Field Wiring Diagrams
 - d. Maintenance manual showing maintenance based on calendar basis and hourly basis.

6. Quality Assurance

- i. Chiller performance shall be rated in accordance with AHRI Standard 550/590, latest edition.
- ii. Equipment and installation shall be in compliance with ANSI/ASHRAE 15 (latest edition).
- iii. Cooler and condenser shall be ASME "U" stamped and nameplate certifying compliance with ASME Section VIII code for unfired pressure vessels.
- iv. Centrifugal compressor impellers shall be dynamically balanced and over-speed tested by the manufacturer at a minimum of 120% design operating speed. Each compressor assembly shall undergo a mechanical run-in test to verify vibration levels, oil pressures, and temperatures are within acceptable limits.

Each compressor assembly shall be proof tested at a minimum 204 psig (1406 kPa) and leak tested at 185 psig (1276 kPa) with a tracer gas mixture.
- v. Entire chiller assembly shall be proof tested at 204 psig (1406 kPa) and leak tested at 185 psig (1276 kPa) with a tracer gas mixture on the refrigerant side. The water side of each heat exchanger shall be hydrostatically tested at 1.5 times maximum working pressure.
- vi. Prior to shipment, the chiller automated controls test shall be executed to check for proper wiring and ensure correct controls operation.

1.2 PUMPS:

(A) Pumps shall be of Horizontal split-case type and suitable for the given duty points and parallel operation -

i	Type	-	Inline / End Suction
ii	Impeller	-	Bronze confirming to BS - 1400
iii	Shaft	-	High Tensile Steel
iv	Bearings	-	Ball/Roller
v	Pump/Motor Body	-	CI confirming to IS -210
vi	Seal	-	Mechanical
vii	Motor	-	Sq. cage T.E.F.C.
viii	Starter	-	Star Delta
ix	Shaft Sleeve	-	Bronze LG2

Pumps shall be selected for the rated conditions indicated. Efficiency of the pump proposed to be used shall be high. Peak efficiency shall be obtained at or near rated conditions. Impellers shall be statically and dynamically balanced.

(B) Motor rating shown are only tentative and tenderer shall select their drives at 5% in excess of the max. BHP of the pumps.

The following accessories shall be provided where required with each pump besides other standard accessories -

- i. Lubrication fittings and seal packing.
- ii. Test and air vent cock.
- iii. Drain Cock.
- iv. Adequately sealed Terminal box for Aluminium conductor armored cable termination.

(C) The following fittings shall be provided with each pump besides other standard fittings (to be measured and paid for separately) -

- i. Suction and discharge shut-off valve, discharge check valve as specified under respective items.
- ii. Suction and discharge pressure gauge not less than 150 mm diameter & of the appropriate rating with gauge cocks etc.
- iii. 25mm GI drain piping up-to the nearest drain point.

- (D) The pump casing should be of closed grain with smooth finishing ensuring minimum frictional losses and having sufficient strength to withstand the forces due to water flow at all working conditions.
- (E) The impeller should be of Bronze and statically and dynamically balanced to ensure smooth working without vibration and noise.
- (F) Pumps shall be installed as per the manufacturer's recommendation. Pump shall be mounted on floating foundations, which in turn are mounted on vibration isolators. The Contractor shall supply the floating frame and vibration isolators & concrete foundation.
- (G) After complete installation, original paint of the pump shall be retouched and accessories, fittings and floating foundations frame shall be given two coats of synthetic enamel paints of color specified in specifications for painting Works / Approved color over a coat of primer.

Specifications for Secondary Chilled Water Variable Pumping System

GENERAL

The variable pumping system should allow for the operation of multiple pumps of the same size in parallel at the same output frequency. It shall stage the pumps on and off as required to meet the system demand to provide increased performance, precision control and maximum energy savings.

The pump controller software package should determine the settings for the controller to help in optimizing the control system by predicting the best staging on and off frequencies.

CONFIGURATION

The pump controller shall form an integral part of the VFD itself and shall not be supplied as a stand-alone basis. It shall have a 4-line alphanumeric display which is capable of displaying all the operating parameters. It shall be possible to program the VFD and the pump controller through the same local display panel. It shall be possible to supply the VFD and pump controller in IP 20 and IP 54 protection. Display key pad should be detachable and can be mounted on the panel door (up to 3 meter distance)

The pump controller shall be capable of running up to five equally sized pumps in parallel in the best efficiency pattern.

The VFD-cum-pump controller shall be suitable for adapting itself to any locally available standard sized pumps and shall be capable of maintaining its best efficiency operating pattern throughout its operating speed. No de-rating of the pump motor shall be applicable to the offered VFDS.

AUTO / OFF/ MANUAL CONTROL

It shall be possible to set the Auto / Manual control for the pumps from the control panel of the VFD. During normal operation on the VFD shall be in the AUTO mode and the pump controller should start and stop the pumps as necessary. The HAND position should allow for the manual start of each pump as necessary e.g. at manual operation, commissioning etc. It shall be possible to permanently disable a pump by setting the switch to OFF. If a pump is disabled for service, the pump controller shall enable the next pump to be switched ON to meet the system demand.

OPERATING MODE

The VPS shall follow a master / slave systems set up, where all pumps and are speed controlled with Variable Frequency Drives. The pumps shall be of the equal size and should be run at the same speed. One of the VFD shall act as a master and the other VFDS shall act as slaves which follow the speed of the master pump. It shall be possible to stage ON and OFF the slave pumps as necessary by the master to match the system requirement.

The in built pump controller shall calculate the best efficiency operation which optimizes the number of pumps to achieve the highest system efficiency based on the number of pumps operating in parallel, the system design head and set point head and the pump curves.

STAGING / DESTAGING DELAY

It shall be possible to program a staging and de-staging delay time to prevent fast cycling of the slave pumps.

PUMP CYCLING

In order to achieve equal operation of the slave pumps, the pumps should be cycled. Whenever a pump has to be started, the pump with the least hours is switched on. In case a pump has to be switched off, the pump with the most hours is switched off.

STAGING FREQUENCIES

It shall be possible to program the staging ON / OFF frequencies in the display panel of the VFD which will determine the frequencies at which the slave pumps should be switched ON & OFF to maintain the best efficiency operation.

DRY RUNNING PROTECTION

The pump controller shall have a provision to wire a flow switch to the interlock terminals to avoid dry running of the pumps.

PID CONTROLLER

The system shall be controlled through a fully programmable PID controller which has the capability to accept the set points in process units (e.g. GPM or m³/h).

The PID controller shall have the provision to accept two remote feedback signals from differential pressure transmitters, giving an out put of 4-20 mA, located in the chilled water pipe line from the field. It shall be possible to select the most deviated signal as feedback for controlling the speed of each pump. Each input signal shall be capable of accepting a different set point. The controller shall be capable of controlling up to 5 pumps in parallel in the master / slave control mode.

It shall be possible to program the proportional, integral and derivative value inputs to the controller for fine tuning of the PID controller.

DISPLAY

The pump controller VFD shall have a 4-line, back lit, alpha numeric display capable of displaying all messages in English in text form. It shall have a quick programming menu for faster commissioning and a detailed menu for fine tuning of the system parameters.

The display panel shall have LED pilot lights for RUN, TRIP and WARNING conditions. The key pad switches shall be of soft touch type.

The following parameters shall be displayed on the display panel-

RPM of the pumps

Differential pressure in kg/cm²

Motor Current in Amperes

Motor voltage in Volts

Energy consumed by individual pump in kWh

Run time of each pump in hours

No of pumps working (on the master drive)

KW consumed by the pump in kW

1.3 VARIABLE FREQUENCY DRIVES FOR AHU's, & PUMPS

The VFD shall be of the type suitable for operation on a 3 phase, 415 V, 50 Hz input power supply at the following conditions:

Input supply voltage variations	:	+ 10 %
Input supply frequency variations	:	48 – 52 Hz + 1%
Ambient temperature	:	0 - 45o C, without derating.
Maximum relative humidity	:	95% non condensing
Vibration	:	0.7 G RMS in 3 directions
Minimum efficiency at full load	:	97%

The VFD's will be mounted in the open near the AHU's / Pumps in the AHU / Plant room. Hence the VFD's shall have integrated; factory built metallic enclosures of IP 55 rating, without any de-rating. VFD's of IP 00 / IP 20 / IP 21 / IP 42 rating enclosures with additional sheet metal enclosures to achieve IP 55 ratings are not permitted.

VFD's shall conform to the recognized international standards like IEC and manufactured according to ISO 9001, BS 5750 part 1 & 2 and shall be UL listed. It shall carry the CE mark on EMC compliance.

The VFD shall be capable of providing a starting torque of 160% for 0.5 sec and an overload torque of 110% torque for 1 minute.

The VFD shall maintain full output voltage during main's variations of $\pm 10\%$ to prevent loss of torque and speed variations occurring during motor operation.

The VFD shall comply with Electro Magnetic Compatibility (EMC) document IEC/EN 61800 -3 for Radio Frequency Interference (RFI) control (emission) as an integral part of its design by incorporating RFI filters to meet C1 -50 Mts, Unrestricted distribution for conducted emission.

For AHU application, VFD should be able to give "Clog Filter" (by potential free contact) indication as per the set pressure requirement.

If a temperature / pressure / flow feedback signal is given to the VFD, it shall use its PID controller to modulate the speed in such a way that the set point of temperature or pressure is accurately maintained. This should eliminate the requirement of PID loop of BMS or external PID controller.

Additional PIDs (3 Nos.) are required to control chilled water valves and fresh air damper. This should be an integral part of the VFD.

The VFD shall be capable of accepting three such feedback signals simultaneously and be able to do a speed control based on average / sum / difference / minimum / maximum / 3 zone control of the above 2 signals. This should work in absence of BMS or should not use PID loop of BMS, in case of presence of BMS.

The PID controller shall be capable of programming the set points and incoming signals in any of the flowing units : RPM, l/s, l/m, l/h, m3/h, m3/s, bar, Pa, kPa, GPM, lb/s, lb/h, CFM, in3/h, inwg, ft wg, PSI, kW, HP, oC, oF, as required by the application, and be able to display the same while in operation. This should eliminate the requirement of PID loop of BMS or external PID controller.

In case the VFD detects a broken belt (AHU etc.) or coupling (pumps etc.), it shall display a warning signal to that effect. There shall be provision to export this warning signal to the BMS system through RS 485, without any need of I/Os of BMS.

For easier maintenance and to reduce inventory, the VFD shall allow connection of motors one frame size larger and 4 sizes smaller than its nominal rating.

The VFD shall have the following protective functions: Electronic motor overload, Protection to motor and VFD against input transients, phase loss, short circuit, under voltage, over voltage, phase imbalance, motor over temp., phase to phase short circuit or earth fault at motor terminals.

The VFD's shall have internal harmonic filters on the DC bus (on both positive & negative limbs) to reduce THVD to below 5% as per IEEE standard 519-1992. AC line chokes on the input side are not allowed for harmonic current control as it will cause voltage drop to the VFD and motor.

The Upeak of the VFD shall be below 1000 Volts (when measured with a cable length of 50 meters) to prevent damage to motor insulation.

Manufacturer of the VFD shall submit data sheet to verify this requirement in order to permit the usage of standard motors for the applications specified.

The VFD shall be capable of having an output motor cable length of at least 150 meters (armored cabling) without any need of additional equipment like output chokes.

This is essential for applications like chilled water pumps where the motors are located far away from the control center.

The VFD's shall incorporate a surge protection circuit as standard to protect the VFD from transients and spikes in the incoming power supply.

The VFD shall be fully protected from switching a contactor / isolator at the output without causing tripping e.g.: for switching on/off the isolators of the AHU / ventilation fans / pumps near the motor and switching back ON with VFD in on mode.

The display of the VFD shall be Alpha numeric (Graphical) type.

LED displays are not acceptable, as it is not user friendly. Display of all messages and faults shall be in English text format. Codes are not acceptable. The display shall show the following operating parameters:

- Energy consumed in kWh
- Power consumed by motor in kW
- Run time of motor in Hours
- Current drawn by motor in Amps.
- Output frequency in Hz.
- Motor speed in RPM
- Set point in process units
- Feedback in process units

- 1) It shall be possible to see at least 4 of the above operating parameters in the VFD display, simultaneously.
- 2) The VFD's shall have internal galvanic isolation (PELV) to avoid damage to BMS / PLC / DDC system when interconnected. If PELV is not available, the VFD vendor should offer opto-isolators for all the inputs and outputs in the VFD.
- 3) The VFD shall automatically operate at high switching frequency at low speeds and low switching frequency at high speeds to maintain silent operation of the AHU's at all speeds. The switching frequency range shall be from 4-14 kHz for VFD's to be installed on AHU's.
- 4) The VFD shall optimize the magnetizing current on a real time basis based on actual torque requirement (energy optimization function) to minimize the power consumption compared to standard variable torque VFD's. VFD's offering fixed settings of V/f ratios are not permitted.
- 5) The VFD shall have Auto / OFF / Manual switch on the key pad itself. It shall be possible to manually change the speed of the AHU's from the key pad of the VFD, if required, without the

- need of an external potentiometer. In manual mode the speed reference signal shall be from keypad of VFD and in auto mode, the reference shall be from the remote – either BMS or transmitter.
- 6) The VFD shall have self adjustable ramp times to prevent tripping / VFD damage in case in appropriate ramp times is set with respect to application requirement.
 - 7) The VFD's shall have the provision to program a minimum and maximum speed of operations, through the VFD programming itself.
 - 8) In case of a power failure, the VFD shall be capable of automatically restarting after a programmable time delay, without the need of an operator having switch on the unit.
 - 9) To prevent damage to the VFD's due to pre-rotating fans, the VFD shall have the capability to detect such spinning fans and adjust its frequency to its spinning speed before it starts controlling the fan. If the fan is running in the opposite direction, the VFD should brake the fan by sending a DC current, before starting the fan in the right direction.
 - 10) If the transmitter feedback signal goes below a particular low limit value or goes above a particular high limit value, the VFD shall give an alarm signal. It shall be possible to transfer this signal to the BMS system as well.
 - 11) The VFD shall be provided with at least 4 by-pass frequencies with adjustable band width in order to eliminate resonance in duct work and pipe lines occurring within the motor's operating frequency range.
 - 12) The VFD shall have an auto de-rating facility by operating at a lower capacity in case of a phase loss or higher ambient temperature so that minimum air conditioning can be maintained. VFD's that trip on a phase loss or high ambient temperatures are not suitable for this application and hence not permitted.
 - 13) The VFD's shall have the provision of 4 parameter set ups, which can be activated by the BMS or by digital inputs.
 - 14) The variable frequency drives (VFD) shall have the provision to integrate into a BMS system, utilizing a serial communication protocol – open protocol or BMS specific protocol - that enables a full “read & write” seamless interface between the VFD & BMS. The VFD manufacturer shall be responsible for technical support to the BMS Vendor in the implementation of a serial interface to the BMS System. The BMS Vendor shall be responsible for the complete “integration and interoperability” of the VFD through the BMS via the serial interface.
 - 15) The VFD shall provide to BMS, via serial communication (by RS-485, 2 wire), access to the following VFD parameters as a minimum:
 - Motor current
 - Motor kW
 - AHU KWh

- AHU Running hours
 - Auto / Off / Manual status feedback
 - PID controller programming
 - Set point programming
 - Alarms
 - Run & Trip status
 - Air flow status / alarm
 - Dirty filter status / alarm
 - Fault log history
- 16) The VFD shall also be able to provide the following selectable & programmable physical I/Os to the BMS system
- 6 Digital inputs (for start, stop, interlock, auto, manual, setup selection etc).
 - 2 Relay outputs (for reading Auto / Manual status & VFD On / Off indication)
 - 2 Analog input, 4 – 20 mA (for single feedback signal to VFD)
 - 3 Analog inputs 0-10V (for feedbacks, if two feedbacks are taken)
 - 1 Analog Outputs, 4-20 mA (for speed & kW feedback to BMS)
 - 2 Analog Outputs, 0-10V for any other feedback required.
- 17) VFD shall have inbuilt real time clock for scheduling purpose.
- 18) If the VFD loses the feedback signal or reference signal in auto mode, the VFD shall be capable of maintaining the speed at which it is running.
- 19) If the VFD operates at the minimum speed for a set time, it shall be able to program the VFD to automatically switch off to save power.
- A parameter lock shall be available in the VFD local display panel to prevent unauthorized resetting of parameters.

DOUBLE SKIN AIR HANDLING UNIT/s-

Air Handling Units shall consist of fan section, coil section, Pre-filter section & will have the construction as described below -

Air handling units will be in double skin construction fabricated out of Aluminium Extruded section and 43 mm thick Double skin panels for TFA units & 25 mm thick Double skin panels for Recirculation AHUs/ CSUs.

Aluminium sections should have double walled rib having a groove for the gasket on the panel side face and plane surface on internal face. Panel side face should also have additional plane face available for stick on type gasket to facilitate the fixing of additional gaskets in future if required. Units will be supplied with round gasket in solid / tubular construction fixed in the groove. Gasket will be made out of PVC / Synthetic rubber. Extruded section will be having scratchproof anodized finish. The extruded frame structure will be formed using couplers made out of glass filled nylon, (approx. 30% glass and 70% nylon).

a. AHU Casing-

Double skin panels will be fabricated out of best quality 22G G. I. Powder coated sheet on outer side and plane 24G G. I. Sheet on inner side. Polyurethane foam of density not less than 36 Kg./Cu. M. will be sandwiched between inner and outer sheet. The panels will be fixed on Al. Extruded section in such a manner that fixing screw head does not project on outer face on the panel and sharp end of the screw does not project inside the unit through double walled rib. The screw hole on panel will be blocked with Nylon sleeve with cap. The panels shall be 43 mm thick for TFA units & 25 mm thick for Recirculation AHUs/ CSUs. The screw cavity on panel will be blocked with nylon sleeve with cap.

Drain tray will be fabricated out of SS sheet having thickness not less than 1.2mm (18 G). The tray will have sufficient depth and proper size drain connection. The tray will be insulated from outside with nitrile rubber foam sheet having thickness not less than 20mm. The rollers in nylon construction will be provided below the coil for easy removal of coils in the AHUs of areas dealing with powder. Gasket sleeves at chilled water header outlet will be provided in such a design that the same does not obstruct the pulling of coil at the time of removal.

Filter section will have rigid construction filter frame fabricated out of GI sheet to house required size filters. The filters will be in flange type construction having GI casing.

Blower section will consists of extruded sections of proper size to facilitate the mounting of fan and motor bracket. Direct contact of fan base frame and AHU casing will be eliminated through vibration isolator. Also flexible connection will be provided at the fan outlet. Suitable panel of blower section will be provided with hole for cable entry with required arrangement to cover the sharp edge GI sheet. If required, a proper size box cover will be provided on cable entry location. A provision for earthing will be provided on mainframe near the cable entry hole.

Inspection doors at required location will be provided with elegant design hinges made out die cast Aluminium alloy. Two or more number of hinges per door will be provided depending upon the size of the door to provide required rigidity to the door panel. One or more number of door handles will be provided with can type tightening arrangement. The handle and can will be made out of filled nylon having galvanized iron spindle. The inspection door for blower section will be provided at such a location that the motor and drive package and fan bearing can be accessed for easily maintenance. An additional guard made out of GI wire mesh of required strength will be provided at inner side of blower section inspection door. A limit switch / door switch covered electrical terminal will be provided to facilitate the door inter locking with fan operation. An inspection glass fitting having the transparent element on both side of the panel with a common gasket sleeve between two elements will be provided on blower section inspection door to facilitate inspection of drive package in running condition without opening the inspection door. The inspection doors of the sections accommodating filters will be of sufficient size to take care of filter removal.

Necessary arrangement with required plastic / nylon fittings will be provided at required locations to facilitate the mounting of temperature Humidity & pressure sensors as per requirement of BMS vendors.

Properly designed nipples will be provided at required locations to facilitate the connection of manometer tubes / pressure transmitter.

The entire AHU assembly will be mounted on a common skid fabricated out of HDG MS channel of required size. The skid will be secured with AHU frame structure through threaded fasteners. The skid will be duly painted after fabrication with the best quality rust preventive primer followed by two coats of enamel paint.

All nut bolts, sheet metal screws, fasteners will be Zinc / Nickel plated having resistance against rusting.

b. Cooling Coils-

The cooling coils will be 4/6 Row deep, depending on the utility of the AHU. The cooling coils shall be fabricated out of copper tube having OD not less than 12.5 mm and Aluminium fins spaced @ 12 fins / inch. Aluminium fins & copper tubes will have foam bond provided by hydraulic expansion method at the high pressure above yield point. The capacity of the coils shall be as required under the schedule of equipment. Velocity of air across coil face shall not exceed 500 FPM for 4 Row coil and 600 FPM for 6 Row coil. All coils should be AHRI Certified.

c. Fan-

Fan wheels and scrolls shall be fabricated from best quality sheet steel. The fan wheels shall be of the forward / backward curved type enclosed in housing and mounted on a solid shaft.

Fan scrolls shall be fitted with die formed side sheet streamlined inlet and to ensure smooth airflow into the fan.

All Fans should be AMCA Certified, irrespective of the application.

d. Filters-

Pre-filters shall be HDPE washable types with 2" thickness with filtration level of 10 micron & efficiency of 90%. The pre-filter section will be located on suction side of the filters. The filters will be IGBC Compliant and MERV-13 rating.

e. Fan motors-

Fan motors shall be 3 phase, sq. cage, and T.E.F.C. induction type, together with starters, specified in "ELECTRICAL ITEMS" separately. The motors shall be capable of high initial starting torque requirement of fans.

f. Accessories-

Air Handling Units shall be complete with all accessories & shall also include the following- -

- a. Shut-off valves, diverting valve, manual air vents, drain valves for cooling coils and drain piping.
- b. Vibration eliminators and flexible connections.
- c. Supply & return water with dial type thermometer having a range of 0 to 50oC.
- d. 100 mm dia. pressure gauges (0 to 6 Kg/Cm²) with 10 mm of Needle valve at inlet and outlet.
- e. Automatic chilled water flow control with modulating valves.

(All the above specified accessories are quantified in BOQ and shall be measured separately).

g. MIXING BOX (IF REQUIRED)

AHU's requiring mixing boxes as specified in Schedule of Quantities shall be complete with fresh and return air dampers.

h. THERMAL BREAK PROFILE

AHU's such as TFA units, AHU with mixing box having return air ducted shall be provided with thermal break profile as indicated in schedule of quantities.

i. DAMPER

Dampers shall be opposed blade type. Blades shall be made of double skinned aerofoil aluminum sections with integral gasket and assembled within a rigid extruded aluminum alloy frame. All linkages and supporting spindles shall be made of aluminum or nylon, turning in Teflon bushes. Manual dampers shall be provided with a bakelite knob for locking the damper blades in position. Linkages shall be extended wherever specified for motorized operation. Damper frames shall be sectionalized to minimize blade warping. Air leakage through dampers when in the closed position shall not exceed 1.5% of the maximum design air volume flow rate at the maximum design air total pressure.

J. MOTOR AND DRIVE

Fan motors shall be Eff-1, 415±10% volts, 50 cycles, three phases, totally enclosed fan-cooled class F, with IP-55 protection. Motors shall be especially designed for quiet operation and motor speed shall not exceed 1440 rpm. Drive to fan shall be provided through belt-drive arrangement. Belts shall be of the oil-resistant type.

K. FRESH AIR INTAKES

Extruded aluminum construction duly anodized (20 microns and above) fresh air louvers with bird screen and dampers shall be provided in the clear openings in masonry walls of the air handling unit rooms having atleast one external wall. Louvers, damper, pre-filters, ducts and fresh air fan with speed regulator shall be provided as shown on Drawings and in Schedule of Quantities. Fresh air dampers shall be of the interlocking, opposed-blade louver type. Blades shall be made of extruded aluminum construction and shall be rattle-free. Dampers shall be similar to those specified in "Air Distribution". Fresh air fans and fresh air intakes shall be as per the requirements of Schedule of Quantities.

1.5 FAN COIL UNIT

The Fan Coil Units will be made out of GI sheet steel with forward curved fan and three row chilled water coil. The entire FCU will be powder coated and will be provided with filter box. The FCU will also be provided with auxiliary drain pan (sand witched insulated). The drain connection will be made from both the drain points of main drain tray and the auxiliary drain pan. The construction drawing of the FCU will be approved by the Consulting Engineer / Employer and the successful tenderer will have to take specific approval as regards to the installation & various connections from the Consulting Engineer. All the FCUs being installed, as exposed units should be provided with decorative, powder coated extruded sectioned

aluminum grille with approved colour shade. The grilles for the FCU shall be measured separately and paid. The FCU should be designed in a manner that the drain tray is housed within the body of FCU. The FCU shall be front accessible type and of draw through type construction.

1.6 FANS

SCOPE

The scope of this section comprises the supply, erection, testing and commissioning of centrifugal, in-line and propeller type fans and roof mounted units conforming to these Specifications and in accordance with the requirement of Drawings and Schedule of Quantities.

TYPE

Centrifugal, in-line propeller fans and roof mounted units shall be of the type as indicated on Drawings and identified in Schedule of Quantities.

CAPACITY

The air-moving capacity of fans shall be as shown on Drawings and in Schedule of Quantities.

CENTRIFUGAL FAN

Centrifugal fan shall be DWDI / SWSI Class I construction arrangement 3 (i.e. bearings on both the sides) for DWDI fans complete with access door, squirrel-cage induction motor, V-belt drive, belt guard and vibration isolators, direction of discharge / rotation, and motor position shall be as per the Approved-for-Construction shop drawings.

- a. Housing shall be constructed of 14 gage sheet steel welded construction. It shall be rigidly reinforced and supported by structural angles. Split casing shall be provided on larger sizes of fans, however neoprene / asbestos packing should be provided throughout split joints to make it air-tight.
18-gauge galvanized wire mesh inlet guards of 5 cm sieves shall be provided on both inlets. Housing shall be provided with standard cleanout door with handles and neoprene gasket. Rotation arrow shall be clearly marked on the housing.

- b. Fan Wheel shall be backward-curved non-over loading type. Fan wheel and housing shall be statically and dynamically balanced. For fans upto 450 mm dia, fan outlet velocity shall not exceed 550 meter/minute and maximum fan speed shall not exceed 1450 rpm. For fans above 450 mm dia, the outlet velocity be within 700 meter/minute and maximum fan speed shall not exceed 1000 RPM. High static pressure fan speed shall be as per manufacturer.
 - c. Shaft shall be constructed of steel, turned, ground and polished.
 - d. Bearings: shall be of the sleeve / ball-bearing type mounted directly on the fan housing. Bearings shall be designed especially for quiet operation and shall be of the self-aligning, oil / grease pack pillow block type.
 - e. Motor : Fan motor shall be energy efficient and suitable for $415 \pm 10\%$ volts, 50 cycles, 3 phase AC power supply, squirrel-cage, totally enclosed, fan-cooled motor, provided with class F insulation, and of approved make. Motor name plate horsepower shall exceed brake horsepower by a minimum of 10%. Motor shall be designed specially for quiet operation and motor speed shall not exceed 1440 rpm.
- The fan and motor combination selected for the particular required performance shall be of the most efficient (smallest horse power), so that sound level is lowest.
- f. Drive to fan shall be provided through belt with adjustable motor sheave and a standard belt guard. Belts shall be of the oil-resistant type.
 - g. Vibration Isolation : MS base shall be provided for both fan and motor, built as an integral part, and shall be mounted on a concrete foundation through resistoflex vibration isolators. The concrete foundation shall be atleast 15 cm above the finished floor level, or as shown in approved-for-construction shop drawings.

AXIAL FLOW FAN

Fan shall be complete with motor, motor mount, belt driven (or direct driven) and vibration isolation type, suspension arrangement as per approved for construction shop drawings.

- a. **Casing** : shall be constructed of heavy gage sheet steel. Fan casing, motor mount and straightening

vane shall be of welded steel construction. Motor mounting plate shall be minimum 15 mm thick and machined to receive motor flange.

An inspection door with handle and neoprene gasket shall be provided. Casing shall have flanged connection on both ends for ducted applications. Support brackets for ceiling suspension shall be welded to the casing for connection to hanger bolts. Straightening vanes shall be aerodynamically designed for maximum efficiency by converting velocity pressure to static pressure potential and minimizing turbulence. Casing shall be bonderized, primed and finish coated with enamel paint.

- b. Rotor : hub and blades shall be cast aluminium or cast steel construction. Blades shall be die-formed aerofoil shaped for maximum efficiency and shall vary in twist and width from hub to tip to effect equal air distribution along the blade length. Fan blades mounting on the hub shall be statically and dynamically balanced. Extended grease leads for external lubrication shall be provided. The fan pitch control may be manually readjusted at site upon installation, for obtaining actual air flow values, as specified and quoted.
- c. Motor: shall be energy efficient squirrel-cage, totally-enclosed, fan cooled, standard frame, constant speed, continuous duty, single winding, suitable for $415 \pm 10\%$ volts, 50 cycles, 3 phase AC power supply, provided with class 'F' insulation. Motor shall be specially designed for quiet operation. The speed of the fans shall not exceed 1000 RPM for fans with impeller diameter above 450 mm, and 1440 RPM for fans with impeller diameter 450 mm and less. For lowest sound level, fan shall be selected for maximum efficiency or minimum horsepower. Motor conduit box shall be mounted on exterior of fan casing, and lead wires from the motor to the conduit box shall be protected from the air stream by enclosing in a flexible metal conduit.
- d. Drive : to fan shall be provided through belt drive with adjustable motor sheave and standard sheet steel belt guard with vented front for heat dissipation. Belts shall be of oil-resistant type.
- e. Vibration Isolation : The assembly of fan and motor shall be suspended from the slab by vibration isolation suspension of rubber-in.

PROPELLER FAN

Propeller fan shall be direct-driven, three or four blade type, mounted on a steel mounting plate with orifice ring.

- a. **Mounting Plate** shall be of steel construction, square with streamlined venture inlet (reversed for

supply applications) coated with baked enamel paint. Mounting plate shall be of standard size, constructed of 12 to 16 gauge sheet steel depending upon the fan size. Orifice ring shall be correctly formed by spinning or stamping to provide easy passage of air without turbulence and to direct the air stream.

- b. **Fan Blades** shall be constructed of aluminium or steel. Fan hub shall be of heavy welded steel construction with blades bolted to the hub. Fan blades and hub assembly shall be statically and dynamically balanced at the manufacturer's works.
- c. **Shaft** shall be of steel, accurately ground and shall be of ample size for the load transmitted and shall not pass through first critical speed thru the full range of specified fan speeds.
- d. **Motor** shall be standard (easily replaceable) permanent split capacitor or shaded pole for small sizes, totally enclosed with prelubricated sleeve or ball bearings, designed for quiet operation with a maximum speed of 1000 rpm for fans 60 cm dia or larger and 1440 rpm for fans 45 cm dia and smaller. Motors for larger fans shall be suitable for $415 \pm 6\%$ volts, 50 cycles 3 phase power supply, and for smaller fans shall be suitable for $220 \pm 6\%$ volts, 50 cycles single phase power supply. Motors shall be suitable for either horizontal or vertical service as indicated on Drawings and in Schedule of Quantities.
- e. **Accessories** : The following accessories shall be provided with propeller fans :
 - i. Wire guard on inlet side and birdscreen at the outlet.
 - ii. Fixed or gravity louvers built into a steel frame at the outlet.
 - iii. Regulator for controlling fan speed for single phase fan motor.
 - iv. Single phase preventors for 3 phase fans.

STRAINERS

Strainer shall be provided at the suction side of pump and chilled water cooling coil. Strainer shall be ISI Marked and preferable of approved type and shall have fabricated steel bodies of ample strength to withstand the test pressure specified for the gate valves.

Strainer shall have flanges for connecting the piping. Strainer shall be designed so as to enable blowing out accumulated dirt & facility of removal & replacement of the screen without disconnecting from main piping. Each strainer shall be provided with equal size isolating valves so that strainer may be cleaned without draining the system.

PIPING INSTALLATION-

The drawing indicates schematically the size and location of pipes. The Contractor, on the award of the work, shall prepare detailed working drawing. He must keep in view the specific opening in building and other structures through which the pipes are designed to pass.

Piping shall be properly supported on or suspended from stands, clamps, hangers etc., as specified & required. The Contractor shall adequately design all the brackets, saddles, clamps, hangers etc. and shall be responsible for their structural integrity. The pipe hangers shall provide vibration free installation.

Pipe support shall not exceed the following spacing -

Maximum Spacing of pipe Supports

1.	Nominal pipe size mm.	25	50	75	100	150	
		200	300				
2.	Maximum span meters	2	3	3.5	4	5	6
		6					

Insulated piping shall be supported in such a manner as not to put undue pressure on the insulation. Metal sheet shall be provided between the insulation and clamp, saddle or roller extended at-least 150mm on both sides of the clamp, saddle or roller. High-density polyurethane saddles be used between M.S. angles & pipes.

Vertical piping shall be parallel to walls and column lines and shall be straight and plumb. Risers passing from floor to floor shall be supported at each floor by clamps or collars attached to pipe and with a 10mm thick rubber pad or any resilient material. Where pipes pass through the terrace floor, suitable flashing shall be provided to prevent water leakage.

Pipe sleeve of 50 mm larger than the pipe diameter shall be provided wherever pipe pass through walls and the annular space filled with felt and finished with plaster. Moreover, pipes shall be insulated with Rockwool and fire retardant sealant wherever it crosses fire barricaded walls.

All pipes using screwed fittings shall be accurately cut to the required sizes and threaded in accordance with IS - 554 and burrs removed before laying. Open ends of the piping shall be blocked while working to avoid entrance of foreign matter. Wherever reducers are to be made in horizontal runs, eccentric reducers shall be used if the piping is to drain freely. In other locations, concentric reducers may be used.

Drains shall be provided at all low points in the piping system and shall be of the following sizes with valves.

Mains	Drains
Up to 150mm	25 mm
Over 150 mm	65 mm

Air vents of 15 mm with vent valves of equal size be provided at all high points in the piping system for venting.

PRESSURE GAUGES & Thermometer-

1. Pressure gauges shall be not less than 100 mm dia. & appropriate range and be complete with shut off valves, stainless steel or CP Brass stem etc.
2. Pressure gauge shall be provided to measure the pressure at the following locations -
 - i. On inlet and outlet of each chiller,
 - ii. Suction and discharge of pumps,
3. Care shall be taken to protect pressure gauges during pressure testing.

EXPANSION JOINTS-

Where necessary expansion joints or expansion loops shall be provided to take care of expansion and contraction of pipes due to variation in temperature.

CENTRIFUGAL TYPE AIR SEPERATOR-

An adequately sized Centrifugal type Air separator to remove air from closed chilled water pipe circuit. The unit shall have inlet & outlet connections tangential to the vessel shell. Vessel shell diameter to be three times the nominal inlet/outlet pipe diameter.

The unit shall have an internal stainless steel air collector tube with 5/32" diameter perforations and 63% open area designed to direct accumulated air to the compression tank via an NPT connection at top of unit.

The unit shall have a removable galvanized steel system strainer with 3/16" diameter perforations and a free area of not less than five times the cross-sectional area of the connecting pipe. A blow down connection shall be provided to facilitate routine cleaning of the strainer.

Manufacturer to furnish data sheet specifying air collection efficiency and pressure drop at rated flow.

TESTING-

All water piping shall be tested to hydrostatic test pressure of at-least two times the maximum operating pressure, but not less than 10 Kg/cm² for a period of not less than 24 hours.

All leaks and defects in joints revealed during the testing shall be rectified to the satisfaction of the Consultant. Piping repaired subsequent to the above pressure shall be retested in the same method as mentioned above.

CLEANING OF PIPING-

After piping system has been tested and proved tight and leak free, the Contractor shall clean piping system for dirt, scale, oil, grease, waste & other foreign substances which may have accumulated during process of installation. Strainer, screens shall be removed, cleaned and replaced after cleaning process & cleaned after flushing process.

PASSIVATION OF WATER PIPING

The M. S. pipe line should be passivated by following method-

- Rinse the M. S. pipe line with water 4 times to remove all dust & dirt.
- Circulate mild solution (@5%) of Sulphuric acid or oxalic acid for 24 HRS.
- Rinse the M. S. pipe line with water to remove the acid content.
- Circulate mild solution (@2%) of Caustic soda for 24 HRS and rinse the line with water.
- Circulate solution of SODIUM HEXA META PHOSPHATE in ratio of 10 Gm. per Liter for 12-14 hours.
- Drain the solution and check the pipe surface. If found okay, fill the line again and drain again before final charging of fresh soft water.

A required dosing of Anti Oxidant is required to add periodically.

The sample of water which will be used for the chilled water system shall be analyzed by the successful contractor free of cost. The analysis report shall be submitted to PMC / HVAC Consultant with the recommendation as to any changes in water input is required.

PAINTING-

After all piping has been installed, tested and run for at-least 2 weeks it shall be coated with primer coat and synthetic enamel paints of approved shades as per the colour code. The direction of fluid flow in the pipes shall be visibly marked with arrow.

BALANCING VALVE

The balancing valves shall be double regulating type with flow measuring facilities and drain cock. The pressure measuring nipples to measure differential pressure shall be integral part of the body. All valves shall be double regulating type with indicator scale from full shut to full open setting position.

The computerized balancing instrument with ISO certificate shall be used to measure the flow rate and DP. The instrument shall have the capability to store the results of balancing and to log the measured values. The print outs of the saved data shall form the part of commissioning document.

SELF BALANCING DYNAMIC FLOW CONTROL VALVES**[15-40 MM SIZE]****1. PRESSURE INDEPENDENT DYNAMIC CONTROL VALVE**

- a) Valve shall be electronic, dynamic, modulating, 2-way, control device.
- b) Dynamic control valve shall accurately control flow, independent of system pressure fluctuation.
- c) Maximum flow setting shall be adjustable to 51 different settings within the range of the valve size.

VALVE ACTUATOR

- a) Valve actuator housing shall be rated to IP 44.
- b) Actuator shall be driven by a 24 VDC motor, and shall accept 2-10 VDC, 0-10 VDC, 4-20 mA, 3-point floating or pulse width modulation electric signal and shall include resistor to facilitate any of these signals.
- c) Actuator shall be capable of providing 4-20 mA or 2-10V DC feedback signal to the control system.
- d) External LED read-out of current valve position and maximum valve position setting shall be available.

VALVE HOUSING

- a) Housing shall be constructed of forged ASTM (CuZn39Pb2) brass rated at no less than 2500 kPa static pressure and 120°C.
- b) Valve housing shall be double union construction with a range of pipe connections available for the appropriate pipe size.
- c) Identification tags shall be available for all valves; tags shall be indelibly marked with part number, production date and pressure differential range. Tags shall be of aluminium and in size 50mm x 25mm.

FLOW REGULATION UNIT

- a) Flow regulation unit shall consist of stainless steel and hydrogenated acrylonitrile butadiene rubber and shall be capable of controlling flow within +/- 5% of each rated flow.
- b) Flow regulation unit shall be accessible, for maintenance.
- c) Optional dual pressure/temperature test plugs for verifying accuracy of flow performance shall be available for all valve sizes.

2. SELF BALANCING DYNAMIC FLOW CONTROL VALVES**[50-150 MM SIZE]****PRESSURE INDEPENDENT DYNAMIC CONTROL VALVE**

- a) Valve shall be electronic, dynamic, modulating, 2-way, control device.
- b) Dynamic control valve shall accurately control flow, independent of system pressure fluctuation.
- c) Maximum flow setting shall be adjustable to 51 different settings within the range of the valve size.

VALVE ACTUATOR

- a) Valve actuator housing shall be rated to IP 44.
- b) Actuator shall be driven by a 24 VDC motor, and shall accept 2-10 VDC, 0-10 VDC, 4-20 mA, 3-point floating or pulse width modulation electric signal and shall include resistor to facilitate any of these signals.
- c) Actuator shall be capable of providing 4-20 mA or 2-10 VDC feedback signal to the control system.
- d) Optional fail safe system to power valve to either open or closed position from any position in case of power failure shall be available.
- e) External LED read-out of current valve position and maximum valve position setting shall be standard.

VALVE HOUSING

- a) Housing shall be constructed of Ductile Iron ASTM A536-65T, Class 60-45-18 rated at no less than 4000 kPa static pressure and 120°C.
- b) Identification tags shall be available for all valves; tags shall be indelibly marked with part number, production date and pressure differential range. Tags shall be of aluminium and in size 50mm x 25mm.

FLOW REGULATION UNIT

- a) Flow regulation unit shall consist of 316 Stainless steel and hydrogenated acrylonitrile butadiene rubber and shall be capable of controlling flow within +/-5% of each rated flow.

- b) Flow regulation unit shall be accessible, for maintenance.
- c) Optional dual pressure/temperature test plugs for verifying accuracy of flow.

3. SEMI AUTOMATIC DIGITAL BALANCING VALVE

TYPICAL SPECIFICATION FOR BALANCING VALVES

- 1.1 Balancing valves shall be supplied and installed as shown on the drawings to ensure proper balancing of waterflows in the hydronic heating and cooling system.
- 1.2 Flow measurement and balancing shall be possible with an accuracy of 4 to 7% in the normal measuring range of the valve. (When valve opening position is more than 50%)
- 1.3 Pressure measuring nipples shall be provided for measuring differential pressure and be integral with the body and incorporate means for positive leaktight shut-off when not in use.
- 1.4 Adjustment and presetting of flows shall be made with a digital handwheel.
- 1.5 The setting shall be lockable with a mechanical stop to allow the valve to be closed but not opened further than to the preset value.
- 1.6 For valves in size 10 to 50mm the balancing valves shall offer a facility for draining of water with a separate hose connection and a stop valve. The optional draining facility shall be capable of being mounted on or removed from the balancing valve without interruption to the system operation.
- 1.7 Material and Pressure Ratings
 - a) Balancing valves with thread connections in sizes from 10 to 50mm shall be made in a dezincification resistant copper alloy with Brinell hardness of at least 130 and a body pressure rating of at least 20 bar (300psi) at 150 degrees C-(AMETAL).
 - b) Balancing valves with flange connections from 20 to 300mm shall be made in cast iron equivalent to BS 1452 for a body pressure rating of at least 16 bar –25 bar 150 degrees C. Valves sized 65mm-300mm shall to be fitted with a pressure balanced cone to reduce closing torque to allow the valve to be closed and opened easily.
- 1.8 Balancing valves shall be sized to operate in a normal measuring range of 50% to 100% of full opening to ensure maximum accuracy.
- 1.9 All the balancing valves shall be manufactured in accordance ISO9001.
- 1.10 Certificate of Origin and Certificate of Quality from factory shall be submitted for inspection when the balancing valves are delivered to site before installation.
- 1.11 Installation of balancing valves without the specified Certificates shall not be permitted.
- 1.12 A computerized balancing instrument (CBI) with ISO9000 calibration certificate shall be handed over after testing & commissioning.

TYPICAL SPECIFICATION FOR BALANCING VALVES

- 2.1 To enable accurate and practical operation, measurement of flow and differential pressure shall be made with a microprocessor instrument which shall enable the operator to read the flow directly without the use of diagrams or tables.
- 2.2 The balancing of the system shall be verified in a written report, documenting valve position and water flow which shall be handed over to the consultant for approval and acceptance.
- 2.3 The CBI shall have two main components:
An instrument which contains a micro computer, input touch pad and LCD display, and re-chargeable batteries and built-in charger.

A sensor unit which contain a piezo-resisting pressure sensor, one measurement valve and connection hoses. The measurement valve shall have a safety function which protects the sensor from high differential pressures.

- 2.4 In addition to measuring flowrate, differential pressure and temperature, the CBI shall have a computer programme to provide the following functions:-
 - to balance the installation of HVAC system and calculate the necessary valve settings, based on system measurements
 - to store the results of balancing
 - to log measured values from a valve (differential pressure, flowrate or temperature)
 - to printout saved data in computerized measurement protocol (CMP) consisting of:
 - i) Name and size of Balancing Valve (BV)
 - ii) Presetting position of BV
 - iii) ΔP at BV
 - iv) flow at BV
 - v) design flow

1.8 SHEET METAL WORK- SMACNA STANDARDS

1. Unless otherwise specified here, the construction, erection, testing and performance of the ducting system shall conform to the SMACNA-1995 standards ("HVAC Duct Construction Standards – Metal and Flexible – Second Edition – 1995"-SMACNA)
2. All ducting shall be fabricated of LFQ (Lock Forming Quality) grade prime G.I. raw material furnished with accompanying Mill Test Certificates.

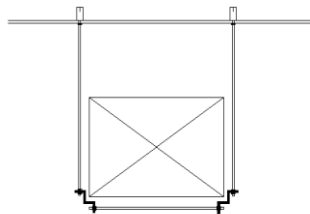
3. Galvanizing shall be of 120gms/sq.m. (total coating on both sides). In addition, if deemed necessary, samples of raw material, selected at random by owner's site representative shall be subject to approval and tested for thickness and zinc coating at contractor's expense.
SELECTION OF G.I. GAUGE AND TRANSVERSE CONNECTORS
4. Duct Construction shall be in compliance with 1" (250 Pa) w.g. static norms as per SMACNA. All transverse connectors shall be the 4-bolt slip-on flange system standard makes of similar 4-bolt systems with built-in sealant.
5. The specific class of transverse connector and duct gauge for a given duct dimensions will be as per Table given below for the 1" (250 Pa) pressure class.
6. Non-toxic, AC-applications grade P.E. or PVC Gasketing is required between all **mating flanged** joints. Gasket sizes should conform to flange manufacturer's specification.

Notes:

- *1- SMACNA – Sheet Metal & Air conditioning Contractors' National Association Inc – "HVAC Duct Construction Standards- Metal and Flexible"-1995, U.S.A.
 - *2- Reading Guide- For duct sizes between, say, 651 mm and 700 mm, when the pressure class is 1" w.g. static, we require a standard 'E' class flange and duct gauge of 26. For the same size range but with static pressure at 4" w.g. a standard 'H' class flange with duct gauge of 24 should be used.
 - *3- The standard flange classes available are designated E, H and J. For E & H class of standard make use gasket size 10 mm wide and 4.5 mm thick. For standard J-class use 15 mm wide and 6 mm thick gasket.
7. DUCT CONSTRUCTION
The fabricated duct dimensions should be as per approved drawings and all connecting sections are dimensionally matched to avoid any gaps.
 8. Dimensional Tolerances: All fabricated dimensions will be within +/- 1.0mm of specified dimension. To obtain required perpendicularity, permissible diagonal tolerances shall be +/- 1.0 mm per meter.
 9. Each and every duct pieces should be identified by color coded sticker which shows specific part numbers, job name, drawing number, duct sizes and gauge . Ducts shall be straight and smooth on the inside. Longitudinal seams shall be airtight and at corners only, which shall be either Pittsburgh or Snap Button Punch as per SMACNA practice, to ensure air tightness
 10. Changes in dimensions and shape of ducts shall be gradual (between 1:4 and 1:7). Turning vanes or air splitters shall be installed in all bends and duct collars designed to permit the air to make the turn without appreciable turbulence.
Plenums shall be shop/ Reinforcement of ducts shall be achieved by either cross breaking or straight beading depending on length of ducts

As per SMACNA page no. 1.74, fig. 1-8 “Duct Sizes 19” (483 mm) wide and larger which have more than 10 ft² of unbraced panel shall be beaded or cross broken unless ducts will have insulation covering or acoustical liner. This requirement is applicable to 20 G (1.00 mm) or less and 3” W.G. (750 Pa) pressure or less. Ducts for 4” W.G. (1000 Pa) or more do not require beads or cross-breaks.” factory fabricated panel type and assembled at site.

SUPPORT FOR HORIZONTAL RECTANGULAR DUCT



Sr. No.	Maximum Duct Size(mm)	Hanger Rod Diameter	Interval (mm)
1	Upto - 700	6 mm	2400
2	701 - 1200	8 mm	2400
3	1201 - 2000	10 mm	2400
4	Above 2000	12 mm	2400

11. As an alternative, slotted galvanized brackets attached to the top two bolts of the Rolamate system may also be used as appropriate for the site condition. To provide the required thermal brake effect, Neoprene or equivalent material of suitable thickness shall be used between duct supports and duct profiles in all supply air ducts not enclosed by return air plenums.
12. **INSTALLATION PRACTICE**
All ducts shall be installed as per tender drawings and in strict accordance with approved shop drawings to be prepared by the Contractor. The Contractor shall provide and neatly erect all sheet metal work as may be required to carry out the intent of these specifications and drawings. The work shall meet with the approval of Owner’s site representative in all its parts and details.
13. All necessary allowances and provisions shall be made by the Contractor for beams, pipes, or other obstructions in the building whether or not the same are shown on the drawings. Where there is interference/fouling with other beams, structural work, plumbing and conduits, the ducts shall be suitably modified as per actual site conditions.
14. Ducting over false ceilings shall be supported from the slab above, or from beams. In no case shall any duct be supported from false ceilings hangers or be permitted to rest on false ceiling. All metal

work in dead or furred down spaces shall be erected in time to occasion no delay to other contractor's work in the building.

15. Where ducts pass through brick or masonry openings, it shall be provided with 25mm thick appropriate insulation around the duct and totally covered with fire barrier mortar for complete sealing.
16. All ducts shall be totally free from vibration under all conditions of operation. Whenever ductwork is connected to fans, air handling units or blower coil units that may cause vibration in the ducts, ducts shall be provided with a flexible connection, located at the unit discharge.

TESTING

After duct installation, a part of duct section (approximately 5 % of total ductwork) may be selected at random and tested for leakage. The procedure for leak testing should be followed as per SMACNA- "HVAC Air Duct Leakage Test Manual" (First Edition)

LOW LEAK DAMPER-

Damper shall be opposed blade type, blades shall be made of double skinned aerofoil Aluminium (G.I. for ventilation) sections with integral gasket and assembled within a rigid extruded Aluminium alloy frame.

All linkages and supporting spindles shall be made of Aluminium or nylon, turning in Teflon bushes and linkages shall be extended for motorized operation wherever specified. Manual dampers shall be provided with a Bakelite knob for locking the damper blades in position. Damper frames shall be sectionalized to minimize blade warping.

Air leakage through dampers when in the closed position shall not exceed 1.5 % of the maximum design volume flow rate at the maximum design pressure.

Perforated Face Diffuser

Diffusers should be constructed from Aluminium frames and perforated face plates. The diffuser cores are removable type and damper operation from front. They should be suitable to fit in grids of tile type false ceiling.

Installation

A good quality neoprene rubber of uniform thickness and width shall be used as gasket between flange joints. The felt shall be fixed by a suitable adhesive and holes made by passing a heated rod through. The slope of the duct shall be such that the rainwater cannot enter the premise i.e. the slope of duct shall be

towards the outside wall to prevent rainwater entry. Special care shall have to be taken by the contractor in the time of erection.

i. All ducts shall be rigid and shall be adequately supported and where required with standing seams, tees or angles of ample size to keep the ducts true to shape and to prevent buckling, vibration or breathing. All the joints shall be made airtight by soldering & all interior surfaces shall be smooth. Bends shall be made with radius not less than one half the width of the duct or with properly designed interior curved vanes. Where metal ducts or sleeves terminate in woodwork, brick or masonry openings, and tight joints shall be made by means of closely fitting heavy flanged collars.

Ducting over false ceiling shall be supported from the slab above or from beams. In no case a duct is to be supported from the false ceiling hangers or to be permitted to rest on a hung ceiling.

ii. All holes concrete, masonry etc. made by contractor for fixing supports etc. shall be made good and restored to original finish by him.

iii. Air handling units and fans shall be connected to duct work by inserting at air inlet and air outlet a double canvass sleeve. Each sleeve shall be minimum 100 mm long, securely bolted to duct and units. Each sleeve shall be made smooth and the connecting ductwork rigidly held in line with unit inlet or outlet.

Grilles and Diffusers

All grilles (SA & RA), diffusers (SA & RA) will be made from heavy gauge extruded Aluminium sections duly powder coated to match the interior requirements of Architect/Client. All the supply air grilles/diffusers will be provided with opposed blade dampers fabricated from galvanized steel sheet painted in two coats of matt black stoving enamel paint. The damper should be suitable for operation from front face of grille/diffuser.

Testing

The entire air distribution system shall be balanced to supply the air quantities as required in various zones and rooms to maintain the specified room conditions. The final balancing of air quantity through each grille or diffuser shall be recorded and submitted to the Consultant / Employer for approval.

Painting

Angle iron flanges, stiffeners, hangers and supports shall be painted with two coats primer and those remaining uncovered further two coats of synthetic

1.9 DAMPERS-

All dampers shall be of 18 S.W.G. G.I sheets louver dampers of robust construction and tight fitting. The design, method of handling and control, shall be suitable for the location and service required. Dampers shall be provided with suitable links, levers and quadrants as required for their proper operation, control or setting in any desired position. Dampers and their operating devices shall be made robust, easily operable and accessible through suitable access door. Every damper shall have indication device clearly showing the damper position at all times. All the bushing will be of brass only.

A fire damper shall be provided between each air handling unit room and the rest area and at crossing of fire rated walls. The fire dampers shall be confirm to UL-655 and other applicable fire codes. The dampers shall be operated through either fusible link or solenoid valve.

1.10 FIRE & SMOKE DAMPERS

- a. All supply and return air ducts at AHU room crossings and at all floor crossings shall be provided with Motor operated Fire & smoke damper of atleast 90 minutes rating as per UL555/1995 tested by CBRI. These shall be of multi-leaf type and provided with Spring Return electrical actuator having its own thermal trip for ambient air temperature outside the duct and air temperature inside the duct. Actuator shall have Form fit type of mounting, metal enclosure and guaranteed long life span.
- b. Fire damper blades and outer frames shall be of 16G galvanized steel construction fitted with 18 gage extended sleeves on both sides. The damper blade shall be pivoted on both ends using chrome plated spindles in self lubricated bronze bushes. Stop seals shall be provided on top and bottom of the damper housing made of 16G galvanized sheet steel. For preventing smoke leakage metallic compression seals will be provided.
- c. The electric actuator shall be energized either upon receiving a signal from smoke detector installed in AHU room supply air duct/ return air duct or temperature sensor. The fire damper shall also close upon sensing temperature rise in supply air ducts thru the electronic temperature sensor.
- d. Each damper shall be provided with its own control panel, mounted on the wall and suitable for 240 VAC supply. This control panel shall be suitable for spring return actuator and shall have atleast the following features:
 - Potential free contacts for AHU fan ON/ Off and remote alarm indication.
 - Accept signal from external smoke / fire detection system for tripping the electrical actuator.
 - Test and reset facility.
 - Indicating lights / contacts to indicate the following status:
 - Power Supply On
 - Alarm

- Damper open and close position.
- e. Actuators shall be mounted on the sleeve by the damper supplier in his shop and shall furnish test certificate for satisfactory operation of each Motor Operated Damper in conjunction with its control panel. Control panel shall be wall mounted type.
- f. It shall be HVAC Contractor's responsibility to co-ordinate with the Fire Alarm System Contractor for correctly hooking up the Motor Operated Damper to Fire Detection / Fire Management System. All necessary materials for hooking up shall be supplied and installed by HVAC Contractor under close co-ordination with the fire protection system contractor.
- g. HVAC Contractor shall demonstrate the testing of all Dampers and its control panel after necessary hook up with the fire protection / fire management system is carried out by energising all the smoke detectors with the help of smoke.
- h. HVAC Contractor shall provide Fire retardant cables wherever required for satisfactory operation and control of the Damper.
- i. HVAC Contractor shall strictly follow the instructions of the Damper Supplier or avail his services at site before carrying out testing at site.
- j. Fire/smoke damper shall be provided with factory fitted sleeves; however, access doors shall be provided in the ducts within AHU room in accordance with the manufacturer's recommendations.
- k. The Contractor shall also furnish to the Owner, the necessary additional spare actuators and temperature sensor (a minimum of 5% of the total number installed) at the time of commissioning of the installation.

1.11 SUPPLY AND RETURN AIR REGISTERS

Supply & return air registers shall be of either steel or aluminium sections as specified in schedule of quantities. Steel construction registers shall have primer Coat finish whereas extruded aluminium registers shall be either Anodized or Powder Coated as specified in Schedule of Quantities. These registers shall have individually adjustable louvers both horizontal and vertical. Supply air registers shall be provided with key operated opposed blade extruded aluminium volume control damper anodized in matt black shade.

The registers shall be suitable for fixing arrangement having concealed screws as approved by Architect. Linear continuous supply cum return air register shall be extruded aluminium construction with fixed horizontal bars at 15 Deg. inclination & flange on both sides only (none on top & bottom). The thickness of the fixed bar louvers shall be minimum 5.5 mm in front and 3.8 mm in rear with rounded edges. Flanges on the two sides shall be 20 mm/30 mm wide as approved by Architect. The grilles shall be suitable for concealed fixing. Volume control dampers of extruded aluminium anodized in black colour shall be

provided in supply air duct collars. For fan coil units horizontal fixed bar grilles as described above shall be provided with flanges on four sides, and the core shall be & suitable for clip fixing, permitting its removal without disturbing the flanges.

- a. All registers shall be selected in consultation with the Architect. Different spaces shall require horizontal or vertical face bars, and different width of margin frames. These shall be procured only after obtaining written approval from Architect for each type of register.
- b. All registers shall have a soft continuous rubber/foam gasket between the periphery of the register and the surface on which it has to be mounted. The effective area of the registers for air flow shall not be less than 66 percent of gross face area.
- c. Registers specified with individually adjustable bars shall have adjustable pattern as each grille bar shall be pivotable to provide pattern with 0 to +45 degree horizontal arc and upto 30 degree deflection downwards. Bars shall hold deflection settings under all conditions of velocity and pressure.
- d. Bar longer than 45 cm shall be reinforced by set-back vertical members of approved thickness.
- e. All volume control dampers shall be anodized aluminum in mat black shade.

GRILLES AND DIFFUSERS-

All grilles (SA & RA), diffusers (SA & RA) will be made from heavy gauge extruded Aluminum sections / M.S. (As specified in the BOQ) duly powder coated to match the interior requirements of Architect / Client. All the supply air grilles/diffusers will be provided with opposed blade dampers fabricated from Al. The damper should be suitable for operation from front face of grille/diffuser.

INSTALLATION-

A good quality felt/expanded polyethylene /rubber of uniform thickness and width shall be used as gasket between flange joints. The gaskets shall be fixed by a suitable adhesive and holes made by passing a heated rod through.

1. All ducts shall be rigid and shall be adequately supported and braced where required with standing seams, tees or angles of ample size to keep the ducts true to shape and to prevent buckling, vibration or breathing. All the joints shall be made tight and all interior surfaces shall be smooth. Bends shall be made with radius not less than one half the width of the duct or with properly designed interior curved vanes where metal ducts or sleeves terminate in woodwork, brick or masonry openings, tight-flanged collars. Ducting over false ceiling shall be supported from the slab above or from beams. In no case a duct shall be supported from the false ceiling hangers or to be permitted to rest on a hung ceiling.

2. All holes in concrete, masonry etc. made by contractor for fixing supports etc. shall be made good and restored to original finish by him.
3. Air handling units and fans shall be connected to duct work by inserting at air inlet and air outlet a double canvass sleeve. Each sleeve shall be minimum 100mm long, securely bolted to duct and units. Each sleeve shall be made smooth and the connecting ductwork rigidly held in the line with unit inlet or outlet.

TESTING AND BALANCING

After the installation of the entire air distribution system is completed in all respects, all ducts shall be tested for air leaks by visual inspection.

The entire air distribution system shall be balanced using an anemometer. Measured air quantities at fan discharge and at various outlets shall be identical to or less/excess than 5 percent in excess of those specified and quoted. Branch duct adjustments shall be permanently marked after air balancing is completed so that these can be restored to their correct position if disturbed at any time. Complete air balance report shall be submitted for scrutiny and approval, and four copies of the approved balance report shall be provided with completion documents.

PAINTING-

Angle iron flanges, stiffeners, hangers and supports shall be painted with 2 coats of anti rust primer and those remaining uncovered shall be further painted with 2 coats of synthetic enamel paints of black colour enamel paints of approved color.

1.12 INSULATION

FOR G.I. DUCTING

SPECIFICATION FOR THERMAL & ACOUSTIC INSULATION

SCOPE

The scope of this section comprises the supply and application of insulation conforming to these specifications.

(A) DUCT THERMAL INSULATION

MATERIAL

1. Insulation material shall be Closed Cell Elastomeric **NITRILE RUBBER**
2. Density of Material shall be between 40 to 60 Kg/m³

3. Thermal conductivity of elastomeric NITRILE RUBBER shall not exceed **0.034** W/m.K at mean temperature of 0°C
4. Insulation material shall have anti-microbial product, which is EPA (Environmental Protection Agency), USA approved, as an integral part of insulation that cannot be washed off or worn off.
(NITRILE RUBBER is anti-Microbial polymer)
5. It shall give enhanced level of protection against harmful Microbes such as bacteria, mold, mildew and fungi and should confirm to following standards: Fungi Resistance – ASTM G21 and Bacterial resistance – ASTM G 22 / ASTM 2180.
6. The insulation shall have fire performance such that it passes **ASTM – E – 84 test** Method
7. Material should be FM (Factory Mutual), USA approved.
8. Water vapor permeability shall not exceed 1.74×10^{-14} Kg / (m.s.Pa), i.e. Moisture Diffusion Resistance Factor or 'μ' value should be minimum 10000.

Thickness of the insulation shall be as specified for the individual application.

THICKNESS SELECTION CHART FOR NITRILE RUBBER INSULATION	
Design Basis: Condensation Control	
OUTDOOR ,ATTIC & UNCONDITIONED SPACES VENTED TO OUTDOOR	
Design Conditions: 32 Deg. C & 85% RH (as per ASHRAE guidelines)	
DUCT INSULATION	
	Required Thickness (mm)
Supply Air Duct (Line Temperature 14 Deg. C)	25
Return Air Duct (Line Temperature 22 Deg. C)	25

THICKNESS SELECTION CHART FOR NITRILE RUBBER INSULATION	
Design Basis: Condensation Control	
INDOOR (CONDITIONED / SEMICONDITIONED AREAS)	
Design Conditions: 26.8 Deg.C & 85% RH (WITH PROPER Ventilation)	
DUCT INSULATION	
	Required Thickness (mm)
Supply Air Duct (Line Temperature 14 Deg. C)	19

Return Air Duct (Line Temperature 22 Deg. C)	13
Supply Air Duct in Return Air Path (Line Temp. 14 Deg.C)	13

THICKNESS SELECTION CHART FOR NITRILE RUBBER INSULATION			
Design Basis: Condensation Control			
Non - Coastal Areas	Pune, Delhi, Hyderabad, Bangalore etc		
(OUTDOOR & INDOOR)			
Design Conditions: 30 Deg. C & 82 % RH (WITH PROPER Ventilation)			
DUCT INSULATION			
	Required Thickness (mm)		
Supply Air Duct (Line Temperature 14 Deg. C)	19		
Return Air Duct (Line Temperature 22 Deg. C)	13		
Supply Air Duct in Return Air Path (Line Temp. 14 Deg.C)	13		

External thermal insulation shall be provided as follow:

The thickness of the NITRILE RUBBER shall be as shown on drawing or identified in the schedule of quantity. Following installation procedure should be adopted:

1. Duct surfaces shall be cleaned to remove all grease, oil, dirt, etc. prior to carrying out insulation work.
2. Measurement of surface dimensions shall be taken properly to cut closed cell elastomeric rubbers sheets to size with sufficient allowance in dimension.
3. Material shall be fitted under compression and no stretching of material should be allowed.
4. A thin film of adhesive shall be applied on the back of the insulating material sheet and then on to the metal surface.
5. When adhesive is tack dry, insulating material sheet shall be placed in position and pressed firmly to achieve a good bond.
6. All longitudinal and transverse joints shall be sealed as per manufacturer recommendations.
7. The adhesive shall be strictly as recommended by the manufacturer.
8. The detailed Application specifications are as per the manufacturer's recommendation.

INSTALLATION OF DUCTS EXPOSED DIRECTLY TO SUNLIGHT:

For installations exposed to sunlight, after giving 36 hours curing time for the adhesive apply manufacturer's recommended UV/Mechanical Protection. Please refer the separate detailed guidelines on UV/Mechanical Protection.

(B) INSULATION FOR CHILLED WATER/ DRAIN PIPING-

The complete chilled water piping including with pipes, bends, flanges, valves, hanger support etc. will be insulated as per the following -

MATERIAL

1. Insulation material shall be Closed Cell Elastomeric Nitrile Rubber
2. Density of Material shall be between 40 to 60 Kg/m³
3. Thermal conductivity of elastomeric nitrile rubber shall not exceed 0.035 W/m^{°K} at an average temperature of 0°C
4. The insulation shall have fire performance such that it passes Class 1 as per BS476 Part 7 for surface spread of flame as per BS 476 and also pass Fire Propagation requirement as per BS476 Part 6 to meet the Class 'O' Fire category as per 1991 Building Regulations (England & Wales) and the Building Standards (Scotland) Regulations 1990
5. Material should be FM (Factory Mutual), USA approved.
6. Water vapor permeability shall not exceed 0.017 Perm inch (2.48 x 10⁻¹⁴ Kg/m.s.Pa), i.e. Moisture Diffusion Resistance Factor or 'μ' value should be minimum 7000.

Thickness of the insulation shall be as specified for the individual application

All chilled water, refrigerant and condensate drain pipe shall be insulated in the manner specified herein. An air gap of 100 mm shall be present between adjacent insulated surfaces carrying chilled water or refrigerant and also between the insulated surface and the wall to allow natural ventilation without affecting its external surface coefficient of heat transfer. Before applying insulation, all pipes shall be brushed and cleaned. All Pipe surfaces shall be free from dirt, dust, mortar, grease, oil, etc. Nitrile Rubber insulation shall be applied as follows:

1. Insulating material in tube form shall be sleeved on the pipes.
2. On existing piping, slit opened tube of the insulating material (slit with a very sharp knife in a straight line) shall be placed over the pipe and adhesive shall be applied as suggested by the manufacturer.

3. Adhesive must be allowed to tack dry and then press surface firmly together starting from butt ends and working towards centre.
4. Wherever flat sheets shall be used it shall be cut out in correct dimension. All longitudinal and transverse joints shall be sealed as per manufacturer recommendations.
5. The insulation shall be continuous over the entire run of piping, fittings and valves.
6. All valves, fittings, joints, strainers, etc. in chilled water piping shall be insulated to the same thickness as specified for the main run of piping and application shall be same as above. Valves bonnet, yokes and spindles shall be insulated in such a manner as not to cause damage to insulation when the valve is used or serviced.

The detailed application specifications are as mentioned separately. The manufacturer's trained installer should only be used for installation.

RECOMMENDED ADHESIVE:

In all cases, the manufacturer's recommended Adhesive should be used for the specified purpose.

PUMP INSULATION

Chilled water pump shall be insulated to the same thickness as the pipe to which they are connected and application shall be same as above. Care shall be taken to apply insulation in a manner as to allow the dismantling of pumps without damaging the insulation.

SHELL INSULATION

The chiller shells shall be factory / site insulated in accordance with the manufacturer's standards.

COLD WATER AND EXPANSION TANK INSULATION

Cold water tank, and chilled water expansion tank shall be insulated as per manufacturer's standard.

Pipe Supports

All pipe supports should be factory made as detailed specification attached

INSTALLATION EXPOSED DIRECTLY TO SUNLIGHT:

For installations exposed to sunlight, after giving 36 hours curing time for the adhesive apply manufacturer's recommended UV/Mechanical Protection. Please refer the separate detailed guidelines on UV/Mechanical Protection.

<u>THICKNESS SELECTION CHART FOR NITRILE RUBBER INSULATION</u>			
Design Basis: Condensation Control			
<u>OUTDOOR ,ATTIC & UNCONDITIONED SPACES VENTED TO OUTDOOR</u>			
<u>Design Conditions: 24.4 Deg. C & 90% RH (as per ASHRAE guidelines)</u>			
<u>CHILLED WATER PIPING</u>			
LINE TEMP 7 Deg.C			
Pipe NB (mm)	Required Thickness (mm)		
25 to 40	32		
50 to 150	38		
200 to 600	44		
Cold Water Tank	44		
<u>REFRIGERANT PIPING</u>			
LINE TEMP 3 Deg C			
Pipe NB (mm)	Required Thickness (mm)		
Up to 50	38		
Up to 100	44		
<u>DUCT INSULATION</u>			
	Required Thickness (mm)		
Supply Air Duct (Line Temperature 14 Deg. C)	23		
Return Air Duct (Line Temperature 22 Deg. C)	8		

<u>THICKNESS SELECTION CHART FOR NITRILE RUBBER INSULATION</u>			
Design Basis: Condensation Control			
<u>INDOOR (CONDITIONED / SEMICONDITIONED AREAS)</u>			
<u>Design Conditions: 26.8 Deg.C & 85% RH</u>			
<u>CHILLED WATER PIPE</u>			
<u>LINE TEMP(7 Deg.C)</u>			

Pipe NB (mm)	Required Thickness (mm)			
Up to 65	19			
Up to 600	25			

<u>DRAIN PIPING</u>				
LINE TEMPERATURE 15 Deg.C				
Pipe NB (mm)	Required Thickness (mm)			
Up to 50	13			
REFRIGERANT PIPING				
LINE TEMP 3 Deg C				
Pipe NB (mm)	Required Thickness (mm)			
Up to 40	25			
Up to 100	32			
DUCT INSULATION				
	Required Thickness (mm)			
Supply Air Duct (Line Temperature 14 Deg. C)	19			
Return Air Duct (Line Temperature 22 Deg. C)	9			
Supply Air Duct in Return Air Path (Line Temp. 14 Deg.C)	9			

<u>THICKNESS SELECTION CHART FOR NITRILE RUBBER INSULATION</u>				
Design Basis: Condensation Control				
<u>(OUTDOOR & INDOOR)</u>				
<u>Design Conditions: 30 Deg. C & 82 % RH</u>				
<u>CHILLED WATER PIPING</u>				
LINE TEMP 7 DegC				
Pipe NB (mm)	Required Thickness (mm)			
Up to 32	19			
Up to 600	25			
Chilled Water Tank	25			
<u>DRAIN PIPING</u>				
LINE TEMPERATURE 15 DegC				
Pipe NB (mm)	Required Thickness (mm)			
Up to 50	13			
<u>REFRIGERANT PIPING</u>				
LINE TEMP 3 Deg C				
Pipe NB (mm)	Required Thickness (mm)			
Up to 50	25			
Up to 100	32			
DUCT INSULATION				
	Required Thickness (mm)			
Supply Air Duct (Line Temperature 14 Deg. C)	19			
Return Air Duct (Line Temperature 22 Deg. C)	9			

Supply Air Duct in Return Air Path (Line Temp. 14 Deg.C)	9			

(C) ACOUSTIC INSULATION

1. Material shall be engineered NITRILE RUBBER open cell foam
2. The Random Incidence Sound Absorption Coefficient (RISAC); tested as per ISO 354, should be minimum as per enclosed chart

Freq (Hz)	125	250	500	1000	2000	4000	NRC
10 mm	0.03	0.04	0.14	0.04	0.88	1.00	0.35
15 mm	0.01	0.09	0.29	0.74	1.08	0.83	0.55
20 mm	0.04	0.13	0.4	0.9	1.04	0.90	0.60
25 mm	0.02	0.25	0.86	1.14	0.88	0.99	0.80
30 mm	0.07	0.32	0.99	1.16	0.93	1.08	0.85
50 mm	0.23	0.73	1.29	0.99	1.09	1.11	1.05

3. The material should be fiber free
4. The density of the same shall be within 140-180 Kg/m³
5. It should have antimicrobial product protection, and should pass Fungi Resistance as per ASTM G 21 and Bacterial Resistance as per ASTM E 2180.
6. The material should have a thermal conductivity not exceeding 0.047 W/m.K @ 20 Deg. C
7. The material should withstand maximum surface temperature of +850C and minimum surface temperature of -200C
8. The material should conform to Class 1 rating for surface spread of Flame in accordance to BS 476 Part 7 & UL 94 (HBF, HF 1 & HF 2) in accordance to UL 94, 1996.
9. The insulation should pass Air Erosion Resistance Test in accordance to ASTM Standard C 1071-05 (section 12.7).

Thickness of the material shall be as specified for the individual application. The insulation should be installed as per manufacturer's recommendation.

DUCT ACOUSTIC LINING

Ducts so identified and marked on Drawings and included in Schedule of Quantities shall be provided with acoustic lining of thermal insulation material for a distance of minimum 5 meters.

Installation Procedure

The inside surface for the ducts shall be covered with adhesive recommended by the manufacturer. Cut Foamed sheets into required sizes apply adhesive on the foam and stick it to the duct surface

The fire-stop penetration seal for pipes

The flexible fire stop pipe seal with a fire resistance of > 90 min. for non-combustible/combustible supply pipes and/or non-combustible waste pipes in solid ceilings/walls or light weight walls.

Create fire-resistant seals for pipework using closed-cell, flexible elastomeric insulation with intumescent effect

The material should have following properties

Temperature Range: -50 Deg. C to +85 Deg.C

Thermal Conductivity: 0.05 W/m.K at 0 Deg.C

Water Vapor Diffusion Factor $\mu < 10,000$

Reaction to Fire : B2 in accordance to DIN 4102

Fire reaction to structural element: R 30 to R 90

(in accordance to prEN 1366-3.2:N185 2007-07 and DIN EN 13501-2: 2008-01, section 7.5.8)

Installation:

The intumescent insulation is to be either sleeved over the pipe or slit and sealed using manufacturer's recommended adhesive. Longitudinal seams and butt joints are to be covered with EPDM / NITRILE RUBBER rubber self-adhesive tape. The gap remaining between the insulation and the wall/ceiling is to be closed completely using mineral mortar. In lightweight walls, the gap is closed using loose fill within the wall and filler against the gypsum board (annular gap up to 50 mm).

The length of the intumescent insulation is to be determined depending on the pipe material and diameter according to manufacturer's recommendation as per the standard / test report for the R 90 test.

The Pipe diameters above 89 mm can be insulated with sheets which are additionally fixed with the binding wire (wound around 6 times per running meter). Binding of wire should be done for tubes as well.

Installation with zero clearance between the insulated pipes is permitted in the area of penetration is permitted. In case of chilled water lines condensation aspect should be considered.

Work should be carried out in accordance with relevant R 90 testing standard / test report.

Pipe Support Specifications:

Insulated pipe support, single piece with self-adhesive closure, PUR/PIR load bearing Insert (Density 140 - 180 kg/m³) embedded in elastomeric EPDM / NITRILE RUBBER rubber insulation with two outer metal shells made of aluminum sheet, which also acts as a vapor barrier for the PUR/PIR inserts.

Technical Details:

Temperature Range	:	-50°C to +105°C
Moisture Resistance Factor μ	:	5000
Thermal Conductivity at 0°C	:	0.035 W/(m·K)
Thermal Conductivity at 40°C	:	0.039 W/(m·K)
Color:		Black

UV / Mechanical Protection for Piping / Ducting / Vessel

Specification Clause:

For protection against mechanical impact and Scratch – treated woven glass fiber covering - should be applied.

(For Indoor application only)

Technical Details:

Temperature Range: -50°C to +150°C Overall

Temperature Range: - 50°C to +105°C If based on EPDM / NITRILE RUBBER Rubber Insulation

Temperature Range: - 50°C to +150°C If based on EPDM / NITRILE RUBBER Rubber Insulation

Color: Black

Density: 205+10 gms/sq.meter

Application Notes:

The covering should be cut to size according the circumference of the insulated pipe – please allow an additional 50mm for the overlap of the covering material. The Overlap shall be securely fixed using recommended Adhesive.

Spread thin film of recommended on the 50mm overlap and close the seam. When covering fittings, please consult the manufacturer’s Application Manual. All fittings have to be covered to the same standards as the covering of the pipe work. No additional vapor barrier is needed.

Covering Specification Clause:

For protection against mechanical impact & scratch, a lightweight, Aluminum foil with woven glass fiber reinforcement covering -- with a good resistance to Oil and Chemicals - should be applied. (For Indoor application only)

Technical Details:

TemperatureRange:-50°Cto+150°COverall

Temperature Range: - 50°C to +105°C If based on EPDM / NITRILE RUBBER Rubber Insulation

Temperature Range: - 50°C to +150°C If based on EPDM / NITRILE RUBBER Rubber Insulation

Dust & Fiber Free

Color : Silver

Application Notes:

The covering should be cut to size according the circumference of the insulated pipe – please allow an additional 50mm for the overlap of the covering material. The Overlap shall be securely fixed using recommended Adhesive.

Spread thin film of recommended on the 50mm overlap and close the seam. When covering fittings, please consult the manufacturer’s Application Manual. All fittings have to be covered to the same standards as the covering of the pipe work. No additional vapor barrier is needed.

UV Resistant Paint and CSM

It’s a two component composite system of Chopped Strand Mat (CSM) and special UV resistant paint.

Procedure:

Apply UV paint liberally on Insulation.

Immediately spread the 225 GSM Chopped Strand Mat (with minimum overlap of 1 inch at joints) on insulation without allowing paint to dry.

Immediately apply another coat of paint liberally on CSM.

Even out with brush and allow it to dry for 2-3 hours.

Note: Mechanical Protection should be applied after 36 hours of Curing of adhesive. It is the minimum time required for complete curing of adhesive.

(D) FALSE CEILING INSULATION –

The false ceiling shall be insulated with 50 mm thick fiberglass slab of 16 Kg. / Cu. M. density. The fiberglass slab shall be wrapped in polyethylene bags.

(E) UNDERDECK INSULATION –

MATERIAL-Insulation material shall be Closed Cell Elastomeric **NITRILE RUBBER**

1. Density of Material shall be between 40 to 60 Kg/m³
2. Thickness of the insulation shall be 25mm.
3. Thermal conductivity of elastomeric EPDM / NITRILE RUBBER shall not exceed **0.034** W/m.K at mean temperature of 0°C
4. Insulation material shall have anti-microbial product, which is EPA (Environmental Protection Agency), USA approved, as an integral part of insulation that cannot be washed off or worn off.
(NITRILE RUBBER is anti-Microbial polymer)
5. It shall give enhanced level of protection against harmful Microbes such as bacteria, mold, mildew and fungi and should confirm to following standards: Fungi Resistance – ASTM G21 and Bacterial resistance – ASTM G 22 / ASTM 2180.
6. The insulation shall have fire performance such that it passes **ASTM-E-84 test** Method.
7. Material should be FM (Factory Mutual), USA approved.
8. Water vapor permeability shall not exceed 1.74×10^{-14} Kg / (m.s.Pa), i.e. Moisture Diffusion Resistance Factor or 'μ' value should be minimum 10000.

(F) FOR AHU ROOM –

AHU ROOM ACOUSTIC INSULATION

1. Material shall be engineered NITRILE RUBBER open cell foam

2. The Random Incidence Sound Absorption Coefficient (RISAC); tested as per ISO 354, should be minimum as per enclosed chart

Freq (Hz)	125	250	500	1000	2000	4000	NRC
20 mm	0.04	0.13	0.4	0.9	1.04	0.90	0.60

3. The material should be fiber free.
4. The density of the same shall be within 140-180 Kg/m³.
5. It should have antimicrobial product protection, and should pass Fungi Resistance as per ASTM G 21 and Bacterial Resistance as per ASTM E 2180.
6. The material should have a thermal conductivity not exceeding 0.047 W/m.K @ 20 Deg. C.
7. The material should withstand maximum surface temperature of +850C and minimum surface temperature of -200C.
8. The material should conform to Class 1 rating for surface spread of Flame in accordance to BS 476 Part 7 & UL 94 (HBF, HF 1 & HF 2) in accordance to UL 94, 1996.
9. The insulation should pass Air Erosion Resistance Test in accordance to ASTM Standard C 1071-05 (section 12.7).

Thickness of the material shall be as specified for the individual application. The insulation should be installed as per manufacturer's recommendation.

(G) CAVITY/RAISED FLOOR INSULATION

Material

Insulation material shall be Closed Cell Elastomeric Nitrile Rubber.

Density of Material shall be between 40 to 60 Kg/m³. Thermal conductivity of elastomeric nitrile rubber shall not exceed 0.037 W/m²K at an average temperature of 0° C. The insulation shall have fire performance such that it passes CLASS 1 as per BS476 Part 7 for surface spread of flame as per BS Standards & B-1 as per DIN Standards. Water vapor permeability shall not exceed 0.03 Perm inch (2x 10⁻¹⁰ Kgs/m.hr.Pa).

Thickness of the insulation shall be 25 mm.

3. **Installation procedures**

- First the supports for raised floor should be installed on to the floor. Then the floor shall be cleaned with brush to remove all dirt, cement etc. If floor is uneven it should be made smooth prior to carrying out insulation work.
- Allow an additional 5 mm to the total dimensions while cutting Insulation sheet. Ensure you measure the cutting dimensions on the top surface of the insulation sheet. This can be identified by the products markings; “they are always on the top surface. This surface is the one you will see after installation.
- All Insulation sheet and floor surfaces shall have all-over adhesive coverage. Adhesive should be applied on the side that has no product markings and identification printing. This side is the one that curves inwards.
- During installation avoid air bubbles. Always apply pressure on fixing the Insulation sheet, this action will ensure maximum bond strength.
- All cut Insulation sheet edges shall be of a “clean cut nature & not cut rough”.
- All seams and joint shall be sealed with SR 505 adhesive. All seams and joints should have no more than 10mm of adhesive showing on the outer skin of the finished Insulation sheet installation.
- Measurement of surface dimensions shall be taken properly to cut closed cell elastomeric rubbers sheets to size with sufficient allowance in dimension. Material shall be fitted under compression and no stretching of material shall be permitted. A thin film of adhesive shall be applied on floor with brush and then on to the back of the insulating material sheet with brush/small piece of sheet metal having smooth edges. When adhesive is tack dry, insulating material sheet shall be placed in position and pressed firmly to achieve a good bond. All joints shall be sealed. SR 505 adhesive of Pidilite should be used for all cavity floor applications.

1.13 CROSS TALK SILENCER

The cross talk silencer should incorporate aerodynamic side lines with erosion protected class “O” acoustic in fills covered with perforated sheet metal. The casing should be manufactured as per DW 142 class B code and should be of galvanized sheet metal 1 mm thick to BS 2989 grade Z2 G275.

1.14 FLEXIBLE DUCTING

The scope of this section comprise supply, installation, testing and commissioning of flexible ducting conforming to these specification & in accordance with the requirements of drawings and schedule of quantities.

Wherever specified uninsulated flexible duct shall be made of double lamination of Metalized Polyester film permanently bonded to a coated spring steel wire helix. Duct shall be tear & puncture resistant construction.

Wherever insulated flexible duct are specified inner core for the same should be made of double lamination of Metalized Polyester film permanently bonded to a coated spring steel wire helix. Fiber glass insulation of minimum 14 kg/cu meter density having R-value $4.2^{\circ} \text{ F} - \text{Ft}^2 - \text{hr/Btu}$ & 32 mm thickness shall be wrapped over the inner core & covered with strong outer jacket cum vapor barrier made of fiberglass reinforced Metalized polyester film laminate.

Care must be taken to install all the flexible duct in fully extended position & bends made with adequate radius as per manufacturer recommended practices.

Duct should confirm to Australian Fire Standard AS 4254.

1.15 AIR CURTAIN

Air Curtain shall be furnished as factory assembled units consisting of casing, centrifugal fan, protective inlet screen, discharge nozzles and motor. The curtain shall provide uniform velocity across the entire length of discharge area.

The lower air blower assembly shall be bolted to the top casing with two (2) bolts on each end allowing access to the entire lower blower section. The bolts shall be easily removed for inspection or maintenance. The blower section shall be accessed either by removing the inlet screen, or access panels. The lower air blower assembly shall contain all mechanical parts and shall be mounted on a rigid base of minimum 14 G steel. Housing end plates shall be a minimum of 12 G steel. The rigid base and top cover shall be reinforced by 1.5" x 1.5" angle extending the full length of the unit and shall permit the unit to be supported from both ends without the need for intermediate support. All internal components shall be of welded construction. Units shall be supplied with epoxy zinc based two pack jet-black coating.

Units shall be equipped with dynamically balanced forward curved double inlet double width blower wheels with welded / riveted hubs. The blower wheels, housings and inlet cones shall be constructed of heavy gauge Aluminium alloy. The blower wheel shall be driven through flexible / rigid couplings to insure proper alignment of the blower shafts. Each blower wheel shall be supported on either side by heavy duty deep groove totally sealed permanent lubricated double bearing housed in suitable bearing housing.

The units shall be supplied with TE motor of suitable rating. Moreover, the unit shall have 2" deep discharge nozzle equipped with end aerodynamically shaped Aluminium airfoil air direction vane to insure deflection of entire air stream +/- 20 degree without loss of discharge velocity of opening area.

Sound level measured 5 ft. from the unit in a free field shall be no more than 68 dBA. The average velocity at the supply end of the curtain shall be between 15 to 17 Mtrs./Sec. While at the floor level it should be between 1.5 to 2 Mtrs./Sec.

1.16 AIR COOLED SPLIT UNITS

CONDENSING UNIT

The compressor(s) shall be hermetically or semi-hermetically sealed reciprocating / scroll and designed for continuous operation even at high ambient temperatures of 46°C. The condenser shall be air cooled, made of Cu. tubes with extended Aluminium fins. Cabinets shall be fabricated out of heavy gauge steel, properly formed for close fit and structural rigidity. All access panels shall be so constructed as to be quickly and easily removable. All outside surface shall be finished with powder coating for protection against humid weather. The condenser fans shall be directly driven and designed to achieve low condensing temperatures & operate continuously and silently.

EVAPORATING UNIT

The cooling coils shall be made of Copper Tubing having extended Aluminium fins. The tubes shall be mechanically expanded for positive bonding between tubes and fins. The cooling coils circuit shall be fed with liquid refrigerant through the expansion device and distributor. The blower shall be statically and dynamically balanced and designed for silent operation at required airflow rates against required static pressure. The filters shall be washable synthetic media type arranged for convenient cleaning and replacement. The drain pan shall be fabricated out of heavy sheet steel, insulated with 1/4" expanded polyethylene sheet. The casing shall be of heavy gauge GI, duly powder coated for weather protection.

Refrigerant gas to be used should be R-410A OR R-407C.

Note: All outdoors units shall be mounted on MS angle frame structure. The MS angle frame structure shall be painted with epoxy paint. The shade of the paint shall be approved by approved by the consultants / client.

CONTROLS AND INTERLOCKING

Electrically / electronically operated controls shall be provided with all components, auxiliary relays, capacitors including wiring for controls and interlocking.

1.17 PRECISION AIRCONDITIONING SYSTEMS –

PACKAGE UNITS AIR COOLED TYPE WITH ELECTRONICALLY COMMUTATED MOTORS

Scope of this Section comprises the supply, erection, testing and commissioning of the Microprocessor based BMS Compatible Packaged units conforming to these specifications outlined as below and in accordance with the requirements of the Schedule of Equipment. Refrigerant gas to be used should be R-134A OR R-407C. Units should be with multiple compressors.

Cabinet Construction

The frame and panels shall be constructed of heavy gauge corrosion resistant sheet steel and have modular construction with aluminium based railing and hinged doors.

The cabinet shall be powder coated and have a textured finish.

The cabinet Shall be provided with double skin side panels with inner panel of minimum thickness of 0.8mm and outer panel of thickness of 1.0mm.

Refrigeration Circuit

The refrigeration system shall be of the direct expansion type and each unit must incorporate hermetic scroll compressors having independent evaporator coil circuit. Compressors will be with necessary protection devices and valves complete. The system shall include a manual reset HP control and an auto reset LP switch, filter drier and charging port. A thermal expansion valve, sight glass and filter drier shall be provided in each circuit. Additionally, the system must be provided with vibration absorbers on the discharge side of compressor piping to minimize chances of any leaks due to compressor vibrations during start / stop cycle; this must be in addition to the anti -vibration mounts provided for the compressors.

Evaporator Coil

The evaporator coil shall be constructed of rifled bore copper tubes and louvered aluminium fins, with the frame and drip tray fabricated from heavy gauge steel. The drip trays must be double angled for condensate flow and easily removable for cleaning. The cooling coil shall be of suitable rows deep and designed for high sensible cooling. The distance between the fins should not be less than 1.8 mm and the face velocity shall not be more than 2.75 m/sec.

Compressor

The compressor shall be of the high efficiency complaint scroll design with an EER of not less than 11.1 BTUH/watt (COP of not less than 3.25) at ARI rating conditions. Each compressor shall have in-built overloads, HP and LP controllers and mounted on vibration isolators.

Vibration Absorber

All units must have VIBRATION ABSORBERS in compressor discharge lines to prevent cracks on high pressure copper pipe lines during start/stop cycle of the compressor.

Power Monitoring Switch

All units must be provided with CE certified main power line supervisor switch to monitor under voltage / over voltage / phase reversal of incoming power supply. Provision of one common power monitoring device in electrical panel will not be acceptable. The switch provided must be of reputed make and complying with EU norms.

Fan and Motor: ELECTRONICALLY COMMUTATED DRIVES

Fans: Unit must be provided with direct drive backward curved fans each running with DC drive electronically communicated motors, the fans should be aligned and balance statically and dynamically. The fan speed must be controlled based on the room return air Temperatures and also must have automatic speed control without manual intervention.

Units shall be factory balanced in accordance with Section 15071, Mechanical Sound and Vibration Control.

Only direct drive fans to be provided in offered units and centrifugal fans with belt drive is strictly not acceptable.

Noise Level: 70 db from 1 MT of unit in free filed conditions.

Service Area

The unit shall be serviceable from the front with a maximum service space required of 1 meter.

Electrical Heating

The electric heating elements shall operate at a level not exceeding 60 KW / m². The low watt density elements shall be of finned tubular nickel plated steel construction.

The heating circuit shall include dual safety protection through loss of air and high temperature controls.

Humidification

Steam humidifier capacity 5/8 or 10 kg/hr with 3 phase electrodes having function of auto drain and proportional control for capacity complete with steam supply and water drain hose pipe.

Filtration

Filtration level shall be microvee filters of 90% - 10 microns. Filter clog pressure switch is compulsory.

Electrical Panel

Control cabinet to be NEMA 250; Type 2 enclosure, with grounding lug, combination magnetic starters with overload relays, circuit breakers and cover interlock, and fusible control circuit transformer.

The electric panel provided for the unit must be equipped with main incoming power isolation switch, additionally the unit must be provided with under voltage / over voltage / phase reversal / single phasing protection, all three phase motors must be operated only via 24V coil voltage contactors and MPCB's, additionally step down transformer must be provided for power supply to the unit controller. The electrical panel must also be providing with relay block for common alarm.

AIR Cooled Condenser

The condensers shall be factory matched to provide an operating range of (-) 5 °C to 45°C ambient. Condensers shall be suitable for 24-hour operation and be capable of providing vertical or horizontal discharge.

The condenser frame shall be constructed from heavy duty steel and incorporate a copper tube and aluminium fin coil.

The coil shall be a maximum of 6 rows deep, with a minimum fin spacing of 2.0 mm with a maximum face velocity of 3.6 m/s.

The condenser fans shall be direct drive axial type operating at not more than 1440 rpm variable voltage electric motors. 6 pole 900 rpm fan motors will be used for low noise level applications.

Electronic Fan Speed Controller for Condenser fans

The condensers must be provided with electronically controlled fan speed controllers, the speed of fans must be controlled based on temperature sensing of liquid line to ensure compressor constant head pressure, pressure monitoring electronic switch must be suitable for application up to 12 Amps to take care of high motor amps.

Micro Processor Controller

Each Air conditioners should have single microprocessor with following controls :

Control Type

The controls shall be a microprocessor programmable logic controller. The controls shall have separate indication of operating modes (cooling, heating, humidifying and dehumidifying), alarm conditions (temperature high, loss of sensor, compressor HP & LP, wet floor, no air flow and low humidifier water). The display and indication shall be visible on the front without removing any external panels. Local and remote alarms will be triggered if an alarm condition is reached. Each unit must be provided with large screen GRAPHICAL DISPLAY and additionally the controller must have feature of DUAL SET POINT programming.

Alarms

The alarm should operate with the audible signal.

Following alarms should be available:

1. Temperature High / Loss of Sensor
2. Compressor 1 High / Low Pressure
3. Compressor 2 High / Low Pressure
4. Wet floor
5. No Air flow
6. Low Humidifier Water.
7. Filter clog
8. Temperature high / low
9. Humidity high / low

The control should have an auto-restart feature which will return the unit to normal operation resumption of mains power.

Automatic load / time and alarm sequencing function to be performed by the unit.

Microprocessor must have output point for ON/OFF of motorized damper and must be suitable to be integrated with fire point for unit shut off in case receiving signal from fire panel or fire detectors.

The unit controller must have option of {DUAL SET} point for energy saving i.e. customer must have the option to set two independent set points for the unit based on operational requirements and energy saving concepts.

Display

In normal operating mode the screen should display unit number, temperature and relative humidity set points and actual, operating status.

The unit must have a large screen LCD display on controller with user friendly menus and minimum two level password protections.

RS485 interface port for BMS compatibility with ModBus RTU protocol is required.

REFRIGERATION PIPING & INSULATION

The refrigeration piping between indoor and outdoor units will be carried out with good quality soft / hard copper piping. The complete piping work shall be insulated with formed sections of expanded polyethylene.

The piping shall be clamped with GI saddles with wooden strips with walls.

- a. All refrigerant pipes and fittings shall be hard /soft drawn copper tubes and wrought copper / brass fittings suitable for connection with silver solder / phos-copper.
- b. All joints in copper piping shall be sweat joints using low temperature brazing and / or silver solder. Before jointing any copper pipe or fittings, its interiors shall be thoroughly cleaned by passing a clean cloth via wire or cable through its entire length. The piping shall be continuously kept clean of dirt etc. while constructing the joints. Subsequently, it shall be thoroughly blown out using carbon dioxide / nitrogen.
- c. Refrigerant lines shall be sized to limit pressure drop between the evaporator and condensing unit to minimum.
- d. Sight glass with moisture indicator and removable type combination dryer cum filter with MS housing and brass wire mesh / punched brass sheet shall be installed in liquid line of the

- refrigeration system.
- e. Horizontal suction line shall be pitched towards the compressor and no reducers shall be provided for proper oil return.
 - f. After the refrigerant piping installation has been completed, the refrigerant piping system shall be pressure tested using Freon mixed with nitrogen / carbon dioxide at a pressure of 20 kg per sq. cm (high side) and 10 kg per sq. cm (low side). Pressure shall be maintained in the system for a minimum of 12 hours. The system shall then be evacuated to a minimum vacuum of 70 cm of mercury and held for 24 hours. Vacuum shall be checked with a vacuum gage.
 - g. All refrigeration piping shall be installed strictly as per the instructions and recommendations of air conditioning equipment manufacturer and the piping design will have to be endorsed by equipment manufacturer.
 - h. The Contractor shall make sure that the clamps, brackets, clamp saddles and hangers provided for pipe supports are adequate. Piping layout shall take due care for expansion and contraction in pipes and include expansion joints where required.
 - i. During construction, the contractor shall properly cap all lines, so as to prevent the entrance of sand, dirt, etc. Each system of piping shall be flushed thoroughly after completion (for the purpose of removing dirt, grit, sand etc. from the piping and fittings) for as long a time as is required to thoroughly cleans the system.
 - j. Wherever pipes pass through the brick or masonry / slab openings, the gaps shall be sealed with fire barrier caulks.
 - k. Insulated piping shall be supported in such a manner as not to put undue pressure on the insulation. 20-gauge metal sheet shall be provided between the insulation and the clamp, saddle or roller, extending at least 15 cm on both sides of the clamp, saddles or roller.
 - l. All piping work shall be carried out in workmen like manner, causing minimum disturbance to the existing services, buildings and structure. The entire piping work shall be organized, in consultation with other agencies work, so that laying of pipes, supports, and pressure testing for each area shall be carried out in one stretch.

1.18 BUILDING MANAGEMENT SYSTEMS

1.0 SCOPE

Scope of this section comprises the supply, installation, testing and commissioning of Building Management System including Building Performance Management.

1.1 DESCRIPTION OF PLANT OPERATION

1.1.1 Central Chilled Water System

1.1.1.1 The central chilled water system shall consist of the following items of plant :

- a. Water chilling machines.
- b. Primary Chilled water pumps.
- c. Secondary Chilled water pumps with VFD (variable speed).
- d. Variable frequency drives.

Total number of Chilled water circuit

The following functions shall be carried out by the Building Automation System.

- a. Enable and disable each chiller unit through Chiller Manager
- b. Monitor status and lockout conditions of each chilling unit and subsequently give an alarm.
- c. Monitor the status of each variable frequency inverter upon receiving signal from pump controller installed in plant room.
- d. Switch ON/OFF each pump / chilling unit to maintain the chilled water load demand.
- e. Sequence each pump / chilling unit to maintain equal run time.
- f. Carry out chilled water temperature reset with respect to chilled water valve position at the AHU's.
- g. Monitor status of each of the primary chilled water pumps through a differential pressure switch and keep a log of run-time.
- h. Monitor current drawn and power consumption by each of the chiller compressor and all pumps and subsequently give an alarm for abnormal consumption.
- i. Monitor the common chilled water supply and return temperatures.
- j. Monitor the chilled water supply temperature at outlet of each Chiller.
- k. Monitor the chilled water supply/return temperature of each CHW circuit.
- l. Monitor the common chilled water supply pressure through a pressure transmitter.
- m. Monitor the chilled water supply & return header pressure on each of the chilled water circuits.
- n. Monitor the energy consumption through BTU meters.
- o. Monitor the Chilled water flow rate in return header in each of the chilled water circuits.
- p. Monitor flow direction in the chilled water bypass line through flow switches.
- q. Monitor the outside air temperature and relative humidity.
- r. Monitor any item of plant being switched on a manual basis (i.e. an indication / alarm to come on the screen, if any equipment is running in manual mode.

1.1.1.2. Ventilation & Exhaust System

Basement, Plant Room, Pump Room, STP, Exhaust Air Fans

- a. Control Start/Stop of each fan.

- b. Indicate any unit running in Manual mode and subsequently give an alarm.
- c. Carry out monitoring tripping & subsequently give an alarm.

1.1.1.3. Public Toilet Exhaust Fans

- a. Control Start/Stop of each fan.

1.1.1.4. Fans for Kitchen, Supply, Exhaust

- a. Control Start/Stop of each fan.

1.1.1.5. Air Handling Units

- a. Program the start/stop of each air handling unit supply fan and carry out the duty cycling.
- b. Monitor the running status of each blower fan Air Differential Pressure Switch.
- c. Monitor filter status of AHU by a pressure differential switch & give an alarm in case the filter gets choked.
- d. Monitor the supply and return air temperature & give an alarm for a high/low supply air temperature.
- e. Control the chilled water two way modulating valve, to maintain the room conditions.
- f. Indicate any unit running in Manual mode.
- g. Calculate power consumption in KWH from VFD panel

1.2 Building Performance Management shall comprise of :

- a. Maintenance Software
- b. Complaint Tracking Software
- c. Energy Software
- d. Calculation software
- e. Document Software

2.0 SYSTEM DESCRIPTION & INPUT OUTPUT SUMMARY

The proposed system shall be a Direct Distributed Digital Control (DDC) system. It shall be a PC based system with web based operator interface and shall combine latest state of the art technology with simple operating techniques. The System will consist of flat open architecture that utilizes LON Talk / BACnet protocol between all controlled and controlling devices. The controllers shall have resident real time clock, peer to peer communication and min 16 / 32 bit processor. The features shall be distributed both physically and functionally over the field controllers. A web server with a network interface card shall gather data from this system and generate web pages accessible through a conventional web browser on each PC connected to the network. Also operators shall be able to perform all normal operator functions through the web browser interface.

System shall use the BACnet protocol or Lon works for communication to the operator workstation or web server and for communication between control modules. I/O points, schedules, set point, trends, and alarms specified in "Sequence of Operations" shall be BACnet objects.

Performance Standards : System shall conform to the following minimum standards over network connections. Systems shall be tested using manufacturer's recommended hardware and software for operator workstation (server and browser for web-based systems).

- i. Graphic Display. A graphic with 20 dynamic points shall display with current data within 10 sec.
- ii. Graphic Refresh. A graphic with 20 dynamic points shall update with current data within 8 sec. and shall automatically refresh every 15 sec.
- iii. Configuration and Tuning Screens. Screens used for configuring, calibrating, or tuning points, PID loops, and similar control logic shall automatically refresh within 6 sec.
- iv. Object Command. Devices shall react to command of a binary object within 2 sec. Devices shall begin reacting to command of an analog object within 2 sec.
- v. Alarm Response Time. An object that goes into alarm shall be annunciated at the workstation within 15 sec.
- vi. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 sec. Select execution times consistent with the mechanical process under control.
- vii. Performance. Programmable controllers shall be able to completely execute DDC PID control loops at a frequency adjustable down to once per sec. Select execution times consistent with the mechanical process under control.
- viii. Multiple Alarm Annunciations. Each workstation on the network shall receive alarms within 5 sec of other workstations.

- ix. Reporting Accuracy. System shall report values with minimum end-to-end accuracy, Control Stability and Accuracy. Control loops shall maintain measured variable at set point within tolerances.
- x. Energy Management through optimization of all connected electrical and mechanical plants.
- xi. Prevention of unauthorized or unwanted access.
- xii. Suggestive preventive maintenance for all equipment as well as own error diagnosis.
- xiii. Building Performance Management
- xiv. Optimum support of personnel.
- xv. Data Visualization Tool

All DDC controllers shall be connected via an industry standard communication Bus. Communication between controllers shall be such that, controllers can communicate between themselves without having to first communicate with the control station. The communication between the different buses shall be through the system integration units or routers rather than through the control stations. All the system integration units shall be placed on a Local Area Network (Industry standard open back bone like Ethernet / BACnet / Lon works etc.). The speed of communication desired between DDC controllers shall be exceeding 9.6 kbps and on Local Area Network shall be 10 mbps. No proprietary LAN shall be allowed.

Communication

Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BACnet internet work. Controller and operator interface communication shall conform to ANSI/ASHRAE Standard 135-2004, BACnet.

Install new wiring and network devices as required to provide a complete and workable control network. Use existing Ethernet backbone for network segments marked "existing" on project drawings. Project drawings indicate remote buildings or sites to be connected by a nominal 56,000 baud modem over voice-grade telephone lines. In each remote location a modem and field device connection shall allow communication with each controller on the internet work as specified in Paragraph D.

Each controller shall have a communication port for temporary connection to a laptop computer or other operator interface. Connection shall support memory downloads and other commissioning and troubleshooting operations.

Internet work operator interface and value passing shall be transparent to internet work architecture.

- i. An operator interface connected to a controller shall allow the operator to interface with each internet work controller as if directly connected. Controller information such as data, status, and control algorithms shall be viewable and editable from each internet work controller.
- ii. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internet work. Program and test all cross-controller links required to execute control strategies. An authorized operator shall be able to edit cross-controller links by typing a standard object address or by using a point-and-click interface.

Controllers with real-time clocks shall use the BACnet Time Synchronization service. System shall automatically synchronize system clocks daily from an operator-designated controller via the internet work. If applicable, system shall automatically adjust for daylight saving and standard time.

System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring.

System shall support Web services data exchange with any other system that complies with XML (extensible markup language) and SOAP (simple object access protocol) standards specified by the Web Services Interoperability Organization (WS-I) Basic Profile 1.0 or higher. Web services support shall as a minimum be provided at the workstation or web server level and shall enable data to be read from or written to the system.

- i. System shall support Web services read data requests by retrieving requested trend data or point values (I/O hardware points, analog value software points, or binary value software points) from any system controller or from the trend history database.
- ii. System shall support Web services write data request to each analog and binary object that can be edited through the system operator interface by downloading a numeric value to the specified object.
- iii. For read or write requests, the system shall require user name and password authentication and shall support SSL (Secure Socket Layer) or equivalent data encryption.

System shall support discovery through a Web services connection or shall provide a tool available through the Operator Interface that will reveal the path/identifier needed to allow a third party Web services device to read data from or write data to any object in the system which supports this service.

Each stand-alone intelligent outstation shall control a maximum of two Air Handling Units and shall be located adjacent to the air handling unit. These shall also control any other operations on the floor and shall be sized to suit the operation center's requirement. This shall help in reducing the site electrical installation.

The number of controllers for central plant room equipments shall be decided by the contractor with a maximum capacity limited to 48 points per controller. Overall, the system shall be provided with 15% spare capacity, with spare of at least 15% points on each controller. Also, in case of HVAC system, each controller shall control maximum one chiller and associated chilled water pump.

There shall be one control station located in Chief Engineer Room. The computer shall be sized to cover the graphic display memory and planning information. The display shall be in the form of dynamic color graphics and text format with menu driven pop-up windows and help facility.

The following software packages shall be loaded into the system as minimum standard :-

- a. Complete system operational software
- b. Site specific data manipulation software
- c. Active graphics software
- d. Energy management system software
- e. Alarm indication software
- f. Maintenance package (schedule to be developed with Estate Manager).
- g. Data Visualization Package
- h. Internet Enabled Remote Monitoring Package.

All Web server or workstation and DDC controllers shall communicate using BACnet protocol. Web server or workstation and control network backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing as specified in ANSI/ASHRAE 135-2004, BACnet. Communication between controllers shall be such that, controllers can communicate between themselves without having to first communicate with the control station.

Each Building Controller shall reside on or be connected to a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing.

BACnet routing shall be performed by BCs or other BACnet device routers as necessary to connect BCs to networks of Advanced Application Controllers and Application Specific Controllers.

Each AAC shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.

Each ASC shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.

Each SA shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.

Each SS shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using ARCNET or MS/TP Data Link/Physical layer protocol.

In case of Hot redundant Central Operating Workstation on a peer Bacnet / IP with mirroring function, second operator workstation would have interoperable feature i.e. incase set points, logic, password are changed in the second Operator Work Station (OWS) the same would get updated automatically and instantaneously in the other OWS.

3.0 CENTRAL STATIONS HARDWARE

The Control stations shall comprise of Personal computers (PC) providing high level operator interface with the system. The terminals shall be capable of providing the operator with the facility for remote system interrogation, control, retrieval/storage of logged data, annunciation of alarms and reports, analysis of recorded data and the formatting of management reports.

The control station shall consist of the following hardware with all of them suitable for the power supply voltage of 230 V AC $\pm$ 10% , 50 HZ $\pm$ 3%.

a. Minimum Specifications for Workstations

FEATURES	DESCRIPTION
Processor	Intel Dual Core Pentium D Processor 3.2 GHz with EM 64 Technology
Memory	2GB (2 x1 GB) dual channel DDR2 533 memory, Up to 8 GB Max. memory expandable through four DIMM slots
Cache (External)	2 x 2 MB L2 Cache
ROM	512 MB Flash ROM, Can be upgraded from a diskette
Expansion Bus	2nos PCI Express (x1), 4nos 32 bit PCI slots, 33 MHz PCI 2.2 slots, 1-graphics slot
Graphic Accelerator	NVIDIA Quadra FX 4400(DVI/VGA)with 512 MB Memory with dual monitor capable graphics card
Hard Disk	120 GB 7.2K rpm SATA hard disk
Power Supply	375 W switchable/50 Hz with dual power supply provisions
Keyboard	Cordless 104 keys window 98 keyboard, PS/2 Compatible
Operating System	Supports Windows XP, OS/2 Warp, Windows NT, DOS 6.22
Software	Windows Professional and Windows 2000, Microsoft Internet Explorer
Power Management	EPA compliant
Desktop Manager	Based on SNMP protocol
Antivirus Software	PC-Cilin or equivalent pre-loaded
Diagnostic Software	PAQ 95 or equivalent pre-loaded
Network	Broad cam 10/100/1000 Mbps Ethernet adapter Network Interface Card with wake on LAN support
Interfaces	1 parallel, 8 USB 2.0, 1 serial, 2 Ultra ATA/100,2 optional IEEE1394, 1 PS/2 Keyboard, 1 PS/2 Mouse, 1 video, 1 Microphone jack, 1 Line-in jack, 1 RJ-45, 1 Headphone jack & 1 line-out jack (analog/SPDIF digital
Audio Card	Integrated AC 97/16 bit Stereo full-duplex and integrated speaker
Mouse	Cordless Mouse
Monitor	Monitors shall be with a minimum 19 inch color TFT flat panel display.
CD DVD Writer	DVD/CD-RW Combo Drive with speakers
Printer	Laser Jet 20 ppm, A3 paper size.

b) Key board : The central station shall be complete with detached 101-keys keyboard which includes

full upper/lower case ASCII key set, a numeric pad, dedicated cursor control pad, and a minimum of 10 programmable functional keys.

- c) Color Monitor : The color TFT screen shall be with a minimum 19 inch diagonal no glare screen and minimum Super VGA resolution of 1024 pixels horizontal, 768 lines vertical and minimum 16 base colors. The monitor shall be with tilt and swivel facilities.
- d) Mouse (Optical): For keyboard less operation, in addition to the enhanced keyboard, a mouse shall also be provided as an alternative user interface for day to day system operation. 2 Nos. mouse pads shall be provided for each mouse.
- e) Printers: The contractor shall provide printers as specified in the schematic diagram for printing alarms, operator transactions and reports.
The printer shall be configuring for alarm printing reports, trend log, summary, total logging, recording alarms and providing system reports etc.
- f) The available PCI slots on the PC shall be used only for communication cards and shall not be utilized for mounting protocol converter cards. If protocol converter cards are used, they shall be external to PC and separately powered and backed-up by the UPS supply.

4.0 CENTRAL STATION SOFTWARE

4.1 USER PROGRAMMABLE SOFTWARE

The system shall have a flexible software package to allow an operator with minimal knowledge of software programming to construct programs for plant control and management information. The BAS contractor shall provide system software based on server/thin-client architecture, designed around the open standards of web technology. All system software shall be field proven. The BAS server shall communicate using ASHRAE's BACnet/IP protocol, and in addition, offer concurrent support over the same data-link of the following protocols: Lon Works, MODBUS, and SNMP. Server shall be accessed using a web browser over intranet and remotely over the Internet. Tenders shall not quote for untested and unproven software.

The intent of the thin-client architecture is to provide the operator(s) complete access to the BAS system via a web browser.

The BAS server software must support at least the following server platforms (Windows NT, Sun Solaris and Linux). The BAS server software shall be developed and tested by the manufacturer of the system standalone controllers and network controllers/routers. Third party manufactured and developed BAS software is not acceptable.

- 1) All programming shall be done in clear English language.

- 2) The system shall hold a complete set of instructions in the software which can be viewed by the operator whilst in the operating mode.
- 3) The system shall provide run simulation of the programs to allow operator verification before the program is down loaded to the controllers.
- 4) It shall be possible to assign alarm functions to any programs created as required.
- 5) Full arithmetic operators shall be available for use in the programs as required e.g.: +, -, /, *, ().
- 6) Programs shall permit the use of comparison statements such as : =, >, <, =< etc.
- 7) Programs shall permit logical operators to be used such as : NOT, AND, OR, AND MASK.
- 8) Direct reference to any point shall be available to obtain its current value. Such references shall be using standard language such as, ON, OFF, MANUAL, SETPOINT, EXPIRED TIME, PRIORITY, ALARM.
- 9) It shall be possible to refer to time and calendar functions directly, so that DATE, TIME, HOUR, MINUTE functions may be used.
- 10) It shall be possible to use such mnemonics as ABS (absolute value), SQRT (square root), INT (integer), MAX (maximum), AVG (average) etc.
- 11) It shall be possible to set timers so that a timed delay may be introduced before an action is carried out.
- 12) In short it should have Trending, Scheduling, Dynamic Graphics, Tree Navigation, Set point, Operator Configuration, and Global Commands Execution & Parameters Properties as minimum features.

Following Software shall be provided besides the software for automation system :

Memory Manager	-	QEMM Version 5.11 (or higher)
Multitasking	-	Deskview version 2.31 (or higher)
Mouse Driver	-	Microsoft bus mouse 6.2
Data Base Manager	-	Latest Version
BAS Server Database		

The BAS server software shall utilize a Java DataBase Connectivity (JDBC) compatible database such as: MS Access, MS SQL 8.0, Oracle 8i or IBM DB2. BAS systems written to Non standard and/or Proprietary databases are NOT acceptable.

Database Open Connectivity

The BAS server database shall be Java DataBase Connectivity (JDBC) compatible, allowing real time access of data via the following standard mechanisms:

Open protocol standard like CORBA or SOAP

OLE/OPC (for Microsoft Client's/Server platform only)

Import/Export of the database from or to XML (extensible Mark-up Language)

Windows	-	Latest Version
Maintenance Manager	-	Latest version with details to be submitted alongwith tender.
Lighting Management	-	For time schedule & occupancy interface.

Management station software shall also be provided all the functions to manage application software packages within a Preemptive Multitasking environment.

Third Party Integrations:

The software shall be open architecture & support based for industry standard integrations with third party mechanical & electrical sub-systems. The same shall be capable to support multiple protocols over a TCP/IP Network allowing many equipment items to be connected directly to the main backbone IT protocol. The software using BACnet® shall be connected to an IP, ARCNET, MS/TP, or Point to Point (PTP) network segment. The system shall allow for seamless interconnection to equipment using BACnet, Modbus or Lon Works, as well as an extensive list of proprietary protocols.

The software shall mainly cover the following third party integrations:

- Chiller Integration
- Generator Integration
- Electricity / Water / Steam / D.G. Sets / VFD's

The above Utility systems shall be incorporated for options such as alarming, automatic demand reduction and utility bills. It shall have control everything from mission critical cooling to emergency back-up generators. Special function like unique schedule for a group of rooms shall be provided. Feature like "holiday" schedule to save energy in different space of the building.

The request based feature like for example, if the one of the department is going to work on Saturday and needs air conditioning in the main conference room, the software shall have the feature of occupation schedule for in the real time calendar, and the system shall do the rest. When the rooms need cooling, they

will send a request to the air handler telling it to start. If the air handler in turn needs cold water from a chiller, it will send a request to the chiller. With request-based applications, the equipment shall be controlled by the customer's schedule, rather than forcing the customer to adapt to the equipment's schedule.

The system shall have energy management applications, providing features like learning adaptive optimal start, trim and respond, and demand-based set point adjustment which automatically fine tune the system to run at peak efficiency.

It shall have networking, trending, alarming, and reporting capabilities,

- Boiler Integration:

The software shall be a web based data management tool and consist analysis modules for boiler water and cooling water systems, respectively. These programs are designed for use in monitoring boiler, steam cycle and cooling system performance in industrial or utility boiler installations. Boiler, cooling system and other steam cycle parameters can be trended and alerts can be set for key parameters that are detected to be in an abnormal condition and diagnoses the reason(s) for many common problems in steam plants and cooling water systems. It also calculates the total energy consumed v/s the produced energy (Steam) trending with real time computation of system's efficiency.

Communication Protocol(s)

The native protocol for the BAS server software shall be BACnet over Ethernet DataLink as defined by ASHRAE standard SPC135. The BAS Server shall support BACnet/IP Annex J to enable communication through common routers. Proprietary protocols over TCP/IP are NOT acceptable. In addition, the software shall be able to support concurrent operation of multiple standard and non-standard protocols such as:

- SMNP
- Lon Works over IP*

* IMPORTANT NOTE: LonMark or Lon Works devices must be networked from LonTalk to an Ethernet Datalink and IP data structure, using a LonTalk to IP Router like an i1000 Echelon Router. Binding of all LON devices including Domain, Subnet, Node ID, and the SNVT's structure, in addition to configuration of all network variables for IP tunneling shall be the responsibility of the LON device supplier. ALL I/O points listed in the I/O Point Summary shall be configured through the i1000 LON/IP router(s). A copy of Echelon's proprietary LNS Services and LON Manager shall be supplied at no cost to us by the supplier of the LON devices.

The following user programs must be processed by the Control Station

- i. Operating functions:
 - Via graphic management schematics with dynamic display of actual status information.
 - manual control of parameters and status variables of the electrical and mechanical plant.
 - manual switch of programs which are not part of progress routines.
- ii. Monitoring functions:
 - automatic monitoring of connected plant and equipment
 - automatic monitoring of the system (idle or operation)
- iii. Data Visualization functions :
 - individual processing of operating data for Building Management.
 - comfort chart data for temperature / humidity using psychrometric charts
- iv. In standardized form for:
 - trend reports(Historical)
 - consumer statistics
 - fault statistics
 - maintenance management
- v. Display functions:
 - for the representation and display of operating data and management information in alphanumeric and graphic form.
- vi. Management functions:
 - for optimization of energy consumption.
 - for rational use of personnel
- vii. Access control functions:
 - different operating levels for all information and all data by way of code word or user key.
- viii. Commissioning functions:
 - for system specific software of the field stations and the management system

- downloading the system specific software to the DDC units.
- testing of the software in connection with electrical and mechanical plant.
- automatic and periodic storage of all system data.

ix. Test functions:

- automatic and continuously running test functions for system tests (hardware and operating software) and management system configuration (communication)
- test tools for individual hardware and software components which can be activated manually.
- Self test functions for individual system components which can be activated manually.

4.2 OPERATOR INTERFACE

All communications between the operator and the system shall be in clear language, without reference to special code or codes. Generation and editing of software shall be via clear English language menus. The purposed software shall be capable to forfeit the requirement of integrated maintenance management solution. Web based data management software & its application plays a critical part providing a single repository for all assets. This repository is necessary to go from preventive to predictive and proactive maintenance programs Lifetime maintenance and parts costs can be stored with the asset database, and repair or replace decisions become a financial analysis. The system should self diagnostic e.g. enthalpy control, energy recovery lops. With the below specified feature / requirements this software shall be deemed to act in a way to provide the information in “predictive & preventive maintenance.”

The Thin Client web browser GUI shall provide a comprehensive user interface. Using a collection of web pages, it shall be constructed to “feel” like a single application, and provide a complete and intuitive mouse/menu driven operator interface. It shall be possible to navigate through the system using a web browser to accomplish 2.2 B thru 2.2 J of this specification. The Web Browser GUI shall (as a minimum) provide a Navigation Pane for navigation, and a Action Pane for display of animated graphics, schedules, alarms/events, live graphic programs, active graphic set point controls, configuration menus for operator access, reports, and reporting actions for events.

4.3 PASSWORD ACCESS

- 1) None of the features of the Operators Panel shall be accessible without the user first being required to log on by entering a password.
- 2) Alpha numeric passwords of up to 15 characters shall be available and definable by individual operators.
- 3) It shall be possible to grant or deny access to any terminal and/or functions for individual user. The

ability to use this feature itself shall also be definable.

- 4) It shall also be possible to grant or deny access to individual points or groups of points by function or type.
- 5) It shall also be possible to define a timeout value for individual user. Automatic log-off of the operator shall occur if no keyboard or mouse activity is detected during this timeout period. It shall also be possible to allocate an infinite timeout.
- 6) A log of atleast previous 100 users shall be available at each control station. A record of the user's name, the time and date of log ON and log OFF shall be available from this file.
- 7) Password summary shall be available to the operators with the highest level of access. The summary shall display all passwords and their associated parameters.
- 8) Password data base shall be stored in multiple locations in an encrypted form so that the failure of any one device shall not make the system inoperative.

4.4 CONTROL STATION GRAPHICS CAPABILITIES

The work stations shall have Graphics as the basis of operation. Animated .gif or .jpg, active set point graphic controls shall be used to enhance usability. Graphics tools used to create Web Browser graphics shall be non-proprietary. The software shall have following advanced techniques for ease of operation:

- 1) Color banding of screen displays shall be provided for display and differentiation of normal and abnormal signals. This shall allow operator instant recognition and response to critical building operation.
- 2) To provide instantaneous confirmation to system operator of equipment status, graphic screen animation shall be provided. This shall allow full color animated displays of equipment in site layouts, building floor plans, and other system configurations. All graphic displays shall be online programmable via keyboard or mouse selection of graphic library stored symbols and system profiles. Fully implemented graphic displays are to be provided for all systems so identified in the Input/Output Summary section of this document.
- 3) Split screens capability shall be provided to allow operator to observe multiple dynamic graphic screens at the same time to enable operator to manage several separate building operation tasks concurrently.
- 4) To enable operator to "find" his way in and out of the system, a stacked display of windows shall be included to provide orderly reference. Operator option of enlarged full screen display at any penetration level shall also be included.
- 5) Alarm class differentiation shall define coloration, and storage requirements for different alarms.

- 6) Graphic driven point identification and selection shall be provided to allow operator to select a point by “clicking on” the graphic symbol representing the point type. Consequently display will appear to enable the operator to select the desired command.
- 7) The system shall be capable of running programs in both the foreground mode and background mode simultaneously. The system running only foreground “window” while keeping the other programs dormant in the background “window” shall not be acceptable as this slows down the availability of control and essential information to be made available to the operator in the system.
- 8) Capability of on-line graphics generation shall be a major requirement i.e. the operator shall have the ability to create new graphics on-site from a menu of symbols.
- 9) Historical system trouble, fault, false alarms shall be stored on line in the hard disk for trouble analysis.
- 10) It shall be possible to define upto 12 functional categories in the plant schematic each of which shall be removable from the screen individually. This shall allow the operator to delete temporarily any equipment and have a better overview of the other sections of the system.
- 11) Maintenance software such as inventory control, work orders shall also be on-line with the historical data- file for proper maintenance of the system.
- 12) Data Base Manager shall manage all data on an integrated and non-redundant basis. It shall allow addition and deletions to the data base without any detriment to the existing data. Cross linkages shall be provided such that no data required by a software program can be deleted by the operator until that data has been deleted from its respective programs.
- 13) Dynamic data such as temperature and humidity values, fans and motor status, alarm point condition, etc. shall be embedded in the graphics as the sensing location. Points in alarm condition shall be animated by color changes and flashing/blinking icon, symbol, or value.
- 14) Commandable points shall be uniquely identified by color and/or discrete symbol and shall be directly addressable and commandable from the graphic display. It shall not be necessary for an operator to type in command request or point names. Direct entry of commandable point address or positioning of the cursor to the point shall cause a display of associated command states for digitals, the set point value and valid range for analogs. Cursor positioning shall be via a “mouse”.
- 15) In order to allow the operators to view graphics in greater detail, zoom /pan display feature shall be provided to return zoomed/panned graphics to their original status. A “return to original” feature shall also be provided. The mouse shall be used to pan in all directions in real time, and to jump, from any section of the plant schematic directly to another section or to another level.
- 16) Sample Graphics to be approved during technical submittal.

4.5

USER INTERFACE

The operator panel on a terminal shall provide the primary interface for operator access to the BAS while also providing a vehicle for the annunciation of alarms and the reporting function. The operator shall have the option of switching between a text based and graphic based user interface at any time. In particular following standard functions shall be provided.

- 1) It shall be possible to carry out the following commands by use of dedicated function keys on the keyboard and by the mouse :
 - a. ON - digital points
 - b. OFF - digital points
 - c. AUTO - analogue and digital points
 - d. SET TO VALUE - analogue points
 - e. ALARM REVIEW
 - f. POINT TYPE REVIEW
 - g. POINT GROUP REVIEW
 - h. HOURS RUN REVIEW / Run Time
 - i. REVIEW CANCEL
 - j. GRAPHICS ENABLE
 - k. HELP
 - l. ALARM ACKNOWLEDGE
- 2) It shall be possible to add new points, and reconfigure or modify existing points without taking any part of the system off-line. It shall be possible to change designation of operator passwords, access levels, point segregation and auto sign off, designation of backup consoles and printers. It shall also be possible to add/change descriptors for points, segregation groups and access levels, and action messages for alarms and trouble condition, system/point enable/disable, input or output value, and assignment of alarm/warning limits. All additions and modifications shall be on-line programmable via operators keyboard and then down the line loaded to distributed processing units.
- 3) It shall be possible to address plant, zones, points etc., using clear language descriptors. Each individual point may also be identified by a unique alpha-numeric mnemonic address entry. Simple key names may be assigned to points to allow direct display. These key names shall be fully operator assignable and depending on how frequently they have to be accessed, they may be as simple as one, two or three characters or as lengthy as 20 characters.
- 4) The operator shall be able to access any point on any graphic without going through the penetration path. Graphics shall be menu-driven. Direct access to graphics shall be menu selectable wherein the operator may select optionally by entering the name of the graphic system desired or by

selecting the desired graphic via cursor positioning.

- 5) It should be possible to identify some points which are frequently addressed as “frequent access” points. This listing shall be selectable from a screen top menu bar drop down menu item with a user address, descriptor and value/status of each “frequent access” point displayed.
- 6) A wild card search utility should be provided which shall be operated by a partial data entry. For example, by listing chiller 1, all chiller no. 1 points shall be listed.
- 7) The information displayed for individual points during a review shall be :
 - its unique mnemonic address
 - its current state or value (in Engineering units)
 - its type of point (analog/digital, input/ output)
 - any secondary or tertiary value
 - reason for state, if applicable
- 8) An Electronic message facility shall be provided on the operator station for any operator to enter a message to another operator of the same station or different station, by selecting the receiving operator’s ID and entering the message. When the operator with a queued message, signs onto the operator station, a “mail message waiting” prompt shall be issued. Upon displaying a mail message, the display shall prompt the operator with three message options to execute, delete, print, and save. Messages shall also include the senders personal ID and a brief title or subject description.
- 9) Dynamic data shall be automatically updated on the central station . Manual update shall also be provided via a screen update key.
- 10) It shall be possible to enter any of the subroutines such as the editor functions, or the Data Manipulation function from the central station without closing down the terminal or the programs currently running.
- 11) The operator shall be provided with the facility to override the use of portable operators terminal.

4.6 HELP FACILITY

Software shall be provided to facilitate programming and storage of the system operation manuals in the hard-disk. The operation manual shall be retrieved by On Line Help mode so as to enable the operator to self learn the system operation, command, or function as and when needed.

This ‘help’ facility shall be made available to the operator by use of a dedicated key or a single key click on the mouse. A minimum help shall be available for every menu item and dialogue box.

The facility shall contain both text and graphics to provide information about the selected function directly.

The information provided shall be in simple clear language and shall be capable of being added to or modified by an authorized operator.

4.7 ALARMS

Multiple priority levels of alarm shall be made available. Priority levels shall be deemed Critical Alarms and Non- critical (general) Alarms. Normally, critical alarms shall take precedence over non-critical alarms, and high priority over low priority.

Each analog point shall have the following limits defined ; wherever required

- High priority critical alarm limit
- Low priority critical alarm warning limit
- Low priority warning limit
- Low general alarm limit

When an analog point goes outside the low priority critical alarm limit or Low priority warning limit, a user defined warning message shall be directed to the appropriate alarm printers at the control station.

The Warning limits shall be used to monitor controllability, not comfort conditions. The alarm limits shall be used to monitor comfort conditions. When a set point is changed, the warning limits shall automatically change while the alarm limits shall not change.

When an analog point goes outside any of the limits defined, a user defined alarm message for that level shall be directed to the appropriate alarm printer and to respective operator workstation. Alarm message shall require operator acknowledgement.

When a digital point goes into alarm, a user defined alarm message shall be output to the appropriate alarm printer and to respective control station. Alarm messages shall require operator acknowledgement.

When a point is overridden by operator command from an operator workstation or a local workstation, an alarm message shall be output to the appropriate alarm printer and to respective operator workstation. Alarm messages shall require operator acknowledgement.

When a point returns to normal, the event shall be recorded in control stations as 'Return to Normal'.

The Operator workstations shall be capable of displaying a list of all points in alarm for the building in a single summary. Systems which require the operator to make a separate summary for alarms, shall not be acceptable.

- 1 Annunciation: Alarms shall be annunciated at a terminal by an audible tone and icon. Critical alarms shall be defined by a different color than non-critical alarms.
- 2 Printing: Alarms shall automatically be printed on the defined alarm printer. The printout shall contain the address, state or nature of the alarm, alarm priority, and time and date of occurrence. It shall be possible to route alarms to any printer on the system, in case the allotted printer fails. Critical alarms like Fire can be sending via sms to responsible person.
- 3 It shall be possible to produce a user definable full text message to accompany the annunciation of any alarm. This shall provide further information about the alarm and any action required to be taken by the operator or indicate that action is automatically programmed in the system. These messages shall be automatically printed on a designated printer. There shall be no practical limit to the length of messages created.
- 4 Acknowledgement: It shall be necessary for all alarms to be acknowledged by an authorized operator. The facility shall exist for an additional message to be appended at the time of acknowledgement to provide further information as to any action taken. Acknowledgement of alarms shall be automatically printed and will indicate the time, date, and any message generated by the operator. Alarm silencing shall be by the authorized operators by pressing the silence key.
- 5 Alarm Clear: When alarms are cleared, then a message shall be produced to indicate the description of the alarm point, its current state, and the time and date.
- 6 Disk Records: With the exception of extended text messages, all the information produced above, alarm annunciation, acknowledgement, and clearing, shall be automatically recorded on the fixed disk for historical purposes.
- 7 Alarm Inhibits: It shall be possible to inhibit the transmission of alarms in the following ways:
 - (i) Operational Inhibits - to allow time for stabilization of power after the normal power is restored.
 - (ii) Transient Inhibit - to make allowance for fluttering contacts or allow internal responses. It shall be possible to select time periods for inhibits (i) and (ii) and may be applied when entering into alarm, out of alarm, or both.
- 8 Point lockout: It shall be possible for the operator to lockout the control for any point, to force it to remain in its current state.

A summary showing locked out points shall be available. Systems which require the operator to make a separate lockout summary shall not be acceptable.

- 9 Alarm Review: Points in alarm shall be displayed on the operators panel using the alarm review function.

4.8

LOGGING

- 1 It shall be possible to log the status or value of system points at regular intervals or on change of state and store this on hard-disk at any of the central station.
- 2 It shall be possible to archive this information for future reference.
- 3 In the case of timed interval logs, it shall be possible to specify a time interval (in minutes) and the points which are required to be logged.
- 4 Storage of logged information shall be able to be carried out in any of three ways, single-shot, roll-over, or split. These are defined as follows: -
 - 4.1 Single-shot: In this type of file, logging shall be carried out only during a pre-defined period for which the start and finish time and date shall be configurable.
 - 4.2 Roll-over : This file shall be wrap-around where oldest data shall continuously be overwritten by new incoming data. It shall be possible to configure the number of records to be stored or the duration in hours, days or months before wrap around occurs.
 - 4.3 Split: Data shall be continuously stored in a series of files automatically created. The change-over or creation of subsequent files shall be created by splits at user-defined boundaries. The boundaries shall be able to be defined by duration (hours, days, months) and by time and day of the first split.
- 5 Logging files shall be terminal based not system based, to provide true multi-terminal capability.
- 6 Data produced by the logging facility must be able to be used by standard spread-sheet package for the analysis of information and the preparation of management report.
- 7 In addition to the above, the data may be presented in a simplified customized package. The package should have the following features as minimum:
 - Charting of logged data on disk in line graph, bar graph or pie format.
 - Presentation of logged data on disk in tabular format.
 - Charting of dynamic data (up to 8 points) in real time.
 - Presentation of dynamic data in tabular format in real time.
 - Selection of Auto/ manual scaling of X(time) axis and Y(variable) axis.
 - Tailoring of charts by selection of line width and background colors.
 - Optional grid overlays (full and dotted lines).
 - Selection of horizontal/ vertical arrangement of windows or a 'cascade' presentation.

- Multiple Windows.
- Printing of completed presentations.
- User configurable data selections.
- Optional display of point titles.
- Selection of primary or secondary values for display.
- Presentation of both analog and digital values (ON/OFF etc.).

4.9

REPORT GENERATION:

Standard historical reports shall be provided, which shall be operator selectable to appear on the operator station, any selected printer or both. A “terminate report” command shall be available to allow the operator to stop any report in the process of being printed. Standard pre-formatted reports to be provided shall include:

1. Point summary reports may be requested at any penetration level. Point summary reports shall include the current value/status and condition, point descriptors and all relevant information. Point summary reports shall be selectable for all points.
All reports shall be capable of being scheduled to run at a specific time and/or interval via an operator function supported by necessary data entry templates and interactive prompts.
2. As a minimum, the system shall provide the following summaries:

Point summary

Alarm summary
Limits summary
Lockout summary
Off-line summary
Override summary
Utility summary
Point status (alarm, locked out, off-line, override)
Point name
Point status/value (automatically updating)
Engineering units.

The alarm summary shall list all points in alarm in the selected system. It shall be possible to print on a single summary, all points in alarm in the building. As a minimum, the alarm summary shall include :

Point name
Point status/value (when alarm occurred)

Alarm message

Date and time of alarm occurrence

The limits summary shall list all the alarm limits, and warning limits.

The lockout summary shall display points in the selected system which have either reporting or triggering locked out.

The off-line summary shall display points in the selected system which have lost communication with the system.

The override summary shall display points in the selected system which have been overridden by operator command.

The utility profile shall display the total consumption, measured peak for the current period and the previous period.

3. Trend historical reports shall allow the operator to randomly select logical group of points to be recorded at selectable time intervals. It shall be possible to assign up to ten variables to each trend report. The format, headers, footers, and calculations shall be selectable by the operator. The trend report shall be stored to disk and shall be subsequently capable of being displayed, and/or printed by the operator.
4. Dynamic trends shall provide upto eight points and show real time activity of the associated points. This information shall be printed and/or displayed in numeric, bar chart, curve plot, pie chart, etc., as selected by the operator. Graphic plots shall allow a unique color for each point. Sample interval of points selected for dynamic trend shall be user selectable. 3- Dimensional dynamic trending must be provided in the system.
- 5 Alarm and run time reports shall be automatically issued to assigned printers immediately upon occurrence, and shall consist of the point with engineering unit, the time, and the date, and the alarm message.

4.10 DATA STORAGE:

A history file capability shall be provided to allow automatic storage of certain records plus allow the operator to selectively direct critical real time system data and activity to a mass storage device for later recall and analysis.

1. All alarm and return to normal activity shall automatically be routed to history files. Alarms and return-to-normal shall include warning and alarm threshold violations with no-response, trouble, run time exceeded, demand alarms, and command failures. It shall be possible to request a report by specifying points of interest, the time window of interest, and the type of alarms of interest. Locking out or disabling of points shall also be historically stored and output in the all- type reports.
2. Operator shall be able to select, via the CRT terminal keyboard, those analog and digital inputs and outputs to be stored and the interval at which samples are taken.
3. It shall be possible to access software packages such as MS-Office / MS-Excel or similar, so that the operator may format display or printouts in the form of :
 - (a) Spread sheets.
 - (b) Bar charts.
 - (c) Curve plots.
4. History files shall be the source data for stored trend reports to be used for records and system analysis. Operator shall be able to select specific points to be trended, the time period of the trend, the sample interval, and time at which the report is printed. Trend output format shall be as specified for trend logs (shaded, unshaded etc)

4.11 UTILITIES :

The Central Station personal computer (P.C.) shall be provided with the following menu selected graphic system utilities or desktop application packages .

The system provided must be capable of running standard software packages concurrently with the real time system. System should be capable of supporting third party software packages like spreadsheet, word processing etc.

1. The base system software shall include a CRT “windowing” feature to allow the operator to monitor the real time system and use the third party software simultaneously.
2. All third party software packages identified shall have access to the system historical data base.

4.12

TIME SCHEDULING

- 1) There shall be real time clock facility to help in time scheduling. The scheduling feature shall not be dependent on a central database or an operator workstation.
- 2) The following commands shall be able to be time scheduled to be issued at a later day and time

- from the operator workstation or portable workstation:
 - Start and stop a point
 - Adjust analog value
 - Change set point
- 3) The following commands shall be able to be time scheduled to be issued at a later day and time from the operator workstation:
 - Change alarm limits or warning
 - Lock/unlock point reporting or point control
 - Demand limit target setting
 - Load rolling target setting
 - Reset tracking period for energy statistics
 - Trend point enable/ disable for a point
 - Totalization enable/ disable for a point
 - Reset totalization value
- 4) The following summaries shall be able to time scheduled to be printed or stored in a disk file at a later day and time from the operator workstation:
 - Standard point summary
 - Alarm summary
 - Off-line summary
 - Override summary
 - Disabled summary
 - Lockout summary
 - Utility summary
 - Alarm limits summary
- 5) Commands shall be able to be issued repeatedly on specified days of the week at specified times.
- 6) Schedules shall comply with the BACnet Standard. A system wide calendar shall be set up to define each day as:
 - Regular day
 - Special day
 - Holiday

The system wide calendar shall be stored in multiple locations so that the failure of any one device does not cause the system to fail.

The calendar shall automatically accommodate the leap year and the turn of the century.

The calendar shall allow the days to be scheduled one year in advance from the current system date.
- 7) Separate schedules shall be stored for :

Regular days

Special days

Holidays

- 8) The system shall accept one-time schedules to accommodate overtime usage.
One-time schedules shall be automatically deleted from the system after execution.
The system shall allow one-time schedules to be programmed up to one year in advance.
- 9) After recovery from a power failure, the system shall determine any time scheduled commands which should have been issued during the period that the power was off. These commands shall automatically be issued.

4.13 Point History

- 1) For every analog point in the system, a 24-hour record of the value sampled on regular interval shall be maintained. The operator shall choose whether samples older than 24 hours shall be discarded or archived. The most recent 24 hours of analog point history shall be able to be displayed at the Control Station.
- 2) For every digital point in the system, a point history of the last 10 change of states shall be maintained. The operator shall choose whether point history previous to the last 10 change of states shall be discarded or archived.
The most recent 10 samples of digital point history shall be able to be displayed at the Control Station.
- 3) Point history samples with time/date shall also be taken under the following conditions:
Point in alarm/return to normal
Point overridden/released by operator
Point on-line/off-line
Point reliable/unreliable
A report shall be available showing all points for which point history is being archived.
- 4) The system shall provide point history graphs for analog/digital points.

4.14 Point Trend

- 1) The trend feature shall be able to record any of the following parameters for any point:
Point value
Point alarm status
Controlling feature
Operator override flag
On-line/Off-line flag

- 2) The operator shall be able to select points and define any interval on which samples may be taken.
- 3) For long term storage of samples, trend data shall automatically be updated.
- 4) A report shall be available listing all points being trended. The report shall display:
 - Trend status
 - Point name
 - Parameter being trended
 - Display units
 - Sample interval
 - Number of samples taken.
- 5) A trend for a point shall be able to be started either by operator command or according to a time scheduled command. A trend for a point will end as a result of an operator command, time scheduled command or when the required number of samples have been collected.
- 6) Trend samples shall be displayed in either tabular or graphical format. A minimum of eight trended points shall be able to be displayed concurrently on a graph or report.
- 7) The trend graph display shall automatically scale the value and time axis to display all samples. From the trend graph, the operator shall be able to select and read the instantaneous value of any previous sample.
- 8) The trend point graphing capability shall be a built-in feature of the system and shall not require operator set- up. Systems which require trend point data to be exported to third party software shall not be acceptable.

4.15 Totalization

- 1) For every digital point, the system shall be able to calculate:
 - Cumulative on-time
 - Cumulative off-time
- 2) For every point, analog and digital, the system shall be able to calculate:
 - Cumulative time in alarm
 - Cumulative time overridden by operator
 - Cumulative time off-line
- 3) Time totalization shall have a resolution of one minute or less.
- 4) Time totalization shall be displayed in hours.

4.16 Demand Limiting / Load Rolling

The system shall calculate the instantaneous demand based on the sliding average of the previous 30 minutes of the consumption.

The system shall calculate a predicted demand based on the sliding window average of the previous 20 minutes of consumption. The predicted demand shall be used for control calculations.

The operator shall be able to “lock” a load so that it is ineligible for shedding by demand, limiting or load rolling.

The operator shall be able to use the scheduling feature to program time/days for a load to be locked and unlocked.

The operator shall be able to use the scheduling feature to program time/days for target values for the demand limiting and load rolling features.

The demand limiting/ load rolling features shall allow a minimum of four priority groups to be defined.

Within a priority group, a rotational shedding algorithm shall be used.

The operator shall be able to define a target reduction of electrical consumption and the load rolling feature shall turn off equipment to meet this target.

The operator shall be able to define a demand target that is not to be exceeded and the demand limiting feature shall analyze trends and electrical demand and turn off equipment when a demand peak is anticipated.

The demand limiting and load rolling features shall be fully integrated with all other features so that the following safety parameters are maintained:

Minimum on time

Minimum off time

Maximum off time

Maximum number of cycles per hour

At the end of the minimum off time, a comfort parameter, such as a temperature, shall be sampled. If the comfort parameter is in alarm, the point being controlled shall be turned on.

The following statistical data shall be maintained:

Date / time of start of current period

Total consumption for current and previous period

Actual peak demand with time/ date for current and previous period.

Instantaneous demand

Interval demand

Total shed loads

The operator shall be able to define the tracking period for the statistical data as:

- Hourly (automatic reset)

- Daily (automatic reset)

- Weekly (automatic reset)

- Monthly (automatic reset)

- Manual reset

To provide the operator with an opportunity to manually shed loads that are not available to demand limiting or load rolling, the operator shall be notified when the demand limiting or load rolling run out of loads to shed.

To advise the operator when the performance is outside of expectations, the operator shall be notified when the demand peak target or load rolling target is exceeded.

4.18 Site specific data manipulation software

Site specific data manipulation software shall be provided to allow the user to modify and tailor the BAS software to the changing requirements at the site. The modifications shall be carried out on-line.

The contractor at the time of submission of tender shall list out the modification capabilities of the system.

5.0 Building Performance Management (OPTIONAL)

5.1 Building Performance

5.1.1 Maintenance Software

Maintenance software shall plan and Implement preventive maintenance programs for the Hotel, technical systems and the equipment. This module shall maintain levels, easily communicate tasks and schedules to all parties, and track results and performance. The module shall manage all details of maintenance, including work orders, instructions, and history. Users can view trend reports or look up specific job status with equal ease. The module coordinate activities, create instance work orders and workgroup maintenance plans and track resolution.

- Maintenance schedules
- Maintenance history
- Maintenance instructions
- Resource management
- Weekly work orders
- Reactive maintenance
- Progress monitoring

5.1.2 Complaints Tracking Software Module

This module shall manage complaints and service calls from incident to resolution, and use historical data to identify problem areas and assist in maintenance planning. The module shall also tracks costs and invoicing associated with maintenance and provided with customizable statistical reports such as service throughput and benchmarking.

- Requests
- Work orders
- Contacts
- Resource management
- Monitoring
- Fault history
- Feedback

5.1.3 Energy Software Module

Energy software module shall monitor energy consumption through a variety of customizable reports. Energy software shall act as an especially powerful tool when integrated with the building automation solution, so that it can automatically download real-time information on energy use and environmental settings. It shall easily view monthly consumption, detect deviations, compare and benchmark with similar Hotels or past consumption – all based on the latest current data. Energy software shall track direct energy consumption of all kinds, giving powerful tool for identifying potential savings.

- Energy efficiency Monitoring of MEP equipments such as chillers, pumps, CT, DG Sets, Boilers etc..
- Environmental impact of energy use
- Reading interval adjustment
- Degree – days
- Main and sub meters

- Meter changes
- Versatile reporting
- Meter reading schedules
- Freely definable monitoring objects
- Direct link to building automation system

5.1.4 Calculation Software Module

It shall simulate and analyze various operating scenarios and their effects on energy costs. Calculation software is a ‘what if’ application that lets you easily explore different operating modes, parameters and set points in your facilities, and how they impact energy consumption. For example, operator can compare different recycle alternatives to analyze the savings potential. When integrated with the calculation software building automation system, this module shall gather real energy costs, degree days and real-time data from control network at the starting point for analysis.

- MEP equipment energy consumption
- Download real-time data from the Calculation software
- Temperature set points, time schedules, etc..
- Effect of tariffs

5.1.5 Document Software Module

Document software shall maintain all documents related to facilities and equipment in one organized system that allows easy search and retrieval by all users, wherever needed. Document software shall maintains CAD drawings, manuals, Word and Excel files, digital photographs, and any other electronic information related to facilities. All documents shall be easily accessible from other modules. In addition, documents can be linked to items in the Document software and opened directly from the object.

- CAD drawings
- Word and Excel files
- Digital photographs
- Links to Document software database
- Fire borrowing information
- Search capabilities
- Archiving

5.1.6 Contract Software

Contract software shall control and manage all aspects of Hotel's maintenance contracts, including cost, check dates, contract parties and many other details. It shall group and sort contracts freely, based on operator's account scheme or any desired system. Contracts shall also be linked to objects such as buildings or systems, helping you track contractor performance and building costs. It shall keep every detail under control, while producing a variety of reports that shall make strategic decisions.

- Flexible structure of contracts
- Check dates and other detail controls
- Search and reporting
- Contract parties and contract costs

5.1.7 Executive Software

Executive software shall create high-level executive reports across any or all facilities, to see key business metrics and improve strategic decision-making. Executive software shall leverages the historical data compiled by the database and uses it to answer questions as: What is the energy cost per square meter? Which buildings cost the most to maintain? Why? How much is spent on reactive maintenance? What return was achieved through investments in preventive maintenance? The module includes various ready-to-use executive reports, plus the ability to easily customize and create new ones.

- Long-term planning
- Strategic decision-making
- High-level view of maintenance, energy, etc..
- Links to Executive Software

6.0 DIRECT DIGITAL CONTROLLER

6.1 DIRECT DIGITAL CONTROLLER (DDC) HARDWARE REQUIREMENT:

- 1) DDC controllers shall be capable of fully "stand- alone" operation i.e. in the event of loss of communication with other DDC's or Control Station, they shall be able to function on their own. The controller shall have LON Works / BAC net / MODbus based products. The proprietary controllers will not be acceptable.
- 2) The controllers shall consist of single 16-bit / 32 bit microprocessors for reliable throughput, based with EEPROM based operating system (O.S.). Controllers shall communicate at a minimum of 156 Kbps.
- 3) The memory available to the controller board as working space for storage of the Operating system software and data files shall be decided on the basis of number of points being controlled by them.
- 4) The controllers shall be UL listed and conforming to CE (Euro norms).

- 5) Controllers requiring nickel-cadmium/lithium battery to support the full operation of the RAM, shall have battery back-up upto 12 hours in the event of a localized mains failure. The battery shall not be required to supply power to actuators, valves, dampers etc.
- In addition to the above battery reserve a further battery shall be provided to retain the RAM for a minimum of 2 days, after the expiration of the standard battery.
- A low battery alarm shall be provided with each Controller and with an indication at the Control Station.
- In case the memory is stored on EEPROM, the battery backup will not be required.
- 6) The Controllers shall have proportional control, Proportional plus Integral (PI) Control, Proportional plus Integral Plus Derivative (PID) Control, Two Position Control and Time Proportioning Control and algorithms etc, all in its memory and all available for use by the user, i.e. all the control modes shall be software selectable at any time and in any combination. The analog output of Proportional Control, PI Control, and PID Control shall continuously be updated and output by the program shall be provided. Between cycles the analog output shall retain its last value. Enhanced integral action in lieu of Derivative function shall not be acceptable.
- 7) The controllers shall have a resident real time for providing time of day, day of week, date, month and year. These shall be capable of being synchronized with other clocks in the network.
- Back-up power shall support the clock. Upon power restoration all clocks shall be automatically synchronized.
- 8) The microprocessor based DDC's shall be provided with power supply, A/D and D/A converters, memory, and capacity to accommodate a maximum of 48 input/output (I/O) hardware points (with or without an expansion board). DDC's with a lower capacity of points shall preferably be provided at the locations with relatively less input/output points for AHU, FAN & other utilities (accommodated maximum 2nos. of AHU or FAN). The controller have peer to peer communication and max 100 controller shall be connected per network loop
- 9) If the controllers provided by the contractor have the configurable plug in function cards, then the following minimum specifications shall have to be met :
- i) In addition to the basic outstation, a minimum of two slots shall be provided for the insertion of plug-in function cards.
 - ii) The cards shall provide for analog or digital, input or output, hardwired connections to the installed plant.
 - iii) The quantity and combination of these cards shall be determined by the requirements of the plant in that location with the concurrence of the Owner/ Consultant.
- 10) The DDC's shall have 15% spare capacity (digital/analog input/output) to give flexibility for future expansion.

- 11) All DDC controllers shall be capable of handling voltage, mili-ampere, resistance or open and closed contacts inputs in any mix, if required.

Analog inputs/outputs of the following minimum types shall be supported :

- i) 4-20 mA.
- ii) 0-1 volts.
- iii) 0-10 volts.
- iv) 0-5 volts, and
- v) 2-10 volts.
- vi) Resistance Signals (either PTC or NTC 1.8 KNTC)
(PT 100, PT 1000, PT 3000, Balco 500, NI 1000)

Digital input/output types to be supported shall be, but not limited to the following :

- i) Normally-open contacts.
- ii) Normally-closed contacts.

Modulating outputs shall be true proportional outputs and not floating control type.

- 12) Controller's packaging shall be such that, complete installation and check out of field wiring can be done prior to the installation of electronic boards.
- 13) All board terminations shall be made via plug-in connectors to facilitate trouble-shooting, repair and replacement. Soldering of connections shall not be permitted.
- 14) Controllers shall preferably be equipped with diagnostic LED indicators with atleast indication for Power up Test OK, and Bus Error. All LED's shall be visible without opening the panel door.
- 15) It shall be possible for the controllers to accept regulated uninterrupted power supply to maintain full operation of the controller functions (control, logging, monitoring and communications) in the event of a localized mains failure.
- 16) Controllers requiring fan cooling are not acceptable.
- 17) There shall be the facility for accessing controller data information locally , via a portable plug-in keypad display which can be common to all controllers and normally removed to prevent unauthorized tampering. Alternatively each controller shall have a keypad and display integral with its casing for local interrogation and adjustment. In either case, access to the system thus provided shall be restricted by passwords in the same way as at the main operator terminal.
- 18) In case the Portable operator Terminals (POT) are required to program the controllers, sockets shall be provided for same. Attachment of POT shall not interrupt or disable normal panel

operation or bus connection in any way.

- 19) The controllers shall be housed in vandal proof boxes to protect them from tampering by any unauthorized personnel. All DDC controllers used in plant room spaces and external application shall be housed IP66/IP54 rating enclosures.
- 20) It shall be possible to add new controllers to the system without taking any part of the system off-line.

6.2 DIRECT DIGITAL CONTROLLERS CAPABILITIES:

- 1) The Controllers shall have a self analysis feature and shall transmit any malfunction messages to the Control Station. For any failed chip the diagnostic tests, printout shall include identification of each and every chip on the board with the chip number/location and whether the chip “Passed” or “Failed” the diagnostic test. This is a desired requirement as it would facilitate trouble-shooting and ensure the shortest possible down time of any failed controller. Controllers without such safety feature shall be provided with custom software diagnostic resident in the EEPROM. The tenderer shall confirm in writing that all controllers are provided with this diagnostic requirement.
- 2) Operating system (O.S.) software for controllers shall be EPROM resident.
Controllers shall have resident in its memory and available to the programs, a relevant library of algorithms, intrinsic control operators, arithmetic, logic and relational operators for implementation of control sequences.
- 3) In the event of failure of communication between the controllers and/or Control Station terminal, alarms, reports and logs shall be stored at the controllers and transmitted to the terminal on restoration of communication.
- 4) In the event of memory loss of a Controller, or the expiration of back-up power, on start-up of the unit the necessary data-base shall be downloaded automatically and without operator instruction. Controllers requiring a manual intervention for the re-boot of software are not desired.
- 5) Where information is required to be transmitted between controllers for the sharing of data such as outside air temperature, it shall be possible for global points to be allocated such that information may be transmitted either on change of incremental value or at specific time intervals.
- 6) Controllers must be able to perform the following energy management functions as a minimum.
 - a) Time & Event programs
 - b) Holiday Scheduling
 - c) Maximum and Distributed power demand
 - d) Optimum start and stop program
 - e) Night purge

- f) Load reset
- g) Zero energy band
- h) Duty cycle
- i) Enthalpy analysis and control
- j) Run Time Totalization
- k) Sequencing and Optimization
- l) Exception scheduling

Detailed description of software features and operating sequence of all available energy management software shall be submitted with the tender for evaluation by the Consultant.

- 7) The DDC Controllers shall have Adaptive Control capability whereby the control software measures response time and adjusts control parameters accordingly to provide optimum control. The software shall allow self-tuning of the variable control loops (all or any of P, P+I, P+I+D) of the AHU's and chiller system so as to provide the most efficient and optimized controls at different load conditions. The energy management programs shall update their parameters based on past experience and current operating conditions.
- 8) Alarm Lockout shall be provided to prevent nuisance alarms. On the initial start up of air handler and other mechanical equipment a "timed lockout" period shall be assigned to analog points to allow them to reach a stable condition before activating an alarm comparison logic. Tenders shall indicate their proposed system alarm handling capability & features.
- 9) Run time shall be accumulated based on the status of a digital input point. It shall be possible to total either ON time or OFF time. Run time counts shall be resident in non-volatile memory.
- 10) It shall be possible to accommodate Holiday and other planned exceptions to the normal time programs. Exception schedules shall be operator programmable up to one year in advance.
- 11) Distributed power demand program shall be based on a sliding window instantaneous demand trend algorithm. The DDC interfaced to the demand meter shall calculate the demand, forecast the demand trend, compare it to the established demand limits, and initiate load shedding or re-establishment of loads as required. Shedding shall be on a sequential basis with least important loads shed first and restored last.

6.3 SYSTEM INTERGRATION UNITS (SIU)

SIU shall connect all field DDC's and provide supervisory and Complex Control Algorithm capability to the BMS system. The SIU shall also have Stand-alone Data Storage and Communication capability for

high level integration and networking capabilities including and not limiting to Operator Work Station, Remote Work Station, Third Party Management System etc. The same facility shall be available at controller level in two tier system architecture. Network bridges & routers must be of a modular design to ensure reliability & system performance. The central system shall use the building Local Area Network (LAN) for communication. The communication between the central server and the controllers shall be BACnet/IP. Proprietary protocols are NOT acceptable.

- 1) Where information is required to be transmitted between controllers for the sharing of data such as outside air temperature, it shall be possible for global points to be allocated in the SIU such that information may be transmitted either on change of incremental value or at specific time intervals.
- 2) SIU must be able to perform the following energy management functions as a minimum.
 - a. Time & Event Program
 - b. Holiday Scheduling
 - c. Maximum and Distributed power demand
 - d. Optimum start and stop program
 - e. Night Purge
 - f. Load reset
 - g. Zero Energy band.
 - h. Duty Cycle.
 - i. Enthalpy analysis and control.
 - j. Run Time Totalization.
 - k. Sequencing and Optimization.
 - l. Exception scheduling

Detailed description of software features and operating sequence of all available energy management software shall be submitted with the tender for evaluation by the Consultant.

- 3) Alarm Lockout shall be provided to prevent nuisance alarms. On the initial start up of air handler and other mechanical equipment a “timed lockout” period shall be assigned to analog points to allow them to reach a stable condition before activating alarm comparison logic.
- 4) It shall be possible to accommodate holiday and other planned exceptions to the normal time programs. Exception schedules shall be operator programmable upto one year in advance.
- 5) Distributed power demand program shall be based on sliding window instantaneous demand trend algorithm. The DDC interfaced to the demand meter shall calculate the demand, forecast the demand trend, compare it to the established demand limits, and initiate load shedding or re-establishment of loads as required. Shedding shall be on a sequential basis with least important loads shed first and restored last.

7.0 PORTABLE OPERATORS TERMINAL (POT)

- 1) POT shall be provided to allow operator readout of system variables, override control and adjustment of control parameters. The POT shall be portable and plug directly into individual controllers for power and data.
- 2) The minimum functionality of POT shall include :
 - Set points to a fixed value or state.
 - Display diagnostic results.
 - Display sequentially all point summary and sequentially alarm summary.
 - Display/change digital point state, analog point value.
 - Display/change time and date.
 - Display/change analog limits.
 - Display/change time schedule.
 - Display/change run time counts and run time limits.
 - Display/change time and/or event initiation.
 - Display/change programmable offset values.
 - Access DDC initialization routines and diagnostics.
 - Enable/disable points, initiators and programs.
 - Display/change minimum ON/OFF and maximum OFF times.
 - Trends / Historical data
- 3) The POT shall be complete with command keys, data entry keys, cursor control keys and a 24 character liquid crystal alphanumeric display. Access shall be via self prompting menu selection with arrow key control of next menu/previous menu and step forward/backward within a given menu.
- 4) Connection of a POT to a controller shall not interrupt or interfere with normal network operation in any way, prevent alarms from being transmitted, or interfere with Control Station commands and system modifications.
- 5) Connection of POT at any controller shall provide display access to all controllers on that bus. In case the controller has a fixed LCD display and entry keyboard, then the display access shall be available on each screen.
- 6) It should be possible to override the commands given through POT by the Operator Control Station.

8.0 DATA COMMUNICATION

The communication between controllers shall be via a dedicated communication network as per BACNET / LON Works recommended standards. Controllers microprocessor failures shall not cause loss of communication of the remainder of any network. All networks shall support global application programs, without the presence of a host PC.

Each controller shall have equal rights for data transfer and shall report in its predetermined time slot. There shall be no separate device designated as the communication's master. Those systems using dependent controllers shall be pointed out by the contractor and a dual redundant transmission media with automatic switching and reporting in the event of line faults will have to be provided.

The communication network shall be such that:

- 1) Every DDC must be capable of communicating with all DDC's.
- 2) Network connected devices with no messages to transmit shall indicate "No failure" message each cycle. Lack of this message after successive retries shall constitute a communication or device failure.
- 3) Each controller is to be provided with a communication watchdog to assure that an individual controller does not permanently occupy the bus. If a controller is detected as occupying more time than usual, then it shall be automatically shutdown and an alarm sent to the Control Station.
- 4) Error recovery and communication initialization routines are to be resident in each network connected device.
- 5) For reliability, maintainability, and performance, communication network shall be extendable to 4,000 feet without active links, hubs, or repeaters, Active devices required within buses under 4,000 feet long shall be fully transparent (without compromising any parameter) and totally redundant (including power supply) to provide the reliability specified.
- 6) The communication protocol shall incorporate CRC (Cyclic Redundancy Check) to detect transmission errors. Parity bit error checking shall not be acceptable.

Vendors to give details for their system error checking capability.

Single or multiple stand alone controller failures shall not cause loss of communication between active control panels connected on the communication network. Full communication shall be sustained as long as there are atleast two operational stand alone control panels active on the communication network.

All the System Integration Units shall be linked together on a Local Area Network.

The communication network shall include provision for automatically reconfiguring itself to allow all operational equipment to perform as efficiently as possible in the event of single or multiple failure.

The communication network shall follow the recommendations of ISO 7498 or equivalent standard. The BAS supplier shall be required to provide details of standards to which their system conforms.

9.0 FIELD DEVICES

9.1 ELECTRIC AND ELECTRONIC CONTROLS RELATED EQUIPMENT

General Requirements

All controls shall be capable of operating in ambient conditions varying between 0-55 deg. C and 90% R.H. non-condensing.

All Control devices shall have a 20 mm conduit knockout. Alternatively, they shall be supplied with adaptors for 20 mm conduit.

Ancillary Items

When items of equipment are installed in the situations listed below, the BAS contractor shall include the following ancillary items :

(i) Weather Protection

All devices required to be weatherproofed are detailed in the Schedule of Quantities. IP ratings for the equipment is mentioned in the respective section.

(ii) Pipework Immersion

Corrosion resisting pockets of a length suitable for the complete active length of the device, screwed ½” (13 mm) or ¾” (20 mm) NPT suitable for the temperature, pressure and medium.

(iii) Duct Mounting (Metal or Builders Work)

Mounting flanges, clamping bushes, couplings, locknuts, gaskets, brackets, sealing glands and any special

fittings necessitated by the device.

Additional features

- (i) Concealed Adjustment : All two position switching devices shall have concealed adjustment unless detailed otherwise in the Schedule of Quantities.
- (ii) Operating Voltage : All two position switching devices shall operate on 230 v a.c and all accessible live parts shall be shrouded. An earth terminal shall be provided.

9.2 TEMPERATURE SENSOR

Temperature sensors for space, pipes and ducts, shall be of the Resistance Temperature detector (RTD) type or thermistor. These shall be two wire type and shall conform to the following specifications :

- 1) Immersion sensors shall be high accuracy type with a high resistance versus temperature change. The accuracy shall be atleast ± 0.33 degrees F and sensitivity of atleast 2 ohm/F.
- 2) Immersion sensors shall be provided with separate stainless steel thermo well. These shall be manufactured from bar stock with hydrostatic pressure rating of atleast 10 kgf/cm².
- 3) The connection to the pipe shall be screwed $\frac{3}{4}$ inch NPT (M). An aluminum sleeve shall be provided to ensure proper heat transfer from the well to the sensor. Terminations to be provided on the head. Flying leads shall not be acceptable.
- 4) The sensor housing shall plug into the base so that the same can be easily removed without disturbing the wiring connections.
- 5) Duct temperature sensors shall be with rigid stem and of averaging type. These shall be suitable for duct installation.
- 6) Outdoor air temperature sensor shall be provided with a sun shield.
- 7) The sensors shall not be mounted near any heat source such as windows, electrical appliances etc.

The temperature sensors may be of any of the following types :

- 1) PT 100, PT 1000, PT 3000
- 2) NI 100, NI 1000
- 3) Balco 500.
- 4) Thermistor

9.3 HUMIDITY SENSOR

Space and duct humidity sensors shall be of capacitance type with an effective sensing range of 10% to 90% RH. Accuracy shall be + 3% or better. Duct mounted humidity sensors shall be provided with a sampling chamber. Wall mounted sensors shall be provided with a housing. The sensor housing shall plug into the base so that the same can be easily removed without disturbing the wiring connections. The sensors shall not be mounted near any heat source such as windows, electrical appliances etc.

9.4 FLOW METER

Water flow meters shall be Ultrasonic type. The housing shall have IP 55 protection. Vendors shall have to get their design/ selection approved by the Consultant, prior to the supply.

The exact ranges to be set shall be determined by the contractor at the time of commissioning. It should be possible to 'zero' the flow meter without any external instruments, with the overall accuracy of at least $\pm 1\%$ full scale.

9.5 PRESSURE TRANSMITTER FOR WATER

Pressure transmitters shall be piezo-electric type or diaphragm type. (Bourdon Tube type shall not be acceptable). Output shall be 4-20mA or 0-10V DC and the range as specified in the data sheet depending on the line pressure. Power supply shall be either 24 V AC, 24 V DC or 230 V AC. Connection shall be as per manufacturer's standards. The pressure detector shall be capable of withstanding a hydraulic test pressure of twice the working pressure. The set point shall fall within 40%-70% of the sensing range and detector shall have sensitivity such that change of 1.5% from the stabilized condition shall cause modulation of the corrective element. The sensor must be pressure compensated for a medium temperature of -10°C to 60°C with ambient ranging between 0°C to 55°C .

9.6 DIFFERENTIAL PRESSURE SWITCH FOR PIPE WORK

These shall be used to measure pressure differential across suction and discharge of pumps. The range shall be as specified in the data sheet. Switch shall be ON with increase in differential. Housing for these shall be weather proof with IP 55 protection. The pressure switch shall be capable of withstanding a hydraulic test pressure of 1.5 times the working pressure. The set point shall fall in 40-70% of the scale range and shall have differentials adjustable over 10%-30% of the scale range. The switches shall be provided with site adjustable scale and with 2 NO/NC contacts.

9.7 DIFFERENTIAL PRESSURE SWITCH FOR AIR SYSTEMS

These shall be diaphragm operated. Switches shall be supplied with air connections permitting their use as static or differential pressure switches.

The switch shall be of differential pressure type complete with connecting tube and metal bends for connections to the duct. The housing shall be IP 54 rated. The pressure switches shall be available in minimum of 3 ranges suitable for applications like Air flow proving, dirty filter, etc. The set point shall be concealed type. The contact shall be SPDT type with 230 VAC, 1 A rating.

The switch shall be supplied suitable for wall mounting on ducts in any plane. It should be mounted in such a way that the condensation flow out of the sensing tips. Proper adaptor shall be provided for the cables.

The set point shall fall within 40%-70% of the scale range and have differentials adjustable over 10%-30% of the scale range.

The switches shall be provided with site adjustable scale and with 2 NO/NC contacts.

9.8 AIR FLOW SWITCHES

Air flow switches shall be selected for the correct air velocity, duct size and mounting attitude. If any special atmospheric conditions are detailed in the Schedule of Quantity the parts of the switches shall be suitably coated or made to withstand such conditions. These shall be suitable for mounting in any plane. Output shall be 2 NO/NC potential free. Site adjustable scale shall also be provided.

9.9 AIR PRESSURE SENSOR

The pressure sensor shall be differential type. The construction shall be spring loaded diaphragm type. The movement of the membrane in relation to the pressure should be converted by an inductive electromagnet coupling which would give an output suitable for the controller. The pressure sensor shall be in a housing having IP 54 ratings in accordance with IEC 529. Suitable mounting arrangement shall be available on the sensor. The sensor shall come complete with the PVC tubes & probes.

9.10 WATER FLOW SWITCH

These shall be paddle type and suitable for the type of liquid flowing in the line. Output shall be 2NO/2NC potential free.

9.11 TRANSDUCERS FOR ELECTRICAL SERVICES

Electrical transducers shall be integrated electronic type and rack mounted on the field. These shall work on 230 V supply with the output being standard type i.e. 4-20 mA, 0- 10 Volts etc.

Power factor, Voltage, Current, Frequency and Kilowatt transducers shall have standard output signal for measurement for the specified variable.

Kilowatt-Hour metering (if any) shall be poly-phase, three- element with current transformer (CT) operated type. The metering shall feature high accuracy with no more than +/- 1% error over the expected load range. The coils shall be totally encapsulated against high impulse levels.

9.12 LEVEL SWITCH

The level switches shall have to meet the following requirement :

Type	: Float Type/Capacitance type/Conductivity type
Mounting	: To suit application.
Connection	: Flanged ANSI 150 lbs RF Carbon steel
Float material	: 316 SS
Stem Material	: 316 SS
Output	: 2 NO, 2 NC potential free
Switch Enclosure	: IP 55

9.13 CONTROL VALVES (AIR HANDLING UNITS)

Control valves for the Air Handling Unit's shall be globe type, two & three way suitable for Variable flow hydronic system.

The Manufacturer's standards shall be applicable for these valves.

Valves

a.	Type	:	Two or Three way mixing
b.	Stem / Trim	:	SS-316 or better
c.	Plug and seat	:	SS-316 or better
d.	Plug characteristics	:	Equal Percentage
e.	Service	:	Chilled water
f.	Packing	:	Teflon

Actuator

a.	Actuator	:	Electrical/Electronic/Magnetic.
b.	Actuator type	:	Proportionating(Modulating)
c.	Spring return function	:	No
d.	Travel limit switch	:	2 Nos. for open and close.
e.	Hand wheel	:	Required
f.	Input signal	:	0 – 10 V dc, 4 –20 mA
g.	Power Supply	:	240 V ac
h.	Thrust	:	To be selected by the vendor
i.	End Connections	:	Screwed upto 2” Beyond that ANSI 150 Lb RF
j.	Noise Level	:	Not exceeding 70 DB
k.	Weather Proof	:	NEMAI

Note :

- i. Actuator should be directly coupled to the trim. Eccentric linkages not acceptable.
- ii. Leakage not to exceed 0.1% of flow.

CONTROL FOR FCU

Control valves for the Air Handling Unit's shall be globe type, two way suitable for Variable flow hydronic system as indicated in BOQ.

9.14.1 Two way motorized valves

Two way motorized valves shall be provided in chilled water lines at each fan coil units. The valve shall be actuated by space thermostat. Constant space conditions shall be maintained by allowing chilled water through the coil. The valve shall be provided with spring return function so that it revert to fully closed position when fan is shut off. Valve shall be two/three position with flare connections. Valve shall have the facility to replace motor \ actuator without removing the valve body Actuator shall be suitable for 240 V, 50 Hz ac or 24V ac. Maximum close off pressure shall be selected to suite the CV requirement.

9.14.2 Thermostat

Thermostat shall be snap acting fixed differential type thermostat for air-conditioning application for actuating the two way valve at each fan coil unit with HI-MED-LO fan switch and system setting OFF-FAN-COOL. Switching off must break fan circuit. Thermostat shall be provided with necessary relays to operate valve of cooling coil.

9.15 TWO WAY ON/OFF BUTTERFLY VALVE

9.15.1 Valve

a.	Type of valve	: Butterfly Valve.
b.	Body Material	: Carbon steel ASTM A 216
c.	Body seat ring (if applicable)	: Gr WCB
d.	Vane	: SS-316
e.	Packing	: Teflon
f.	Mounting Stool	: Required.
g.	Shaft	: SS-316
h.	Seat	: Nitrile rubber
i	Fasteners	: SS-316
J	Leakage	: With 100 % Leak proof

9.15.2 Actuators

Type	: Electric	.
Duty.	: On/Off (Maximum 50 operations per day)	
Motor power supply	: 230 V AC or 415 V 3-phase	
Travel limit switches	: 2 Nos	
Torque limit switches.	: 2 Nos	
Hand wheel	: Required	
Speed	: Approx 150 mm/min	

NOTE

- a. Actuator must open/ close with one changeover contact. Control panel, if required, must be supplied integral with the Actuator.

- b. No gear box is envisaged, however if gear box is provided, the travel limit switches must be connected directly to the valve stem.
- c. Cover tube for the valve stem must be provided

10. ELECTRONIC METERING

Electronic metering with BAS connectivity shall be provided on the main LT panel at incoming and outgoing feeders. These meters shall be free supply by the BAS contractor to the Electrical contractor whereby these shall be installed in the LT panel by the Electrical contractor. The electrical contractor shall also provide necessary CT, PT and 220 V power input for the meters. All further control wiring and networking of the meters shall be in scope of BAS contractor.

The specifications for the electronic meters to be supplied by BAS contractor is as follows:

Type : Static Power Meter
Class 1.0 accuracy.

Instantaneous Measurements :

- a. V (1-n), V (1-1) & 1 per ph & avg. V & I unbalance
- b. PF per ph & total, frequency
- c. Power & BI-directional energy (active, apparent, reactive)
- d. Peak & Predictive Demand (I, W, VA, VAR totals)
- e. V & I harmonics (Individual & Total)
- f. Time of use (internal calendar, multiple daily tariff, energy & demand accumulators).

Features :

- a. Event Triggered
- b. Sequence of event
- c. Panel mountable
- d. Internal battery backup
- e. Transducerless connection via standard CT / PT

Display : Local LCD display panel user formattable display with scrollable screens.

Software interface shall be ensured by BAS contractor for the electronic meters. Systems requiring transducers for duplicating the data shall not be accepted.

All the instantaneous measurements shall be displayed on the control stations and the data shall be logged. It shall be possible to access minimum / maximum logging of any parameter with alarm annunciation for unusual measurements. The system shall also accept user defined “Set-Point” limit of any parameter.

10.0 ENCLOSURES FOR CONTROLLERS AND ELECTRICAL PANELS

All the controllers shall be housed in Lockable Vandal proof boxes which shall either be floor mounted or wall mounted. These shall be free standing, totally enclosed, dust and vermin proof and suitable for tropical climatic conditions.

The panel shall be metal enclosed 14 SWG CRCA sheet steel cubicle with gaskets between all adjacent units and beneath all covers to render the joints dust proof. All doors and covers shall be hinged and latched and shall be folded and braced as necessary to provide a rigid support. Joints of any kind in sheet metal shall be seam welded with welding slag grounded off and welding pits wiped smooth with plumber metal.

All panels and covers shall be properly fitted and secured with the frame and holes in the panels correctly positioned. Fixing screws shall enter into holes tapped into an adequate thickness of metal or provided with nuts. Self threading screws shall not be used in the construction of control panels. Knockout holes of approved size and number shall be provided in the panels in conformity with the location of incoming and outgoing conduits/cables. Lamps shall be provided to support the weight of the cables. The dimension of the boxes shall depend on the requirement with the color decided in consultation with the Architect/Consultant.

Note : All panel enclosures used in plant room spaces and external to building shall be suitable for outdoor application (IP 54 protection) and UL listed.

11.0 CONDUITS AND WIRING

Prior to laying and fixing of conduits, the contractor shall carefully examine the drawings indicating the layout, satisfy himself about the sufficiency of number and sizes of conduits, sizes and location of conduits and other relevant details. Any discrepancy found in the drawings shall be brought to the notice of Architect/Engineers. Any modifications suggested by the Contractor shall be got approved by the Architect /Engineers before the actual laying of conduits is commenced.

11.1 CONDUITS/TRUNKER

Conduits and accessories shall conform to relevant Indian Standards. PVC conduits of required dia shall be used as called for in the schedule of quantities. Joints between conduits and accessories shall be securely made, with help of adhesive.

The conduits shall be delivered to the site of construction in original bundles and each length of conduit shall bear the label of the manufacturer.

11.2 CONNECTIONS

All jointing methods shall be subject to the approval of the Architect/Engineer. Separate conduits shall run for all power wiring.

The threads and sockets shall be free from grease and oil. Connections between conduit and controller metal boxes shall be by means of brass hexagon smooth bore bush, fixed inside the box and connected through a coupler to the conduit. The joints in conduits shall be smooth to avoid damage to insulation of conductors while pulling them through the conduits.

11.3 BENDS IN CONDUIT

Where necessary, bends or diversions may be achieved by means of bends and/or circular inspection boxes with adequate and suitable inlet and outlet screwed joints. In case of recessed system each junction box shall be provided with a cover properly secured and flush with a finished wall surface. No bends shall have radius less than 2-1/2 times the outside diameter of the conduit.

11.4 FIXING CONDUITS

The conduits, junction boxes, outlet boxes and controller boxes once installed in position, shall have their outlets properly plugged or covered so that water, mortar, insects or any other foreign matter does not enter into the conduit system. Surface conduits shall be fixed by means of spacer bar saddles at intervals not more than 500 mm.

The saddles shall be 2 mm x 19 mm galvanized steel flat, properly treated, primer coated & painted, securely fixed to supports by means of nuts and bolts/rawl bolts and brass machines screws.

11.5 DRAWING OF CONDUCTORS

While drawing insulated wires/cable into the conduits, care shall be taken to avoid scratches and kinks which may cause breakage of conductors. No joint shall be allowed in case of breakage of any conductor.

No joint shall be shaved off like length of the conductors. Insulation shall be shaved off like sharpening of a pencil and it shall not be removed by cutting it square to avoid depression/cutting of conducting material.

Strands of wires shall not be cut to accommodate & connect to the terminals. Terminals shall have sufficient cross-sectional area to take all the strands.

No wire shall be drawn into any conduit until all work of any nature that may cause injury to wire is completed. Before the wires are drawn into the conduit, the conduits shall be thoroughly cleaned of moisture, dust, dirt or any other obstruction. Where wires are connected to detectors, or panel, sufficient extra length of wires shall be provided to facilitate easy connections and maintenance. If numbers of cables are > 4 then cable tray of appropriate size to be used.

Only licensed supervisors/wiremen shall be employed for cabling and other connected work. Only approved make of cables shall be used. The cables shall be brought to the site in original packing.

11.6 MODE OF MEASUREMENT

Signal Cable

The cabling running between DDC controller to the field devices shall be termed as signal cabling. This cabling along with conduits shall be payable on per I/O point basis.

Communication Cable

The cabling running between the system integration units to the DDC controllers shall be defined as communication cable. This cable along with conduits shall also be measured on per I/O point basis.

LAN Cable

The cable connecting various system integration units to the control station shall be termed as LAN cable. This cable along with conduits shall be measurable on unit length basis.

12.0 SIGNAL CABLING & COMMUNICATION CABLING

The signal cable shall be of the following specifications:

a.	Wire	: Annealed Tinned Copper
b.	Size	: 1.5 sq. mm, 7 strands
c.	No. of conductors	: Two (One pair)
d.	Shielding	: Overall beld foil Aluminium polyester shield.

e.	Jacket	: Chrome PVC
f.	Nominal DCR	: 17.6 ohm/km for conductor 57.0 ohm/km for shield
g.	Nominal OD	: 8.5 mm
h.	Nominal capacitance	: 130 pF/m between conductors at 1 KHz 180 pF/m between one conductor and other conductors connected to shield.
i.	Color	: Black and Red

12.1 COMMUNICATION CABLE

The communication cable shall be of the following specifications:

a.	Wire	: Annealed Tinned Copper
b.	Size	: Minimum 24 AWG stranded
c.	No. of conductors	: Two pair (4 conductor)
d.	Shielding	: Overall beld foil Aluminium polyester shield.
e.	Jacket	: Chrome PVC
f.	Nominal DCR	: 78.7 ohm/km for conductor 55.8 ohm/km for shield
g.	Nominal OD	: 5.64 mm
h.	Nominal capacitance	: 131 pF/m between conductors at 1 KHz 243 pF/m between one conductor and conductors connected to shield. Other
i.	Color	: Black and Red, Black and White)

12.2 LOCAL AREA NETWORK CABLE

Depending on the type of LAN system being used by the contractor, standard, manufacturer's specification shall apply for CAT 5 / CAT 6 cable.

4.0 List Of Approved Makes

S. No	Component	Approved Make
4.1	Air Cooled Screw Chiller	Carrier / Dunham-Bush / Hitachi / York / Daikin / Climaveneta
4.2	Air Handling Units	Voltas / Blue Star / Edgetech/Systemair
4.3	Fan Coil Units	Edgetech / Citizen / Systemair / Voltas / Blue Star
4.4	Motors	NGEF / Crompton / Seimens / Bharat Bijlee / Kirloskar
4.5	Pipes	Tata / Jindal / Zenith / Surya Prakash
4.6	Valves & Strainers :	
	A. Globe Valve	Advance / Leader / Trishul / Divine / Flovel
	B. Butterfly	Advance/Audco / Keystone / Saunders
	C. Balancing	Advance / ITT Bell & Gossett / Flowcon
	D. Diaphragm / Ball Valve	Alfa Laval-Saundar / RB
	E. Wafer Swing Check Valve	Audco / Advance
	F. 'Y' Strainer	Trishul/Leader/L&T
	G. Pot Strainer	Trishul/Leader/L&T
	H. Ball Valve Set	Trishul/Leader
	I. Automatic Air Purging Valve	Trishul/Leader
	J. Gate Valve	Leader/Trishul/Divine/Flovel
	K. Non Return Valve	Leader/Trishul/Divine
4.7	Closed Expansion Tank	KD / Grundfos / ITT Bell & Gossett
4.8	Air Separator	KD / Grundfos / ITT Bell & Gossett
4.9	Insulation	
	A. Fibreglass	FGP / Up Twiga / Khimco
	B. Expanded Polystyrene	Beardsell / Cooline
	C. Expanded Polyethylene	Nikifoam / Profeel
	D. Nitrile rubber	Aerocell / Armaflex / KFlex
4.10	Controls / Measurement Instruments	
	A. Thermometers	H. Guru / Teddington
	B. Water Pr. Gauges	H. Guru / Fiebig
	C. Proportionating	Johnson / Siemens / Thermostat / Humidistat Honeywell / Sauter Controller
	D. 2-Way Valves	Siemens / Johnson / Honeywell

S. No	Component	Approved Make
	E. Motorised Valve	Belimo / Honeywell / Siemens
	F. Actuators	Belimo / Honeywell / Siemens
4.11	Thermostat for FCU	Siemens / Johnson / Honeywell
4.12	Grilles / Diffusers / Diffusers	Cosmos / Dynacraft / Caryaie
4.13	Filters	Kirloskar / Dyna / Klenzaid
4.14	Pumps	Grundfos / Armstrong / Xylem
4.15	Cables	
	Power Cables	ICC / CCI / Gloster / Finolex/ RR Cable
	Control Cables	Finolex/ Polycab
4.16	Circuit Breakers	Seimens / English Electric / L&T/Schneider
4.17	Switches	Seimens / English Electric / L&T/Schneider
4.18	Starters	Seimens / L&T/Schneider
4.19	Push Buttons / Overload Relay	Seimens / Tecnic / L&T/Schneider
4.20	Voltmeter / Ammeter	A/E – Imp
4.21	Cushy Foot Mounts	Dunlop / Poly Bond / Resistoflex
4.23	Expansion Bellows	Cori
4.24	Fan	Nicotra / Punkar / Flakt / Comefri / Kruger
4.25	Propeller Exhaust Fan	GEC / ACCO / Khaitan
4.26	Precision A. C.	Emerson/ Stulz/ Sneider
BMS Components –		
4.27	BMS	Siemens / Honeywell / Johnson / Schneider
4.28	Computer	IBM / HP / Compaq / Dell
4.29	Printer - Inkjet	HP / Epson
4.30	DDC Controller	Siemens / Schneider / Johnson / Honeywell
4.31	System Integration Units	Siemens / Schneider / Johnson / Honeywell
4.32	Immersion Temperature Sensor	Siemens / Schneider / Johnson / Honeywell
4.33	Duct Temperature Sensor	Siemens / Schneider / Johnson / Honeywell
4.34	Outside Temperature Sensor	Siemens / Schneider / Johnson / Honeywell
4.35	Outside Rh / Temp. Sensor	Siemens / Schneider / Johnson / Honeywell
4.36	Outside Rh. Sensor	Siemens / Schneider / Johnson / Honeywell
4.37	Pressure Transmitter	Siemens / Schneider / Johnson / Honeywell
4.38	Water Flow Switches	Siemens / Schneider / Johnson / Honeywell
4.39	Differential Pr. Switches	Siemens / Schneider / Johnson / Honeywell

S. No	Component	Approved Make
4.40	Differential Pr. Switches	Siemens / Schneider / Johnson / Honeywell
4.41	Differential Pr. Switches	Siemens / Schneider / Johnson / Honeywell
4.42	Flow Meters	Siemens / Schneider / Johnson / Honeywell
4.43	Level Switches	Siemens / Schneider / Johnson / Honeywell
4.44	Air Quality Sensors	Siemens / Schneider / Johnson / Honeywell
4.45	Frequency Transducer	Enercon / Situ
4.46	Current Transducer	Enercon / Situ
4.47	Power Factor Transducer	Enercon / Situ
4.48	Kilowatt Hour Transducer	Enercon / Situ
4.49	Voltage Transducer	Enercon / Situ
4.50	Water Hardness Analyser	Kele
4.51	Ph Sensor	Kele
4.52	Energy Meter	IME / Dukati / L & T / Enercon

HEAT LOAD SUMMARY SHEET FOR CHILLER SYSTEM

SR. NO.	PARTICULARS	AREA FT ²	OCCUPANCY NOS.	HEIGHT FT	LIGHT LOAD W/FT ²	EQUIP. LOAD KW	FRESH AIR CFM	HEAT LOAD TR	AIR QTY. CFM
GROUND FLOOR									
1	CAFÉ	2,154	85	13	0.8	2.00	1,333	18.32	7,635
2	CONFERENCE-01	1,617	40	13	0.8	0.15	386	10.82	5,204
	CONFERENCE-02	1,167	29	13	0.8	0.15	280	6.35	2,917
	AV ROOM	448	28	13	0.8	2.50	217	4.00	1,672
	MEETING ROOM-01	430	12	13	0.8	0.15	112	2.66	1,232
	MEETING ROOM-02	274	12	13	0.8	0.15	99	2.08	916
3	MEETING ROOM-03	331	12	13	0.8	0.15	104	2.37	1,075
	CABIN-01	130	3	13	0.8	0.15	30	0.71	333
	CABIN-02	125	3	13	0.8	0.15	29	0.48	203
	RECEPTION	825	8	13	0.8	0.15	116	2.93	1,425
	GYM	867	22	13	0.8	2.00	775	9.89	3,465
5	OFFICE/RETAIL	709	18	13	0.8	0.15	172	5.43	2,664
	POST OFFICE	499	5	13	0.8	0.45	71	1.73	836
	PHARMACY	412	4	13	0.8	0.15	71	2.71	1,403
	BANK	1,285	20	13	0.8	2.55	295	6.70	2,916
	SECURITY OFFICE	96	3	13	0.8	0.15	27	0.48	184
6	CABIN	118	3	13	0.8	0.15	29	0.53	211
	SUB REGISTRAR	842	15	13	0.8	2.25	163	3.93	1,693
	CFC	676	10	13	0.8	1.05	118	3.97	1,819
6	PUBLIC RELATION & MAINTENANCE T	1,363	14	13	0.8	0.15	197	5.99	2,733
7	DISPLAY AREA	1,327	13	26	0.8	3.00	188	7.94	3,776
8	CONTROL ROOM	1,367	14	11	0.8	29.10	198	14.45	7,156
9	CORRIDOR-01	1,708	17	13	0.8	-	299	5.26	2,184
10	CORRIDOR-02	2,294	23	13	0.8	-	403	7.87	3,351
11	CORRIDOR-03	1,982	20	13	0.8	-	350	7.24	3,422
12	ATRIUM	12,784	128	20	0.8	5.00	1,829	74.31	35,159
13	RACK ROOM	500	-	11	0.8	37.90	-	14.50	7,582
TOTAL - GROUND FLOOR		36,327	561			89.75	7,891	223.69	103,167
FIRST FLOOR									
1	OFFICES-01	3,804	38	13	0.8	6.20	544	17.18	8,635
2	OFFICES-02	2,892	29	13	0.8	4.85	414	13.39	6,750
3	OFFICES-03	3,680	37	13	0.8	6.05	528	12.52	6,000
4	OFFICES-04	2,890	29	13	0.8	4.85	414	13.15	6,615
5	OFFICES-05	3,799	38	13	0.8	6.20	543	16.63	8,323
6	OFFICES-06	2,462	25	13	0.8	4.25	355	10.67	5,321
7	OFFICES-07	2,462	25	13	0.8	4.25	355	10.67	5,321
8	CORRIDOR	3,237	32	13	0.8	-	460	11.86	5,776
TOTAL - FIRST FLOOR		25,225	253			36.65	3,613	106.06	52,742
SECOND FLOOR									
1	OFFICES-01	3,769	38	13	0.8	6.20	541	15.87	7,888
2	OFFICES-02	2,251	23	13	0.8	3.95	325	10.54	5,315
3	OFFICES-03	3,681	37	13	0.8	6.05	528	12.48	5,979
4	OFFICES-04	2,305	23	13	0.8	3.95	329	10.95	5,546
5	OFFICES-05	3,829	38	13	0.8	6.20	546	15.51	7,674
6	OFFICES-06	1,198	12	13	0.8	2.30	171	5.91	3,007
7	OFFICES-07	2,196	22	13	0.8	3.80	314	10.89	5,542
8	OFFICES-08	1,198	12	13	0.8	2.30	171	5.91	3,007
9	CORRIDOR	3,237	32	13	0.8	-	460	12.10	5,911
TOTAL - SECOND FLOOR		23,662	237			34.75	3,385	100.16	49,869
THIRD FLOOR									
1	OFFICES-01	3,769	38	13	0.8	6.20	541	17.03	8,553
2	OFFICES-02	2,242	22	13	0.8	3.80	318	11.29	5,763
3	OFFICES-03	3,678	37	13	0.8	6.05	527	12.47	5,974
4	OFFICES-04	2,892	29	13	0.8	4.85	414	13.32	6,712
5	OFFICES-05	3,799	38	13	0.8	6.20	543	16.61	8,308
6	CORRIDOR	3,237	32	13	0.8	-	460	11.96	5,834
TOTAL - THIRD FLOOR		19,616	196			27.10	2,803	82.67	41,144

HEAT LOAD SUMMARY SHEET FOR CHILLER SYSTEM

SR. NO.	PARTICULARS	AREA FT ²	OCCUPANCY NOS.	HEIGHT FT	LIGHT LOAD W/FT ²	EQUIP. LOAD KW	FRESH AIR CFM	HEAT LOAD TR	AIR QTY. CFM
FOURTH FLOOR									
1	OFFICES-01	3,804	38	13	0.8	6.20	544	17.18	8,635
2	OFFICES-02	2,892	29	13	0.8	4.85	414	13.55	6,846
3	OFFICES-03	3,680	37	13	0.8	6.05	528	13.11	6,339
4	OFFICES-04	2,251	23	13	0.8	3.95	325	11.20	5,692
5	OFFICES-05	3,799	38	13	0.8	6.20	543	16.63	8,323
6	OFFICES-06	1,641	16	13	0.8	2.90	232	9.57	4,971
7	OFFICES-07	1,641	16	13	0.8	2.90	232	9.57	4,971
8	CORRIDOR	3,237	32	13	0.8	-	460	12.76	6,291
TOTAL - FOURTH FLOOR		22,944	229			33.05	3,278	103.58	52,069
FIFTH FLOOR									
1	OFFICES-01	3,769	38	13	0.8	6.20	541	16.29	8,131
2	OFFICES-02	2,820	28	13	0.8	4.70	402	12.38	6,202
3	OFFICES-03	1,859	19	13	0.8	3.35	269	6.72	3,249
4	OFFICES-04	2,251	23	13	0.8	3.95	325	10.70	5,406
5	OFFICES-05	3,799	38	13	0.8	6.20	543	15.86	7,884
6	CORRIDOR	3,237	32	13	0.8	-	460	14.63	7,364
TOTAL - FIFTH FLOOR		17,734	178			24.40	2,540	76.59	38,236
INTERNAL TERRACE									
1	INTERNAL TERRACE-01	1,694	17	13	0.8	-	729	10.22	4,147
2	INTERNAL TERRACE-02	1,694	17	13	0.8	-	729	10.22	4,147
3	INTERNAL TERRACE-03	1,264	13	13	0.8	-	549	11.26	4,992
4	INTERNAL TERRACE-04	2,312	23	13	0.8	-	990	26.72	12,373
5	INTERNAL TERRACE-05	1,264	13	13	0.8	-	549	11.26	4,992
6	INTERNAL TERRACE-09	1,790	18	13	0.8	-	771	21.26	9,872
7	INTERNAL TERRACE-10	1,790	18	13	0.8	-	771	21.26	9,872
TOTAL - INTERNAL TERRACES		11,810	119			-	5,088	112.23	50,396
GRAND TOTAL		157,318	1,773			246	28,598	805	387,623

HEAT LOAD SUMMARY SHEET FOR DX SYSTEM

SR. NO.	PARTICULARS	AREA FT ²	OCCUPANCY NOS.	HEIGHT FT	LIGHT LOAD W/FT ²	EQUIP. LOAD KW	FRESH AIR CFM	HEAT LOAD TR	AIR QTY. CFM
LOWER GROUND FLOOR									
1	UPS ROOM-01	139	-	13	0.8	2.70	30	1.91	1,090
2	UPS ROOM-02	138	-	13	0.8	10.80	-	4.53	2,724
3	BATTERY ROOM	322	-	13	0.8	-	150	1.89	855
TOTAL - FIFTH FLOOR		600	-			13.50	180	8.33	4,670
FIFTH FLOOR									
1	UPS ROOM	314	-	13	0.8	5.40	69	3.29	1,851
TOTAL - FIFTH FLOOR		314	-			5.40	69	3.29	1,851
GRAND TOTAL		914	-			18.90	249	11.63	6,521

VENTILATION SYSTEM

SR. NO.	PARTICULARS	AREA FT²	HEIGHT FT	AIR QTY. CFM	TYPE OF UNIT	EACH CFM	QTY. (NOS.)	TOTAL CFM
LOWER GROUND FLOOR								
1	PARKING ZONE-1	6,404	12	19,212	AXIAL EX. FAN	20000	2	
2	PARKING ZONE-2	7,845	12	23,535	AXIAL EX. FAN	24000	2	
3	PARKING ZONE-3	6,994	12	20,982	AXIAL EX. FAN	21000	2	
4	PARKING ZONE-4	7,000	12	21,000	AXIAL EX. FAN	21000	2	
5	TOILETS	300	9	600	INLINE EX. FANS	600	1	
6	ELECTRICAL ROOM			-	AXIAL EX. FAN	5000	1	
7	PUMP ROOM & STP			-	AXIAL EX. FAN	10000	1	
	TOTAL	28,543						
GROUND FLOOR								
1	KITCHEN	1,208	12	14,496	SISW EX. FAN	15000	1	15000
				13,046	INLINE F.A. FAN	13000	1	13000
2	MALE -TOILETS	272	9	612	INLINE EX.FAN	600	1	600
3	FEMALE-TOILETS	206	9	464	INLINE EX.FAN	500	1	500
4	MALE -TOILETS	272	9	612	INLINE EX.FAN	600	1	600
5	FEMALE-TOILETS	206	9	464	INLINE EX.FAN	500	1	500
6	MALE -TOILETS	272	9	612	INLINE EX.FAN	600	1	600
7	FEMALE-TOILETS	206	9	464	INLINE EX.FAN	500	1	500
	TOTAL	2,642						
FIRST FLOOR								
1	MALE -TOILETS	272	9	612	INLINE EX.FAN	600	1	600
2	FEMALE-TOILETS	206	9	464	INLINE EX.FAN	500	1	500
3	MALE -TOILETS	272	9	612	INLINE EX.FAN	600	1	600
4	FEMALE-TOILETS	206	9	464	INLINE EX.FAN	500	1	500
5	PANTRY-01	150	8	300	INLINE EX.FAN	300	1	300
6	PANTRY-02	150	8	300	INLINE EX.FAN	300	1	300
7	PANTRY-03	150	8	300	INLINE EX.FAN	300	1	300
	TOTAL	1,466						
SECOND FLOOR								
1	MALE -TOILETS	272	9	612	INLINE EX.FAN	600	1	600
2	FEMALE-TOILETS	206	9	464	INLINE EX.FAN	500	1	500
3	MALE -TOILETS	272	9	612	INLINE EX.FAN	600	1	600
4	FEMALE-TOILETS	206	9	464	INLINE EX.FAN	500	1	500
5	PANTRY-01	150	8	300	INLINE EX.FAN	300	1	300
6	PANTRY-02	150	8	300	INLINE EX.FAN	300	1	300
7	PANTRY-03	150	8	300	INLINE EX.FAN	300	1	300
	TOTAL	1,406						
THIRD FLOOR								
1	MALE -TOILETS	272	9	612	INLINE EX.FAN	600	1	600
2	FEMALE-TOILETS	206	9	464	INLINE EX.FAN	500	1	500
3	MALE -TOILETS	272	9	612	INLINE EX.FAN	600	1	600
4	FEMALE-TOILETS	206	9	464	INLINE EX.FAN	500	1	500
5	PANTRY-01	150	8	300	INLINE EX.FAN	300	1	300
6	PANTRY-02	150	8	300	INLINE EX.FAN	300	1	300
7	PANTRY-03	150	8	300	INLINE EX.FAN	300	1	300
	TOTAL	1,466						

SR. NO.	PARTICULARS	AREA FT ²	HEIGHT FT	AIR QTY. CFM	TYPE OF UNIT	EACH CFM	QTY. (NOS.)	TOTAL CFM
FOURTH FLOOR								
1	MALE -TOILETS	272	9	612	INLINE EX FAN	600	1	600
2	FEMALE-TOILETS	206	9	464	INLINE EX FAN	500	1	500
3	MALE -TOILETS	272	9	612	INLINE EX FAN	600	1	600
4	FEMALE-TOILETS	206	9	464	INLINE EX FAN	500	1	500
5	PANTRY-01	150	8	300	INLINE EX FAN	300	1	300
6	PANTRY-02	150	8	300	INLINE EX FAN	300	1	300
7	PANTRY-03	150	8	300	INLINE EX FAN	300	1	300
	TOTAL	1,406						
FIFTH FLOOR								
1	MALE -TOILETS	272	9	612	INLINE EX FAN	600	1	600
2	FEMALE-TOILETS	206	9	464	INLINE EX FAN	500	1	500
3	MALE -TOILETS	272	9	612	INLINE EX FAN	600	1	600
4	FEMALE-TOILETS	206	9	464	INLINE EX FAN	500	1	500
5	PANTRY-01	150	8	300	INLINE EX FAN	300	1	300
6	PANTRY-02	150	8	300	INLINE EX FAN	300	1	300
7	PANTRY-03	150	8	300	INLINE EX FAN	300	1	300
	TOTAL	1,466						
LIFT WELL PRESSURISATION FAN								
1	LIFT WELL-1				AXIAL EX FAN		1	0
2	LIFT WELL-2				AXIAL EX FAN		1	0
	TOTAL							
	GRAND TOTAL-VENTILATION	38,395						

5.0 FIRE FIGHTING WORKS REQUIREMENTS

The design shall comply with rules of the local fire service department / authorities. The Fire Protection System design shall be based on the following codes & Standards :

Table 6: Codes for Fire Fighting Requirements

Codes / Specifications	Description
National Building Code 2005	Part 4, Fire & Life Safety
Tariff Advisory Committee (TAC)-12th Edition-1998	Fire Protection Manual
Tariff Advisory Committee (TAC)-1998 Edition	Rules for automatic Sprinkler Installations
Tariff Advisory Committee (TAC)	Rules for Water Spray System
IS:3844-1989 (1995)	Fire Protection Manual
IS: 13039:1991	Fire Protection Manual
IS 15105: 2002	Design and Installation of Fixed Automatic Sprinkler Fire Extinguishing System-Code of Practice
IS 12459: 1988	Code of Practice For Fire Safety In Cable Runs
IS 12469: 1988	Fire Fighting Pumps
IS 5120: 1977	Technical requirement for Rotodynamic Special Purpose Pumps
IS 325: 1996	Three-Phase Induction Motor
IS 3042: 2003	Specification For Single Faced Sluice Gates
IS 2190: 2010	Selection, Installation and Maintenance of First-Aid Fire Extinguishers-Code of Practice
IS 15683:2006	Portable Fire Extinguishers - Performance and Construction Specification
IS 5: 1994	Colours for Ready Mixed Paints and Enamles (Fourth Revision)
IS 1239 (Part-I): 1990	Mild Steel Tubes, Tubulars and Other Wrought Steel Fittings: Part-I Mild Steel Tubes (Fifth Revision)

IS 1239: (Part-II): 1992	Mild Steel Tubes, Tubulars and Other Wrought Steel Fittings: Part-II Mild Steel Tubulars and Other Wrought Steel Pipe Fittings (Fourth Revision)
IS 3589: 2001	Steel Pipes for Water and Sewage (168.3 to 2540 mm Outside Diameter) – Specification (Third Revision)
IS 6392: 1999	Specification for Steel Pipe Flanges (Seventh Reprint)
IS 12835: Part I: 1989	Code of practice for design and installation of fixed fire extinguishing system Part 1 Low expansion foam
IS:10221:1982	Code of Practice for Coating & Wrapping of underground Mild Steel Pipe Lines
IS: 5290:1983	Specification for Valve Landing (Second Revision)
IS:8442:1977	Specification for stand post type water monitor for fire fighting
IS:636:1988	Non-percolating flexible fire fighting delivery hose
IS:8423:1977	Specification for Controlled percolating hose for fire fighting
IS:4927:1968	Specification for unlined flax canvas hose for fire fighting (Amendment Nos. 1 & 2)
IS:903:1984	Specification for Fire Hose Delivery Couplings, Branch Pipe, Nozzles and Nozzle Spanner (Third Revision)
IS:906:1988	Specification for branch with revolving head for fire fighting purposes
IS 907: 1984	Specification for suction strainers, cylindrical type for fire fighting purposes(second revision)
IS:2871:1983	Specification for branch pipe, universal for fire fighting purposes (First revision)
IS: 884:1985	Specification for First Aid Hose Reel for fire fighting (First Revision) (Amendment No.1)
IS:940:1989	Specification for Portable Fire Extinguisher (Gas Pressure)
IS:2171:1985	Specification of Portable Fire Extinguisher, Dry Powder (Cartridge Type) (third Revision)
IS:2878:1986	Portable & Trolley Mounted CO2 type fire extinguisher (Third Revision)

IS:4947:1985	Specification for Gas Cartridges for use in fire Extinguishers-CO ₂ type (Second Revision) (Amendment Nos. 1 and 3)
IS:944:1979	Functional requirements for 1800 L/min. Trailer pump for Fire brigade use.(Second Revision) (Amendment No. 1)
IS:946:1977	Functional requirements for Engines for Motor Fire Engines (First Revision)
IS:947:1985	Functional requirements for towing tender for trailer fire pump for Fire brigade use (First Revision)
IS:10001, IS:10002	Diesel Engine-General Purpose
IS:13095: 1991	Butterfly valves
IS: 14846	Sluice Valves for Water Works 50-1200mm
IS: 9890	Ball Valves for General Purposes
IS 3624: 1987	Pressure and Vacuumed Gauge (Second Revision)
IS 2097: 1983	Specification for foam making branch pipe (first revision)
IS: 5312	Specification for Swing Check Valve
ASME B 36.10	Welded and Seamless Wrought Steel Pipe
BS:5150	C.I. Gate Valves/ Rising Stem types PN 16
BS:5153	C.I. Reflux Valves/Check Valves (Swing Type) PN16
BS:1414	Steel Wedge Gate Valves
BS:1868	Steel Check Valves
NFPA 1	NFPA Fire Prevention Code
NFPA 10	Standard for Portable Fire Extinguishers 1998 Edition
NFPA-11	Standard for installation of Low expansion Foam system
NFPA-13	Standard for installation of Sprinkler System
NFPA-15	Standard for Water Spray fixed system for the fire protection system
NFPA-20	Standard for the Installation of Stationary Pumps for Fire Protection
NFPA-2001	Standard on clean agent fire extinguishing system
NFPA-25	Standard for the Inspection, Testing, and Maintenance of. Water- Based Fire Protection Systems

NFA-16	Standard for installation of Foam water sprinkler system or Foam water spray system
NEMA	National Electricity Manufacturers Association
IEEE	Institute of Electrical and Electronic Engineers
ISA	Instrumentation, Systems and Automation society
ANSI	American National Standards Institute
DIN	Deutsche Industries Norman
IEC	International Electrochemical Commission
VDE	Verin Deutschar Eisecehnuttenleutte
ISI	Indian Standard Institute
BS 5839	Code of practice for installation of fire alarm system
IS 2189	Code of practice for installation of automatic fire alarm system
IS:817/2008	Welded joints
UL / FM	Underwriters Laboratory / Factory Manual

1.0 MATERIALS:

The pipes shall be galvanized mild steel 'C' class Factory welded pipes and seamless screwed and socket tubes shall be conforming to the requirement of IS 1239-1964 for Heavy grade. They shall be of the Dai. (nominal bore) specified in the description of the item. The representative nominal bores of the pipes for which they are intended shall designate the socket.

The pipes and sockets shall be clearly finished, well Galvanized in and out and free from cracks, surface flows, laminations and other defects. All screw threads shall be clean and well cut. The ends shall be cut cleanly and square with axis of the tube.

All screw tubes & sockets shall have pipe threads conforming to the requirement of IS 544-1955 (or revised) screwed tubes shall have threads while the sockets shall have parallel threads.

2.0 PIPE FITTINGS:

The fitting shall be of malleable cast iron or MS. tubes complying with all the appropriate requirements given as specified. The respective nominal bore of the pipes for which they are

intended shall designate the fittings.

The fittings shall have screw threads at the ends conforming to the requirements of IS 544-1955 (or revised). Female threads on fitting shall be parallel & male threads (except on running nipples & collars of unions) shall be taper.

The pipes shall be cleaned & cleared of all foreign matter before being laid. In jointing the pipes, the inside of the socket & the screwed end of the pipes shall be oiled & rubbed over with white lead & a few turns of spun yarn wrapped round the screwed end of the pipe. The end shall then be screwed in the socket, Care should be taken that all pipes & fitting are properly jointed so as to make the joints completely water tight & pipes are kept at all time free from dust & dirt during the fixing. Burr from the joint shall be removed after laying; the open ends of the pipes shall be temporarily plugged to prevent access of water, solid or any other foreign matter.

All pipes & fittings shall be fixed truly vertical & horizontal unless unavoidable. The pipes shall be fixed to walls with standard pattern holder bat clamps of required shapes & size so as to fit tightly on the pipes when tightened with screwed bolts.

These clamps shall be embedded in brickwork in cement mortar 1:3 (1 cement 3 coarse sand) & shall be spaced at regular intervals in straight lengths as shown in the table given below.

- 1.1.3 Concrete walls / floors at no time shall be chiseled out for fixing the pipes. The contractor shall use masonry drill to drill the hole and use anchor bolts to fix the pipe.

SIZE OF PIPE mm.	LENGTHS	
	HORIZONTAL RUNS Meters	VERTICAL RUNS meters
15	2	2.5
20	2.5	3
25	2.5	3
32	2.5	3
40	3	3.5
50	3	3.5
65	3.5	5
75	3.5	5

The clamps shall be fixed at shorter lengths near the fittings as directed by the Engineer-in-charge.

For GI pipes 15mm to 25 mm Dia. the holes in the walls & floors shall be made by drilling with drill bits & not by dismantling the brick work or concrete. However, for bigger diameter pipes the holes shall be carefully made of the smallest size as directed by the Engineer-in-charge. After fixing the pipes the holes shall be made good with cement mortar 1:3 (1 cement: 3 coarse sand) & properly finished to match the adjacent surface.

3.0 EXTERNAL WORK:

The galvanized iron pipes & fittings shall be laid in trenches. The widths & depths of the trenches for different diameters of the pipes shall be as in the table given below :

DIA. OF PIPE	WIDTH OF TRENCH	DEPTH OF TRENCH
15 mm TO 50 mm	300 mm	60 cm
65 mm TO 100 mm	450 mm	75 cm
150 mm TO 300 mm	600 mm	100 cm

At joints the trench width shall be widened wherever necessary. The work of excavation & refilling shall be done true to line & gradient.

The pipes shall be painted with two coats of Anti-corrosive bitumastic paint of approved quality. The pipe shall be laid on a layer of 7.5cm sand & filled with sand upto 15 cm above the pipes. The remaining portion of the trench shall then be filled with excavated earth. The surplus earth shall be disposed off as directed.

In case of bigger diameter (65mm & above) pipes where the pressure is very high, thrust blocks of cement concrete 1:2:4: (1 cement: 2 coarse sand: 4 grade stone aggregate of 20 mm nominal size) shall be constructed on all bends to transmit the hydraulic thrust without impairing the ground & spreading it over a sufficient area.

4.0 TESTING THE JOINTS:

After jointing, the pipes & the fittings shall be inspected under working conditions of pressure

& flow. Any joint found leaking shall be redone & all leaking pipe removed & replaced without extra cost.

The pipe & fittings after they are laid shall be tested to hydraulic pressure of 15 Kg/cm² (150 meter) The pipes shall be slowly & carefully charged with water allowing all air to escape & avoiding all shocks of water hammer. The draw of taps & stopcocks shall then be closed & specified hydraulic pressure shall be applicable gradually. Pressure gauge must be accurate & preferably should have been re-calibrate before the test. The test pump having been stopped the test pressure should be maintained without loss for at least half an hour. The pipes & fitting shall be tested in sections as the work of laying proceeds, keeping the joints exposed for inspection during the testing.

5.0 GI PIPES & FITTINGS:

The pipes shall be of the class specified in the Schedule of Quantities & shall be of galvanized steel, welded or seamless, screwed & socketed shall conform to IS: 1239. A firm of repute shall manufacture them. All fittings shall be malleable iron galvanized fittings of approved best Indian make. The detail of the pipes regarding nominal bore thickness & weight are given below:

APP. OUT SIDE DIA.	NOMINALBORE		SCREWED & SOCKETED Wt/Mtr		SCREWED & SOCKETED METERS / 1000 KG.			
	MM	NEAREST inch	LIGHT Kg.	MEDIU M Kg.	HEAVY Kg.	HEAV Y Kg.	MEDI UM Kg.	LIGH T Kg.
10.2	6	1/8	0.364	0.41	0.496	2747	2439	2016
13.5	8	¼	0.521	0.65	0.773	1919	1529	1294
17.2	10	3/8	0.680	0.85	1.030	1470	1166	971
17.3	15	½	0.961	1.23	1.460	1040	813	685
26.9	20	¾	1.42	1.59	1.910	704	629	524
33.7	25	1	2.03	2.46	2.990	493	407	334
42.4	32	1 ¼	2.61	3.17	3.870	383	316	258
48.3	40	1 ½	3.21	3.65	4.470	304	274	224
60.3	50	2	4.18	5.17	6.240	239	193	160
76.1	65	2 ½	5.92	6.63	8.020	169	151	125

88.1	75	3	6.98	8.64	10.300	143	116	98
101.6	90	3 ½	8.92	9.90	11.800	112	101	84.6
114.3	100	4	10.2	12.40	14.700	98	80.6	68
139.7	125	5	-	16.70	18.300	-	59.9	54.6
165.1	150	6	-	19.80	21.800	-	50.5	45.9

NOTE: The above weights are for black pipes & theoretical weights of galvanized pipes are 6% higher.

6.0 WATER PRESSURE MAINS:

This Shall conform to the IS 1536 - 11967 (Class LA) as specified in the schedule. They shall be laid, jointed & tested along with the C.I pipes as described in the specification for C.I.S/S pipes.

7.0 FLANGED PRESSURE MAINS:

Flanged joints to be made by painting the face of the flanged with red lead freely & bolting up evenly on all sides.

a) A thin fiber of lead wool shall be used in making the joints water tight where facing of the pipes is not true.

b) Where packing may be used, it shall be of rubber insertion cloth three ply & of approved thickness. The packing should be of full diameter of the flange with proper pipe hole & bolthole, neat & even at both the inner & outer edges.

c) Where the flange is not fully faced, the packing may be of the dimension of the facing strip only. Its proper placing should be tested before another pipe is jointed on.

d) TESTING: After each section of the pipeline has been completed it shall be tested for water tightness before being covered in. This can be done by closing ends & by means of a valve, blank flange, cap or plug & filling the pipe with water. The pressure should be raised by means of a small hand operated pump till it registers 50% above the highest working pressure in the section & the test pressure should be ascertained by means of a reliable gauge. When the pipe is laid on any appreciable gradient, the test should be carried out at the lower end of the section. Any leaking joints should be made good & the above test reapplied until no further leaks are apparent.

8.0 FITTINGS:

General – The brass or gunmetal fittings shall be heavy quality & approved manufacturer &

pattern with screwed or flanged ends as specified. The fittings shall in all respects comply with the Indian standard Specifications NO.IS: 778-1957 & IS.781- 1959. The nominal bore of the pipe outlet to which the fittings are attached shall designate the standard size of brass gunmetal fittings. A sample of each kind of fittings shall be got approved from the Engineer-in-charge & all supplies made according to the approved samples.

All cast fittings shall be sound & free from laps, blowholes & fittings; both internal & external surfaces shall be clean, smooth & free from sand etc. Burning plugging, stopping or patching of the casting shall not be permissible. The bonnets, spindles & other parts shall be truly machined so that when assembled the parts shall be axial, parallel & cylindrical with surface smoothly finished.

The area of the waterway of the fittings shall not be less than the area of nominal bore. The fittings shall be fully examined & cleared of all foreign matter before being fixed. The fittings shall be fixed in the line in a workman like manner. The joints between fittings & pipes shall be made leak proof. The joints & fittings shall be leak proof when tested to a pressure of 15KG/CM² as described in para 1.1.5 - the defective fittings & joints shall be replaced or redone.

9.0 BRASS FULLWAY VALVES:

Fullway valve is a valve with suitable means of connection for insertion in pipeline for controlling or stopping the flow. The valve shall be of brass fitted with a cast iron wheel & shall be of gate valve type opening fullway of the size as specified.

The valve shall be of best quality specified in makes approved by the Engineer-in-charge & shall have the following approximate weight with a tolerance of 5%.

Mm	Flanged ends Kg	Screwed ends Kg
15	1.021 (Provisional)	0.567(Provisional)
20	1.503 (,)	0.680(,)
24	2.645 (,)	1.077(,)
32	3.232 (,)	1.559(,)
40	4.082 (,)	2.268(,)
50	6.691 (,)	3.232(,)
65	10.149 (,)	6.804(,)
75	13.381 (,)	8.845(,)

- 9.1 GUN METAL FULLWAY VALVE WITH WHEEL: These shall be of the Gun metal fitted with wheel & shall be of Gate valve type opening full way & of the size as specified. These shall generally conform to IS.778-1957 & their approximate weights shall be given in para 1.2.
- 9.2 Ball valve: The ball valve shall be of high pressure class & shall be of sizes as specified. The nominal size of a ball valve shall be that corresponding to the size of the pipe to which it is fixed. The ball shall be of brass or Gun metal as specified, & the float of copper sheet. The minimum gauge of copper sheet used for making the float shall be 45 for float upto 115 mm Dai. & 55 for float exceeding 115mm Dai. This shall be spherical in shape. The jointing of the float shall be made by efficiently burnished, lapped & soldered seam or by brazing. Plastic float may also be used if specified. The body of ball valve when assembled in working conditions with the float immersed to not more than half of it's volume shall remain closed against a test pressure of 10.5Kg/sq. Cm. & low pressure shall against a test pressure of 3.5Kg/sq. cm.

The ball valve shall generally conform to IS specifications No. 1703-1962. The weight of ball cock & the size of ball shall be as per table given below.

10.0 SLUICE VALVE & FIRE HYDRANTS:

Sluice valves: The sluice valves are used in a pipeline for controlling or stopping flow of water. These shall be of specified size and class and shall be of non-rising screwed type with either double flange or double socket ends & cap or hand wheel. These shall, in all respects, comply with the Indian standard specifications IS.780-1963 for valves upto & including 300mm size. Class-1 sluice valve are used for maximum working pressure of 10Kg/cm (100 meter head) & Class 2 sluice valve for 15Kg/cm (150 meter head).

The body, domes, covers, wedge gate stuffing box shall be of good quality cast iron, the spindle of bronze, nut & valve seats leaded tin bronze. The bodies spindle & other parts shall be truly machined with surface smoothly finished. The area of the waterway of the fittings shall be not less than the area equal to the nominal bore of the pipe.

The valves shall be marked with an arrow to show the direction of turn for closing of the valve.

The valve shall be fully examined & cleared of all foreign matter before being fixed. The fixing of the valve shall be done by means of bolts, nuts & 3mm rubber insertion of chemically treated compressed fiber board. 1.5mm minimum thickness & of weight less than 0.183 gm/sq. cm with flanges of spigot & socketed tail pieces drilled to the same, specification in case of S & S pipes & with flanges in case of flanged pipes. The tailpieces shall conform to IS. 1938-1960. These shall be jointed to the pipe line by means of lead caulked joints.

- 10.1 Fire Hydrant: The hydrants shall be of spindle type with 65mm outlet combined with sluice

valve unless otherwise specified. The hydrant shall conform to IS.909-1958 & shall consist of the following components:

One sluice valve class 1 type confirms to IS.780-1963.

One duck foot bends.

One 65mm male coupling instantaneous pattern and.

One Cast iron cap permanently secured to the duck foot bend by means of a chain. Where the fire services requirement of coupling differs from the above, the requisite coupling shall be provided at no extra cost.

The body & cover shall be of good quality cast iron spindle & bronze & the nut & the valve seat of leaded in tin bronze. The bodies, spindles & other parts shall be truly machined with surface smoothly finished.

The hydrant shall be fully examined and cleared of all foreign matter before being fixed. The fixing shall be done on the water main, which shall be of minimum 75mm dia. The flanged end of the hydrants shall be fixed to the flanged outlet of a tee in the water main by means of bolts, nuts & 3mm rubber insertion or chemically treated compressed fiber bore 1.5 mm minimum thickness & of weight not less than 0.183 gm. per sq.cm. This can also be fixed by means of flanged tailpiece, which may be connected to the water main by C.I. specials.

10.2 Appurtenances:- The other appurtenances of pipe line are mentioned below:-

Air Vents: These are placed at every summit in the pipeline to permit the escape of air when the main is filled, & afterwards if any air is carried into the mains. These are also placed on long stretches of nearly level main.

Scour Valves: These are placed at bottom of the all depressions of pipes for emptying the main or letting out the sediment.

Reflux Valves: These are fixed so as to open in the direction of flow but automatically to close if the water flows back. They are used to diminish the damage done by the escape of water due to a burst or to prevent damage to impellers of Pump.

Safety or Relief Valves: These are fixed at the down stream ends of long lengths of main or where water hammer may take so as to reduce from any excessive pressure to the nominal if it occurs.

10.3 MASONRY CHAMBERS:

10.3.1 General: All masonry chambers for stop cocks, sluice valves, fire hydrants & meter etc. shall be built as per supplied drawings.

10.3.2 Excavation: The excavation for chambers shall be done true to dimension & level indicated on plans or as directed by the Engineer-in-charge

- 10.3.3 Bed concrete: This shall be of cement concrete 1:3:6 (1 cement:3 fine sand:6 graded stone aggregate 40mm nominal size).
- 10.3.4 Brick work: This shall be in 2nd class bricks in cement mortar 1:5(1 cement : 5 fine sand)
- 10.3.5 Plastering: Plastering not less than 12mm thick shall be done in cement mortar 1:3 (1 cement: 3 coarse sand) finished with a floating coat of neat cement.
- 10.3.6 Surface Box: This shall be of cast iron, well made & free from casting & other defects. All sharp edges shall be removed & finished smooth. The clear of dimensions for surface boxes for stop cocks sluice valves, fire hydrants, water meters, etc. shall be given in drawing.
C.I. surface boxes shall be coated with black bituminous composition except in the case of fire hydrants where the cover of the surface box shall be painted with two coats of rust resisting bright luminous yellow paint for clear visibility during night.
The C.I. surface box shall be fixed on the top of the masonry chamber and provided with plain or reinforced cement concrete 1:2:4 (1 cement: 2 coarse sand: 4 graded stone aggregate 20mm nominal size.)

11.0 HANGERS & SUPPORTS :

GENERAL: Provide proper solid angle iron channel section, supports for all pipes complete with clamps. Wherever insulation cores, to provide wooden guide to support pipe on the angle iron hangers/supports. For attachment in concrete, use "Dash" fasteners or anchor plug type inserts or equivalents. Provide hangers within 0.9 meter of all hangers in direction of mains & a minimum of three hangers per expansion bend wherever shown in drawing. Provide all additional structural steel angles, channels or other members not specifically shown but are required for proper support. At no time concrete reinforcement should be allowed to drill exposed & hangers hang on them.

Where necessary additional hangers to be provided to arrest water hammers or hydraulic resonance with proper rubber padding.

Space hangers, as noted below, except on all soil pipe which shall have a hanger or multiple fittings, sufficient hangers shall be provided to maintain proper slope without sagging, in case of angle suspended line, the following is suggested.

A. Pipe Sizes	Hanger Rod Dia.
20 mm through 50 mm	9 mm.
65 mm through 125 mm	12 mm.
150 mm and over	16 mm.
B. Pipe Sizes	Spacing of Supports
12 mm to 20 mm	1.5 M apart
25 mm to 40 mm	1.8 M apart

50 mm & above 1.8 M apart or as per IS

Provide floor stands, wall brackets of masonry piers, etc., for all lines running near the floor or near walls for those lines can be properly supported from the walls or floors. Pipeline near concrete or masonry walls may be hung also by hangers carried from wall brackets at a higher level than pipes. Hanging of any pipe from another way is prohibited.

HANGERS: Cleaves or band type hangers shall be provided. Hot water piping is to be provided with suspended supports as far as possible. Note that Strap hangers are not permitted & clamps should be of removable type.

12.0 VALVES & PRESSURE GAUGES :

12.1 Pressure gauges shall have not less than 112mm dia. brass body syphon & gauge cock of 9 mm size. Dial ranges shall be adequate for the pressure encountered & as specified.

12.2 Provide valves on branch pipe connection to mains & at connection to equipment where indicated. All valves are to be located for easy access & are to be full bore of pipe connected together. Support all valves wherever necessary. Valves are to be as per IS. 780 (class 1) for GI sluice valve & to IS. 778 for valves & tested & approved.

12.3 VALVE SCHEDULES:

SERVICE	TYPE	SIZE	RATING	ENDS	MATERIALS
Water, Oil, air steam (low pressure)	Gate	65 mm & under	300 psi/20 Kg./sq.cm.	screwed	Bronze
Water	Gate	75 mm & over	300 psi WOG	flanged	CI body bronze trim

Gas	Gate	65 mm & under	600 psi	flanged	Bronze/SS spindle & trim
Water, Oil, air, Gas, steam (low pressure)	Globe & angle	65 mm & under	300 psi.	Screwed	Bronze
Water	Globe & Angle	65 mm & under	300 psi. water	Screwed	Bronze
Water	Globe & Angle	65 mm &	300 psi.	Flanged	Iron body

		over			bronze trim
Water	Horizontal & vertical check	65 mm & under	300 psi.	Screwed	Bronze
Water	Horizontal & vertical check	65 mm & over	300 psi.	Flanged	Iron body bronze trim

12.4 All globe & check valve shall have working parts suitable for hot & cold water, oil or gas as required. Valves shall be tagged with permanent label under band wheel indicating type of duty.

13 WET RISER FIRE HYDRANT

13.1 SCOPE OF WORK:

13.1.1 Work under this section shall consist of furnishing all labor, materials, Equipment & appliance necessary & required to install complete system as shown in the drawings & specified here in after or given in the schedule of Quantities.

13.1.2 The system shall consist of but will not be limited to the Followings:

GI / black steel (cast iron) mains including valves, sprinkler head, hydrants & appurtenances.

G.I./black steel fire risers.

Landing valves, hose reels; hose cabinets, brigade connections to existing fire mains.

13.2 GENERAL REQUIREMENTS:

13.2.1 All materials shall be new & of the best quality conforming to specifications & subject to the approval of the Engineer-in - charge.

13.2.2 Pipes & fittings shall be fixed truly vertical horizontal to in slope as required in neat workmanlike manner.

13.2.3 Pipes fittings & Valves shall be fixed to provide easy accessibility for repair & maintenance & shall not cause obstruction in shafts, passages, etc.

13.2.4 Pipes shall be securely fixed to walls & ceilings by suitable clamps, hangers at intervals specified. Only approved type of Anchor fasteners shall be used for RCC ceiling & walls.

13.3 PIPES & FITTINGS:

Pipes for wet risers shall be black steel tubes conforming to I.S. 1239 (heavy class) 1979 with screwed/ welded joints as specified & directed by the Engineer - in - charge

13.4 JOINTING:

13.4.1 Joints for black steel pipes 50 mm Dai & below fitting shall be metal tapered threaded joints using red lead for rust prevention. Joints shall be welded for sizes 65mm Dai above as approved by the Engineer-in-charge. (Welding shall conform to relevant I.S.)

13.4.2 Joints between GI or black steel pipes & valves & other appurtenances shall be made with G.I or black steel flanges. Flanges joints shall be made with 3mm thick insertion rubber washer. Flanges shall be of Table "E" and shall conform to IS 1538 Part IV to Part VI which shall be cut and drilled out of MS Plates. MS cut flanges shall be galvanized before welding to G.I Pipes.

13.5 SLUICE VALVES & NON RETURN VALVES:

Sluice valves (80mm & above dia) shall be cast iron double flanged with non-rising spindle. Sluice valves below ground shall be provided with caps suitable for operations by a key. Sluice valves in exposed locations shall be provided with cast iron wheel. Sluice valves shall conform to IS 780(class I 1969) & tested to 20 kg/sq. cm pressure.

13.6 FIRE HYDRANTS:

13.6.1 The contractor shall provide on each landing & externally as shown on drawing one (twin headed gun metal landing valve with 63mm dia outlet to & 100mm inlet) IS 5290 -1969 with cast iron wheels. Landing valve shall have flanged inlet & suitable for fire brigade hoses 63mm Dai.

13.7 FIRE HOSE REELS:

13.7.1 The contractor shall provide standard fire hose reels with 20mm Dai high pressure Dunlop rubber hose 30 M long with gunmetal nozzles & control valve, shut off valves, all mounted on circular hose reel of heavy mild steel construction & cast iron bracket. Hose reel to be firex, minimax or equivalent. Hose reel shall conform to I.S. 884 - 1969.

13.8 DRAIN VALVES:

13.8.1 Provide 50mm Dai black steel pipe to I.S. 1239 heavy class with 50mm gunmetal fullway valve for draining any water in the system in low pockets.

13.9 PIPE PROTECTION:

13.9.1 Paint all pipes above ground & in exposed location with one coat of red oxide primer & two or more coats of post office red paint of approved shade as approved by the Engineer - in - charge. (Buried pipe shall be covered by hessian cloth dipped in coal tar, after a coat of bitumen on pipe).

13.10 PIPE SUPPORTS:

13.10.1 Support all pipes adequately from slabs or walls by a structural support fabricated from MS structural rods, channels, angles & flats. All clamps shall be painted with one coat of red oxide

& two coats of post office red channel paint. (Buried pipes shall have 150mm deep PCC bed haunched to half the Dia. of pipe).

13.11 TESTING:

13.11.1 Test all piping in the system to a hydrostatic pressure of 16 KG. /sq.cm without drop in pressure for atleast 2 hours.

13.11. Rectify all leakage's, make adjustment & re-test as required & directed by the Engineer - in - charge.

14.0 FIRE FIGHTING SYSTEM

14.1 Scope of Work:

The scope of work shall cover supply, installation, testing and commissioning of the Fire hydrant system covering the following :

Fire pumps, electric or diesel driven as shown in the equipment schedule and drawings.

Jockey pumps, electric driven as shown in the equipment schedule and drawings.

Automatic fire pump panel with all accessories.

Hydrant mains, external ring and yard hydrants.

Wet risers in the building as specified and shown on drawings.

Landing valves, hose reels, hose cabinets etc.

Fire brigade breaching, Siamese connections and connections to pumps and appliances.

14.2 Standards:

The fire hydrant installation shall conform to and meet with the requirements set out by the following:

1) IS: 1648 - 1961 Code of practice for fire

Safety of buildings (General)

Fire Fighting Equipment and

Its maintenance.

2) IS: 3844 - 1966 Code of practice for installation

Of internal fire hydrants in

Multistoried buildings.

3) Fire Insurance Association of India-Tariff Advisory

Committee rules.

- 4) Compliance with the local fire brigade and the fire enforcing authorities.

14.3 FIRE PUMP:

- 14.3.1 The fire pump shall be single or double suction centrifugal type with split casing and direct driven by electric motor or diesel engine as specified. The pump rating and performance shall conform to the Equipment Schedule and meet the TAC duty requirements.
- 14.3.2 Pump casing shall be of close grained cast iron with bronze impeller. The shaft sleeve shall be brass or SS 304 and the trim shall be brass or bronze.
- 14.3.3 Pump shall be capable of delivering 150% of the rated capacity at 65% of the rated head and the No-delivery head shall be more than 140% of the rated delivery head. The pump casing shall withstand 1.5 times the no-delivery pressure or 2 times of the duty pressure whichever is higher.
- 14.3.4 The pump shall be either electricity driven or diesel driven with direct flexible coupling.
- 14.3.5 The electric drive motor shall be squirrel cage induction conforming to IS325-1978 and rated for continuous duty (S1). Motor shall have not less than class B insulation and minimum enclosure of IP22. The starter shall be air-cooled fully automatic star delta or auto-transformer type. Starters shall conform to BE 8544 and rated for AC- 3 duty conditions.
- 14.3.6 Drive rating shall be based on the largest of the following :
- 1) Rated pump discharge at rated head
 - 2) 150% of rated discharge @ 65% of rated head
 - 3) Maximum power absorbed by the pump in its operating range i.e. no-delivery to free discharge.

MATERIALS OF CONSTRUCTION

Part	Material
Casing	Cast Iron
Impeller	Bronze IS:318, Gr. LTB 2
Casing Wearing	SS
Shaft	AISI – 410 / Stainless Steel
Shaft Sleeve	S.S. 316
Stuffing Box	Gland Packed

Pumps shall be provided with pressure gauge with isolation cock on the delivery side.

In case of motor driven pump the motor rating should be adequate to drive the motor rating should be adequate to drive the pump at 150% of rated discharge.

The pump and its prime mover (Electric motor or Diesel Engine) shall comply with all the equipment of the Rules of the Traffic Advisory Committee.

All pumps shall have positive suction & shall be provided with suction strainer of SS & CI bell mouth.

- 14.3.7 The diesel engine shall be naturally aspirated (non- turbo charged) & electrically started. The engine shall have a speed governor to regulate the rated rpm within 5% of its rated speed. The engine shall be complete with starting batteries full-wave selenium rectifier charger, isolation leads, mounting frame etc. Engine rating shall be same as for the electric motor.

Diesel engine shall have suitable no. of cylinders with individual heat assemblies. The engine shall be water cooled and shall include heat exchanger and connecting piping strainer, isolating pressure reducing valves, bye-pass line, exhaust pipe, silencer, day tank for fuel all interconnected piping etc., complete in all respects.

Engine shall be direct injection type with low noise and exhaust omission levels,

The speed of engine shall match the pump speed for direct drive.

The engine shall be capable of being started without the use of the wicks, cartridge heater plugs or either at engine room temperature of 4°C and shall take full load within 15 seconds from the receipt of the signal to start.

The engine shall effectively operate at 46°C ambient temperature at 150 meter above mean sea level.

Noise level of the engine shall not exceed 120 dB (free sound pressure) at 3 meters distance.

Engine shall be suitable for running on high speed diesel oil.

The system shall be provided with a control panel with push button starting arrangement also wired to operate the engine on differential pressure gauge.

The entire system shall be mounted on a common structural base plate with anti-vibration

mounting, Dunlop make, and flexible connections on the suction and delivery piping.

Contractor provide one fully mounted and supported Day Oil Tank fabricated from 6mm thick MS sheet electrically welded for 8 hours working load and having suitable capacity of oil. Provide level indicators – low level and full level in the Day Oil Tank on the control panel through float switches and an breather. Day Oil Tank shall also be provided with filling connection (Threaded) with cap, gauge glass indication and cocks, drain cock, inspection / cleaning cover with gasket and nuts / bolts. MS dyke to hold 150% of the Day Tank capacity to be built around the Day Tank.

Contractor to provide one exhaust pipe with suitable muffler (residential type) to discharge the engine gasses to outside in open air as per site conditions (Contractor to check the site).

Contractor to provide all accessories, fittings and fixtures necessary and required for a complete operating engine set. The exhaust pipe shall be taken outside the building with minimum number of bends (approx. length 30 Meters) and shall be duly heat insulated with 50mm thick glass wool covered with 24 gauge aluminum cladding.

Contractor shall indicate special requirements, if any, for the ventilation of the Pump Room.

14.4 Jockey Pump & Booster pump

14.4.1 Starting and stopping of Jockey Pump set shall be automatic at predetermined levels through pressure switch. However, arrangements for manual start and stop of the pump shall also be made. Jockey Pump shall take care of small leakages in the piping system and pumps cushion tanks. The Jockey pump shall be similar to the fire pump but need not have a split casing.

14.4.2 A Booster pump shall be provided (if called) at terrace to pressurize the wet riser system. The pump shall be centrifugal mono-block type.

14.5 Accessories:

14.5.1 The fire and Jockey pumps shall be complete with the following accessories:

- 1) Suction and discharge eccentric reducers.
- 2) Pump coupling guard
- 3) Common base frame, fabricated mild steel or Cast iron.

14.5.2 Each pump including jockey pump shall have independent set of pressure switches. The pressure switch shall be snap action SP DT switch rated 10 A @ 220 V operated through a stainless steel diaphragm. The switch shall have a pointer for manual adjustment of set point, and all electrical connections shall be terminated in a screwed terminal connector. The entire unit shall be encased in a cold drawn steel enclosure. The diaphragm shall be designed for a maximum operating pressure of the system. Each pressure switch shall be provided with pressure gauges and pressure switches shall be mounted on the pipeline.

- 14.5.3 Flow switches shall be paddle type SPDT snap acting contacts rated 10 A @ 220 V. The paddle shall be made of either brass or phosphor bronze terminated in a screwed terminal connector. The entire unit shall be encased in cold drawn steel enclosure and the maximum operating pressure of the parts in contact with the liquid shall be consistent with the system pressure. 10 Kg/cm².
- 14.6 System Operation and Control Panels
- 14.6.1 The fire pump shall be started automatically on loss of pressure and the operation sequence of the jockey and fire pumps shall be as follows :
- Jockey pump shall start when the system pressure drops by 0.35 Kg/Sq. cm and stop when the system pressure is reestablished.
- The fire pump shall start when the system Pressure Drops by 1.0 Kg/cm² and shall continue to run till manually switched off.
- Jockey and fire pump starting shall be indicated on the panel with a red indicating lamp. It should also be indicated on the Main and Repeater Alarm Panels(MAP & RAP)
- 14.6.2 The electrical control panel shall be sheet steel enclosed dead front type with easy access to all parts and cable terminations. The panel drawings shall be got approved before fabrication. Panel shall be fabricated out of 14 SWG (2.0 mm) thick steel sheets duly rust inhibited through a process of degreasing and phosphating. The panel shall be complete with ON/OFF push buttons, ammeters, indicating lamps etc. The under voltage protections shall not be provided for fire pumps.
- 14.6.3 The motor starters (direct on line or star-delta or auto- transformer) shall consist of electrically actuated contractors. The starter shall be complete with ON-OFF push buttons, timers and auxiliary contracts and shall be fully automatic. There shall be an indicating lamp with each of the pumps and an ammeter and selector switch with the fire pumps. Fire pump starting shall be annunciated through an electric siren. Autotransformers shall be korndorfer type for smooth transition. The autotransformer shall be oil/air cooled and shall have separate compartment in the panel. In the case of combination fire hydrant and sprinkler systems, the control panel shall cover the sprinkler pump starter, control components etc. complete as for fire pumps.
- 14.6.4 All cabling, to and from the pumps to starters and control switches shall be carried out through armored PVC cables of approved makes. Cables shall be laid in accordance with section "M V CABLING". The pump motors and panels shall be double earthen in accordance with IS 3043-1956 or as shown on drawings.

14.7 Fire Hydrants, & hose reels:

14.7.1 Hydrants shall be provided internally and externally as shown on the drawings. Internal hydrants shall be provided at each landing of an escape staircase and additionally depending on the floor area as shown on drawings. Landing valve shall be single headed gun metal valve with 2-63 mm dia outlets and 100 mm inlet conforming to IS 5290 - 1969. Landing valves shall have flanged inlet and instantaneous type outlets and mounted at 1.0 m above the floor level. Instantaneous outlets for fire hydrants shall be of standard pattern approved and suitable for 63-mm dia fire brigade hoses. Wherever necessary, pressure-reducing orifices shall be provided so as to limit the pressure to 3.5 Kg/sq. cm Or any other rating as required by the local fire brigade.

14.7.2 Each landing valve shall have a hose reel cabinet of 1800 x 900-x 450-mm housing or as shown on drgs.

Landing valve with twin 63-mm dia. capped outlets and one 100-mm inlet.

First-aid hose reel with 30 m long 20 mm dia. high pressure dunlope hose & 20 mm dia gate valve.

2-7.5 m long 63-mm dia. flax canvas controlled percolation hoses with instantaneous couplings.

One copper branch pipe with bronze rings to take the nozzle at one end and fit into the instantaneous coupling at the other.

One leaded-tin-bronze nozzle of 25 mm dia.

The first aid hose shall conform to IS 884-1969 and be wound on a heavy-duty circular hose reel with a cast iron bracket. The hose shall be permanently connected on one end to the standpipe through a 20-mm G.M valve with necessary hose adopter and a gunmetal nozzle at the other end. The reel shall swing out by 270 degree.

Canvas hoses shall be in two lengths of 7.5 m each, of flax or controlled porcelain type with instantaneous couplings, neatly rolled into bundles and held in position with steel brackets. Canvas hoses shall be tested and certified by the manufacturers, to withstand an internal water pressure of not less than 35 Kg/sq. cm without bursting. The hose shall also withstand a working pressure of 7 Kg/sq. cm. without leakage or undue sweating.

The hose cabinet shall be fabricated from 2-mm mild steel sheet duly rust inhibited through a process of degreasing and phosphating. The cabinet shall have double flap-hinged doors with

4mm clear glass and shall have necessary openings for riser main and brackets for all internals. The cabinet shall receive two coats of red oxide primer both inside and outside before two after coats of final paint of approved colour shade.

- 14.7.3 External Hydrants shall be stand post types over ground unless shown otherwise. All external hydrants shall be 80-mm dia with instantaneous spring lock type and 80 mm C.I. Sluice valve. Hydrants shall be located at least 2 M away from and within 15 m from the building wall. Each hydrant shall be provided with a hose cabinet containing 2 x 15 m 63 mm dia. flax or controlled percolation hoses with couplings. Wherever shown, the cabinet may contain a branch pipe and nozzle. The cabinet shall be 900 x 600 x 400 fabricated out of 2-mm mild steel sheet duly rust inhibited through a process of degreasing, phosphating etc. And fitted with 4 mm clear 400 x 400 glass window. The cabinet shall receive two coats of red oxide primer, inside and outside, before 2 coats of final painting of approved shade. The cabinet shall be wall- mounted or free standing with its own steel legs depending on the site conditions and as shown on drawings.
- 14.7.4 The fire brigade connection shall consist of one or two twin-headed 63-mm dia gun metal outlets with built-in check valve and drain plugs connected to a 150 mm dia outlet connection to the water reservoir or to the hydrant main. The fire brigade collecting head shall conform to BE 904-1965.
- 14.7.5 Priming:
A priming tank of the specified capacity shall be provided wherever shown on the drawings and schedule of work. The tank shall be fabricated out of 4-mm mild steel sheets and painted with epoxy based black paint. The tank shall be complete with 25 mm make up float valve with PVC ball, 25 mm over flow and drain connections, 25 mm drain valve, gauge glass, 450 mm manhole with malaria proof cover, 50 mm vent with cowl and mosquito netting.
- 14.8 Piping:
All piping shall be as specified under "piping for Fire Fighting" and the schedule of work for piping.
- 14.9 Testing & Commissioning:
All hydrant piping shall be tested for a hydrostatic test pressure of 30 Kg/sq. cm or 1.5 time the working pressure (whichever is less) for a period of 24 hours at the end of which there shall be no loss in pressure.
- 14.10 HOSES:
Hoses pipes shall be of fabric reinforced rubber lines as per IS:636 Type II or canvas hose as per IS:4927, with nominal size of 63 mm and lengths of 15 meter or 7.5 meter, as per quantities

specified for in schedule or bill of quantity. All hose pipes shall carry ISI marking on the body of the hose.

The hose shall have instantaneous spring lock-type coupling on ends. The instantaneous coupling shall be as per IS:903. It shall be fixed to each other by copper rivets and galvanised M.S. wires and leather bands. All coupling shall be interchangeable with each other, and shall bear ISI markings.

14.11 Branch Pipes:

Branch pipe shall be of either gun metal or aluminium and should conform to IS: 903. One end of the branch pipe will receive the coupling while the other end shall have a nozzle screwed to it. It shall bear ISI marking.

14.12 Hose cabinet (hose Box):

Each hydrant shall be housed in a Hose cabinet of suitable size. The hydrant cabinet shall hold twin headed hydrant, 2 hoses and one branch pipe as required. Internal hydrants shall normally fit the size of the niche made for it. The cabinet shall be of minimum 14 SWG M.S. sheet with centre opening, double glass front doors (cleat glass of 4mm thickness). The glass shall be firmly fixed by means of steel clips and screw with rubber beading. Hinges shall also be screwed and not welded. The corner members (frame) shall be of 25 x 25 x 3 mm thick angle. The hose box shall be firmly fixed to the wall/support by means of brackets and dash fasteners. The steel work shall have one coat of primer and two coats of red paint. The words "Yard Hydrant", "Hydrant" etc. should be painted in white or red on the glass in 75 mm high letters. The hose box shall be lockable.

14.13 Air Cushion Tank:

Every wet riser shall be provided with an air cushion tank at its top most point. The air cushion tank shall be provided with an automatic air release cock, 20 mm dia. drain pipe, drain valve and shut off valve.

14.14 Fire Brigade inlet Connection:

A fire brigade inlet connection with a non-return valve shall be provided to facilitate the fire brigade to pump water into the installation by the use of their own equipment. Four way or 150 mm dia connection to the system shall comprise of four instantaneous pattern 63 mm dia. male inlets shall be with caps and chains complete with 150 mm dia. sluice valves, non-return valve housed in a M.S. cabinet with glass fronted door. The cabinet shall be suitable for recess mounting.

Two way or 100 mm fire brigade inlet connection to the system shall comprise of two instantaneous pattern 63 mm dia. male inlets shall be with caps and chains complete with 100 mm dia sluice valve, non-return valve housed in a M.S. cabinet with glass fronted door. The

cabinet shall be suitable for recess mounting.

14.15 System Drainage:

The systems shall be provided with suitable drainage arrangements with G.I. piping of 40 mm dia. complete with all accessories, and provided with 40 mm dia drain valve.

14.16 Valve Chambers:

A valve chamber shall be brick masonry chamber in cement mortar 1:5 (1 cement: 5 coarse sand) on cement concrete foundation 150 mm thick foundation 1:5:10 mix (1 cement : 5 fine sand : 10 graded stone aggregate 40 mm nominal size), 15 mm thick cement plaster inside and outside finished with a floating coat of neat cement inside with cast iron surface box approved by fire brigade including excavation, back filling, complete. The wall shall be 230 mm thick with heavy duty ISI marked C.I. manhole covers.

14.17 Pressure Gauge:

All pressure gauges shall be dial type with Borden tube element of SS 316. The dial size shall be of 150 mm diameter and scale division shall be in metric units marked clearly in black on a white dial. The range of pressure gauge shall be 0-10 kg.sq.mm. The pressure gauges shall be complete with isolation cock, syphon tubing, etc.

14.18 Pressure Switches:

The pressure switch shall be industrial type single pole double throw electric pressure switch designed for starting or stopping of equipment when the pressure in the system drops or exceeds pre set limits. It shall comprise of a single pole change over switch, below element assembly and differential spindle.

All pressure switches shall have ¼" BSP (F) inlet connection and screwed cable entry for fixing cable gland. All control cabling shall be provided.

15 SPRINKLER SYSTEM

15.1 The scope of work shall cover supply, installation testing and commissioning of the sprinkler system covering the following :

Sprinkler pumps, electric or diesel driven as shown in the equipment schedule.

Installation valve/s with motor-gong.

Sprinklers

Sprinkler piping

Branch flow switches connected to the building fire alarm system.

15.2 Standards

The sprinkler installation shall conform to and meet with the requirements set out by the following :

IS 1648 - 1961 Code of practice for fire Safety of buildings

Fire Insurance Association of India – Tariff Advisory Committee rules.

Local Fire Brigade and Fire Engineering Authorities

15.3 Pumps:

The sprinkler pump shall be single or double suction centrifugal type with split casing and direct driven by electric motor or diesel engine as specified. The pump rating and performance shall conform to the Equipment Schedule and meet the Tariff Advisory Committee duty requirements.

15.4 Pump casing shall be close-grained cast iron with bronze impeller. The shaft sleeve shall be brass or SS 304 and the trim shall be brass or bronze.

15.5 Pump shall be capable of delivering 150% of the rated capacity at 65% of the rated head and the no-delivery head shall be more than 140% of the rated delivery head. The pump casing shall withstand 1.5 times the no-delivery pressure or 2 times of the duty pressure whichever is higher.

15.6 The pump shall be either electrically driven or diesel driven with direct flexible coupling

15.7 The electric drive motor shall be squirrel cage induction conforming to BE 325-1978 and rated for continuous duty (S1). Motor shall have not less than class B insulation and minimum enclosure of IP22. The starter shall be air-cooled fully automatic star delta or autotransformer type. Starters shall conform to BE 8544 and rated for AC- 3 duty conditions.

15.8 Drive rating shall be based on the largest of the following:

1) Rated pump discharge at rated head

150% of rated discharge @ 65% of rated head

Maximum power absorbed by the pump in its Operating range i.e. no-delivery to free discharge.

15.9 The diesel engine shall be naturally aspirated (non- turbo charged) and electrically started. The engine shall have a speed governor to regulate the rated rpm within 5% of its rated speed. The engine shall be complete with starting batteries full-wave selenium rectifier charger, isolator, leads, mounting frame etc. Engineer rating shall be same as for the electric motors.

15.10 The sprinkler pump shall be complete with the following accessories :

1) Suction and discharge eccentric reducers.

2) Pump coupling guard.

3) Common base frame fabricated mild steel or cast iron.

15.11 Installation valve

The sprinkler system shall incorporate one or more (as shown on drawings) installation valve

assemblies comprising :

A mains gate valve

In and Out pressure gauge

Test connection of adequate size with valve and orifice plate with pressure connections.

Water meters and gongs with necessary piping, isolating valve and strainer and drain.

The installation valve shall be straight through type suitable for wet pipe sprinkler systems. Valves shall be of cast iron with gunmetal internals and suitable for vertical or horizontal installation. The valve clack shall be of cast gun metal with neoprene seal and retaining ring and shall incorporate a suitable non-return device to compensate for pressure fluctuations which should not mal-operate the clack. The gun metal internals shall provide for smooth waterways for :

1) Water valve through a retard chamber

2) Test connection and drain.

- 15.12 There shall be two pressure gauges, one for the main side and another for the installation side. Each gauge shall have pressure damping brass piping with gunmetal gauge and drain.
- 15.13 A test connection of adequate size as shown on drawings or as approved shall be provided with a shut-off gate valve, an orifice plates with pressure connections. The discharge from the test connection outlet shall be led to the nearest sump or drain as shown on drawings or as directed.
- 15.14 The mains water motor and going shall preferably be of cast gun metal body and internals. The valve shall have an associated gunmetal gate valve, strainer preceding the water motor. The water motor and gong shall be located on the discharge lead as shown in drawings or as directed.
- 15.15 Flow switches shall be as specified under 'Fire Hydrant System'
- 15.16 Sprinklers Head:
- 15.16.1 Sprinklers shall be thermo-sensitive glass-bulb actuated type and to be standard products from an established firm of repute and standing and approved by an appropriate authority for fire fighting duty. Sprinkler heads shall be pendent/recessed, pendent, concealed, or sideway type.
- 15.16.2 All sprinklers shall be brass castings polished chrome or white (polyester) unless stated otherwise and rated for 12.0 Kg/sq. cm WG and factory tested for 34.0 Kg/sq. cm. Sprinklers shall be pendant or sideway type as specified and shown on drawings. All sprinklers shall be provided with an adjustable escutcheon finished same as the sprinkler head. Wherever shown and specified, sprinklers shall be recessed type.
- 15.17 Temperature classification of sprinklers in each space shall be as shown on the drawings. Sprinklers shall be selected for the coverage shown on the drawings and ordinarily be 12/12

mm with K factor of 115 (metric). Wherever the specified sprinkler is not adequate, the Tenderer may offer appropriate size required.

15.18 Piping:

15.18.1 All piping shall be mild steel medium duty as specified under "Piping for Fire Fighting". Necessary line flushing valves shall be provided as shown on drawings or as required to.

15.19 Testing:

15.19.1 The entire sprinkler piping shall be tested, with the sprinklers in position, to a hydrostatic test pressure of 13.8 Kg/sq. cm for a period of 48 hours at the end of which there shall be no loss in pressure.

15.19.2 Test valves in each sprinkler installation shall be opened (with temporary drain connection) and the following observations recorded :

- 1) Start-up of sprinkler pump
- 2) Operation of water meter gong
- 3) Operation of Flow Switch in the appropriate branch.

All branches shall be so tested and witnesses and attested by the Engineer-in-charge. All the operating tests shall be carried out in the presence of any local authority, Fire Brigade or Insurance Company.

16.0 OPEN DRENCHER SYSTEM

16.1 The scope of work shall cover supply, installation testing and commissioning of the Drenchers system covering the following :

By Pass connection with valves from electric or diesel driven both main fire Pump as shown in Diagram.

Sluice Valve, Drain Valves at bottom of riser.

Drenchers

Drencher piping

16.2 Standards

The Drencher installation shall conform to and meet with the requirements set out by the following :

IS 1648 –1961 Code of practice for fire Safety of buildings

Fire Insurance Association of India - Tariff Advisory Committee rules.

Local Fire Brigade and Fire Engineering Authorities.

16.3 Source of water

The installation shall be connected to the existing Fire Hydrant pumps, with Sluice valve at

riser bottom & 50 mm (2") drain valve fully open between sluice valve & 1st drenchers.

- 16.4 Valve: The controlling valves shall be located in accessible positions. The Positions of each valve & the drenchers it controls must be clearly indicated by a well-written signboard. Painted in post office red paint.
- 16.5 Drencher Head:
- 16.5.1 Drenchers shall be standard products from an established firm of repute and standard and approved by an appropriate authority for fire fighting duty.
- 16.5.2 All Drenchers shall be brass castings polished chrome or white (polyester) unless stated otherwise and rated for 12.0 Kg/sq. cm WG and factory tested for 34.0 Kg/sq. cm. Drenchers shall be walls or Curtain Drenchers type as specified and shown on drawings.
- 16.5.3 Spacing of Drencher heads: Drenchers shall be placed with maximum horizontal spacing of 2.5 meters C/C.
- 16.5.4 Piping
All piping shall be mild steel medium duty as specified under "Piping for Fire Fighting". Necessary Valves & drain valves shall be provided as shown on drawings or as required to.
- 16.5.5 Operation: System shall be operated by the opening of main Sluice valve & closing of drain valve located at bottom of the riser.
- 16.5.6 Drainage: In open drencher system, the drain valve shall always be kept open except when the drenchers are in operation
- 16.5.7 Test Valve: A full way 50mm (2") dia. Valve and shall be provided below the controlling valves, so that the running pressure test can be carried out at any time.

17.0 PUMP PRESSURE DETAILS

- 17.1 The hydrant pump starting and stopping shall be tested by opening the test valve and record the following :

1) Jockey pump start/stop

System pressure at start Up : Kg/sq. cm.

Stop : Kg/sq. cm.

Time elapsed from start to Stop : Seconds

2) Hydrant Pump Start

System pressure at start up : Kg/sq. cm.

Maintained system pressure while discharging the landing valve at the highest point.

- a) Pump end : Kg/sq. cm
- b) Highest outlet : Kg/sq. cm.

17.2 All the operating tests shall be carried out in the presence of any local authority. Fire Brigade or Insurance Co.

18. TESTING OF THE HYDRANT SYSTEM:

- 18.1 All air shall be trapped from the pipeline through hydrants & air valves. Each section of the pipe shall be slowly filled with the water & allow to stand the water for few hours with the ends closed.
- 18.2 Flushing of underground connections: Underground mains and lead-in connections to system risers shall be flushed before connections made to piping in order remove foreign materials which may have entered the underground during the course of installation. For hydrant system the flushing operation shall be continued until water is clear.
- 18.3.3 Underground mains and lead-in connection shall be flushed at a flow rate of not less than 480 Ltrs. Per minute.
- 18.4 Provision shall be made for the disposal of water issuing from test outlets to avoid property damage.
- 18.5 Acceptance Test: At the time of taking over, the hydrant system shall fulfill the following acceptance tests:-
- 18.6 Starting up of the pressure suction (Jockey Pump): The pressure switch shall be set at (-)0.5 kg/cm² below Required Pressure at the lower limit and 0.0 kg/cm² at the upper limit. The system drain shall be opened to cause a drop in the pressure. The Jockey Pump shall start as soon as the pressure gauge needle falls down by (-) 0.5kg/cm². The Jockey pump shall also stop automatically when the system has been pressurised again upto set pressure 0.0kg/cm².
- 18.7 The main electrical pump shall be set to start by (-) 1.5 kg/cm² drop in pressure. An external hydrant valve using a single length of hose and branch pipe shall be fully opened to cause a drop of pressure in the system. At first, the jockey pump shall start when the pressure drops by (-) 0.5 Kg/cm². Further, drop in the pressure by (-) 1.5 Kg/cm² should be allowed to test automatic start-up of the electrical pump. The electrical pump shall continue to run atleast for 5 minutes and register rise in the pressure upto 0.0 Kg/cm² the Jockey Pump shall be automatically stop at this. The electrical pump shall be stopped manually by pressuring the stop button.
- 18.8 After having the system got fully charged at 0.0 kg/cm² the external hydrant valve using hose

and branch pipe at (ii) above shall be opened. When the pressure has dropped by (-) 1.5 Kg/cm², the electric main pump shall come into operation automatically. After the main pump has run for 5 minutes, the power supply in the pump house shall be switched off. The diesel pump shall automatically come into operation immediately.

- 18.9 All these tests mentioned above shall be repeated after one hour interval. The result of all the tests shall be identical again. After the system has satisfactorily withstood the above tests, it can be taken over from the contractor.

19.0 START-UP/SYSTEM TESTING:

- 19.1 It will be the responsibility of the Tendered to cause interim/stage inspection by the TAC/S.F.O during execution of the work as and when so called for by the Employer / Architect and shall carry out any rectification / modification as may be suggested by the Tariff Advisory Committee (TAC) / Chief Fire Officer (CFO).

- 19.2 Soon after the work is completed, the contractor shall inform the TAC/CFO in writing with a copy to the Architect / Employer for getting the complete system including all sub system and instrumentation, control etc. thoroughly inspected and tested for satisfactory performance. After satisfactory completion of tests of the systems by the TAC / CFO the contractor shall be required to submit in built drawings on tracing cloth to the Architect which have been so approved.

In addition to TAC, the contractor shall also be responsible for getting the system and equipment tested and approved by other Statutory Authorities like the Area Fire Officer or the State Fire Services as may be required.

20.0 COMMISSIONING OF SYSTEM:

- 20.1 Pressurised the fire hydrant system by running the main fire pump and after attaining the required pressure shut off the pump.
- 20.2 Open bye-pass valve and allow the pressure to drop in the system. Check that the jockey pump cuts-in and cuts-out at the pre-set pressure. If necessary adjust the pressure switch for the jockey pump. Close bye-pass valve.
- 20.3 Open bye-pass valve and allow the water to flow into the fire water tank in order to avoid wastage of water. The main fire pump should cut-in at the preset pressure and should not cut-out automatically on reaching the normal line pressure. The main fire pump should stop only by manual push button. However, the jockey pump should cut out as soon as the main pump starts.
- 20.4 Switch off the main fire pump and test check the diesel engine driven pump in the same manner

as the electrically driven pump.

- 20.5 When the fire pumps have been checked for satisfactory working on automatic controls, open fire hydrant simultaneously and allow the hose pipe to discharge water into the fire tank to avoid wastage. The electrically driven pump should run continuously for eight hours so that its performance can be checked.
- 20.6 Diesel engine driven pump should also be checked in the same manner as given in para above by running for 8 hours.
- 20.7 Check each Hydrant valve, male and female couplings and branch pipes for compatibility with each other. Any fitting which is found to be incompatible and does not fit into the other properly, shall be replaced by the Contractor. Yard Hydrant valves shall be checked by opening and closing under pressure.

21.0 HANDING OVER & APPROVAL FROM CFO:

- 21.1 All commissioning and testing shall be done by the Contractor to the complete satisfaction of the Engineer-in-Charge / Consultants, and the job handed over to the Client.
- 21.2 Contractor shall also hand over to the Client all maintenance and operation manuals and all items as per the terms of the contract.
- 21.3 Contractor shall obtain the final approval from the Local Chief Fire Officer for the entire system installed at site.

ACCEPTED MAKE OF FIRE FIGHTING SYSTEM:

NO.	LIST OF MATERIALS		NAME OF MANUFACTURER
1	Flow switches		1) Viking
			2) GEM
			3) MCDONOLDS
		YES	4) Switzer
		YES	5) Precision
2	DIESEL, Sprinkler, Hydrant, Booster pumps & Jockey pump	YES	1. H.B.D
			2. Grundfoss

NO.	LIST OF MATERIALS		NAME OF MANUFACTURER
3	Hydrant VALVES & BRANCH PIPES & FIRE EXTINGUISHERS	YES	1) Minimax
			2) SAFEX
			3) MONSHER
		YES	4) NEWAGE
4	Rubber lined hose reel	YES	1) Dunlop
			2) MONSHER
5	Canvas Hose	YES	1) FIRE MARSHAL
			2) MONSHER
			3) NEWAGE
6	G.I. / M.S. Pipes	YES	1) TATA
		YES	2) ZENITH
		YES	3) JINDAL
7	G.I. Fittings SCREWED	YES	1) ZOLOTO
			2) 'R' Marked
			3) Unik
8	Sluice Valve	YES	1) Kirloskar
			2) Indian Valve Co.
			3) H. Sarker.
9	C.I. LA Class Pipes & Fittings		1. NECO
			2. Kesoram
		YES	3. Electro Steel
10	Gate Valve GM	YES	1. Zoloto
			2. Leader
11	Butterfly Valves	YES	1) Audco India

NO.	LIST OF MATERIALS		NAME OF MANUFACTURER
			2) Lehary Valve
		YES	3) DANFOSS
12	Sprinkler Heads	YES	1. TAYCO
		YES	2. H.D.
13	INSTALLATION VALVE (ALARM GONG)	YES	1. H.D.
			2. VIKING
14	BRASS BALL VALVE	YES	1. HONEYWELL
		YES	2. Zoloto
			3 RB
15	DRENCHER NOZZLES	YES	1. TAYCO
		YES	2. H.D.

6.0 PLUMBING WORKS SYSTEM

6.1 WATER SUPPLY SYSTEM

CODES AND STANDARDS

Unless specifically mentioned otherwise, all the applicable codes and standards published by the Bureau of Indian Standards and their subsequent revision shall govern in respect of design, workmanship, quality and properties of materials and method of testing.

IS 10446 – 1983	Glossary of terms relating to water supply and sanitation.
IS 7558-1974	Code of practice for domestic hot water piping installations
IS 2692-1989	Specification for Ferrules For Water Services.
IS 1239	Mild steel tubular and other wrought steel pipes and fittings (Part-I)
IS 1239	Mild steel tubular and other wrought steel pipes and fittings (Part-II)

IS 779 -1978	Specifications for Water Meters - Domestic Type
IS 2104 – 1981	Specification for water meter boxes (Domestic type).
IS 2401–1973	Code of practice for selection, installation, and maintenance of domestic water meters.
IS 7413-1981	Insulation Material
IS 2065 –1983	Code of practice for Water Supply In Buildings (Second Revision)
IS 778- 1984	Specifications for copper alloy Gate, Globe And Check Valves for water supply purposes.
IS 1703 – 1977	Specification for ball valves (horizontal plunger type)including floats for water supply purposes.
IS 3004 – 1979	Specification for plug cocks for water supply purposes.
IS 3950 – 1979	Specifications for surface boxes for sluice valves.
IS 9338 – 1984	Specification for cast iron screw-down stop valves and stop and check valves for water works.
IS 4346 – 1982	Specification for washers for use with fittings for water

The material supplied shall comply with the latest applicable Indian and / or British Standards. Other National Standards are acceptable, if they are established to be equal or superior.

Following codes and standards are made part of this specification:

Table 7: Codes for Plumbing Works

	services.
IS 5219 – Part 1	Specification for cast copper alloy traps – Part1 1982
IS 5312 – part 1	Specification for swing check type reflux (Non-return) 1969 valve for water works purposes part 1 single door pattern
IS 13049 – 1919	Diaphragm type (plastic body) float operated valve for cold water services – specification.
IS 13114 – 1991	Forged brass gate, globe and check valves for water works purposes – specification.
IS 14399 – part 1	Hot press moulded thermosetting glass fibre reinforced & Part 1 – 1996 polyester (GRP) resin sectional water storage tanks.
IS 310 –1965	Code of Practice for Water Supply

SP –35	Handbook of water supply and drainage (with special emphasis on plumbing)
IS 1172-1983	Code of Basic Requirement For Water Supply, Drainage & Sanitation (Third Revision)
IS 12183	Code of practice for Plumbing In Multi- Storey buildings Part I) – 1987 (Part 1 water supply)
IS 1200 - 1992	Method of Measurement Of Building And Civil Engg. Works.(Part 1 earthwork)
IS 2379 –1963	Specification of colour code for the identification of pipes.
SP 7 – 1983	National building code of India (Part IX – Plumbing services)
IS 2401 – 1973	Code of practice for selection, Installation and maintenance of domestic water meters.
IS 780-1984	Specification for Sluice valves for water works purposes (50 to 300mm size) (Sixth Revision)
	The Contractor shall comply with the water requirement, water supply lines and sewer lines as per the following manuals and Standards.
CPHEEO	Manual on water supply and treatment
CPHEEO	Manual on sewerage and sewage treatment

All the requirements must be in accordance with the statutory / authorities requirements.

6.2 SANITARY AND SEWERAGE SYSTEMS

CODES AND STANDARDS

Unless specifically mentioned otherwise, all the applicable codes and standards published by the Bureau of Indian Standards and their subsequent revision shall govern in respect of design, workmanship, quality and properties of materials and method of testing.

Following [Table 8] are the standards and codes are made part of these specifications.

Table 8: Codes for Sanitary and Sewerage System

Codes	Description
IS 10446 – 1983	Glossary of terms relating to water supply and sanitation.
IS 11208 –1985	Guidelines for registration of Plumbers
IS 5382 – 1985	Specification for rubber sealing rings for gas mains, water mains and sewers.

SP – 35	Handbooks of water supply and drainage (with special emphasis on plumbing)
IS 1172-1983	Code of Basic Requirement For Water Supply, Drainage & Sanitation (Third Revision)
IS 1200 - 1992	Method of Measurement Of Building and Civil Engg. Works.(Part 1 earthwork)
IS 2379 –1963	Specification of colour code for the identification of pipes.
SP 7 – 1983	National building code of India (Part IX – Plumbing services)
IS 1742 – 1983	Code Of Practice For Building Drainage (Second Revision)
IS 301 – 1971	Code of practice for Building Drainage
IS12251- 1987	Code Of Practice For Drainage In Basement
BS 5572 -1978 (Amendment No.2)	Sanitary pipe Works
BS 4660- 1973 (Amendment No.1)	PVC Underground Drain Pipes & Fittings.
IS 5329 – 1983	Code of practice for sanitary pipe work above ground for buildings First Revision)
IS 2527 – 1984	Code of practice for fixing rain water gutters and down take pipes for roof drainage. (First Revision) I
IS 5961 – 1970	Specification for cast iron gratings for drainage purposes.
IS 2527 – 1984	Code of practice for fixing rain water gutters and down take pipes for roof drainage. (First Revision)
CPHEEO	Manual on sewerage and sewage treatment
IS 1626 (Part 1)	Specification for asbestos cement building pipes and pipe – 1980 fittings, gutter and gutter fittings, and roof fittings

1.0 WATER SUPPLY

1.1.1 MATERIALS:

The pipes shall be galvanized mild steel 'C' class Factory welded pipes and seamless, screwed and socket tubes conforming to the requirement of IS 1239-1964 for Heavy grade. They shall be of the dia. (nominal bore) specified in the description of the item. The sockets shall be designated by the respective nominal bores of the pipes for which they are intended.

The pipes and sockets shall be clearly finished, well galvanized in and out and free from cracks, surface flows, laminations and other defects. All screw threads shall be clean and well cut. The ends shall be cut cleanly and square with axis of the tube.

All screw tubes & sockets shall have pipe threads conforming to the requirements of IS: 544-1955 (or revised) screwed tubes shall have threads while the sockets shall have parallel threads.

1.1.2 PIPE FITTINGS:

The fitting shall be of malleable cast iron or MS. tubes complying with all the appropriate requirements given in para 1.1.1 or as specified the fittings shall be designated by the respective nominal bore of the pipes for which they are intended.

The fittings shall have screw threads at the ends conforming to the requirements of IS: 544-1955(or revised). Female threads on fitting shall be parallel & male threads (except on running nipples & collars of unions) shall be taper.

1.1.3 CUTTING, LAYING & JOINTING:

The pipes & fittings shall be inspected at site before use to ascertain that they confirm the specification given in para 1.1.1 above. The defective pipes shall be rejected. Where the pipes have to be cut or rethreaded, the ends shall be carefully filed out so that no obstruction to bore is offered. The end of the pipes shall then be threaded conforming to the requirements of IS544-1955 with pipe dies & taps carefully in such a manner as will not result in slackness of joints when the two pieces are screwed together. The taps & dies shall be used only for straightening screw threads which have become bent or damaged & shall not be used for turning of the threads so as to make them slack, as the latter procedure may not result in water tight joint. The screw threads of pipes & fittings shall be protected from damage until they are fitted.

The pipes shall be cleaned & cleared of all foreign matter before being laid. In jointing the pipes, the inside of the socket & the screwed end of the pipes shall be oiled & rubbed over with white lead & a few turns of spun yarn wrapped round the screwed end of the

pipe. The end shall then be screwed in the socket, Care should be taken that all pipes & fitting are properly jointed so as to make the joints completely water tight & pipes are kept at all time free from dust & dirt during the fixing. Burr from the joint shall be removed after laying the open ends of the pipes shall be temporarily plugged to prevent access of water, solid or any other foreign matter. Any threads exposed after jointing shall be painted or in the case of under ground piping thickly coated with approved anticorrosive paint to prevent corrosion.

1.1.4 INTERNAL WORK:

For internal work the galvanized iron pipes & fittings shall run on the surface of the walls or ceiling unless otherwise specified. The fixing shall be done by means of standard pattern holder bat clamps, keeping the pipes about 1.5 cm clear of the wall. When it is found necessary to conceal the pipes chasing may be adopted or pipes fixed in the ducts or recess etc. provided there is sufficient space to work on the pipes with standard tools. The pipes shall not be ordinarily be buried in walls or solid floors, where unavoidable pipes may be buried for short distance provided adequate protection is given against damage & where so required joints are not to be buried. Where directed by the Engineer-in-charge, a MS. tube sleeve shall be fixed at a place a pipe is passing through a wall or floor for reception of the pipe & allow freedom for expansion & contraction & other movements. In case the pipe is embedded in walls or floors it should be covered with hessian cloth dipped in coal tar / Japan black (for cold water pipes) and heat insulation to be provided for hot water pipes as per specification. The pipe should not come in contact with lime mortar or lime concrete as the pipe is affected by lime. Under the floors the pipe shall be laid in layer of sand filling done over concrete floors.

All pipes & fittings shall be fixed truly vertical & horizontal unless unavoidable. The pipes shall be fixed to walls with standard pattern holder bat clamps of required shapes & size so as to fit tightly on the pipes when tightened with screwed bolts.

These clamps shall be embedded in brickwork in cement mortar 1:3 (1 cement: 3 coarse sand) & shall be spaced at regular intervals in straight lengths as shown in the table given below.

Concrete walls / floors at no time shall be chiseled out or reinforcement exposed to lay the pipes. The contractor shall use masonry drill to drill the hole and use anchor bolts to fix the pipe.

	LENGTHS	
SIZE OF PIPE Mm.	HORIZONTAL RUNS Meters	VERTICAL RUNS meters
15	2	2.5
20	2.5	3
25	2.5	3
32	2.5	3
40	3	3.5
50	3	3.5
65	3.5	5
75	3.5	5

The clamps shall be fixed at shorter lengths near the fittings as directed by the Engineer-in-charge. for G.I. pipes 15mm to 25 mm dia. the holes in the walls & floors shall be made by drilling drill bits & not by dismantling the brickwork on concrete. However, for bigger dimension pipes the holes shall be carefully made of the smallest size as directed by the Engineer-in-charge. After fixing the pipes the holes shall be made good with cement mortar 1:3 (1 cement: 3 coarse sand) & properly finished to match the adjacent surface.

1.1.5 EXTERNAL WORK:

The galvanized iron pipes & fittings shall be laid in trenches. The widths & depths of the trenches for different diameters of the pipes shall be as in the table given below:

DIA. OF PIPE	WIDTH OF TRENCH	DEPTH OF TRENCH
15 mm TO 50 mm	300 mm	60 cm
65 mm TO 100 mm	450 mm	75 cm
150 mm TO 300 mm	600 mm	100 cm

At joints the trench width shall be widened wherever necessary. The work of excavation & refilling shall be done true to line & gradient.

The pipes shall be painted with two coats of Anti-corrosive bitumastic paint of approved

quality. The pipe shall be laid on a layer of 7.5 cm sand & filled upto 15 cm above the pipes. The remaining portion of the trench shall then be filled with excavated earth. The surplus earth shall be disposed off as directed.

In case of bigger diameter (65mm & above) pipes where the pressure is very high thrust blocks of cement concrete 1:2:4: (1 cement: 2 coarse sand: 4 grade stone aggregate of 20 mm nominal size) shall be constructed on all bends to transmit the hydraulic thrust without impairing the ground & spreading it over a sufficient area.

1.1.6 TESTING THE JOINTS:

After jointing, the pipes & the fittings shall be inspected under working conditions of pressure & flow. Any joint found leaking shall be redone & all leaking pipe removed & replaced without extra cost.

The pipe & fittings after they are laid shall be tested to hydraulic pressure of 6 Kg/cm² (60 meter) The pipes shall be slowly & carefully charged with water allowing all air to escape & avoiding all shocks of water hammer. The draw of taps & stopcocks shall then be closed & specified hydraulic pressure shall be applicable gradually. Pressure gauge must be accurate & preferably should have been recalibrated before the test. The test pump having been stopped the test pressure should be maintained without loss for at least half an hour. The pipes & fitting shall be tested in section as the work of laying proceeds, keeping the joints exposed for inspection during the testing.

- 1.1.7 MEASUREMENTS: The lengths shall be measured in running meters correct to a cm. For the finished work, which shall include G.I. pipes & G.I. fittings such as bends, tees, elbows, reducers, crosses, plugs, sockets, nipples & nuts, but excludes brass or gun metal taps (cocks), valves, lead Connection pipes & shower rose. The measurements shall be taken separately for internal & external work. The length shall be taken along the central line of the pipe & fittings. All pipes & fittings shall be classified according to their diameters, method of jointing & fixing substance, quality & finish. The diameter shall be the nominal diameter of the internal bore. The pipes shall be described as including all cuttings & waste. In case of fittings of unequal bore, the largest bore shall be measured.

INTERNAL WORK: The rate for internal work shall include the cost of labour & material involved in all the operations described above except in para 1.1.5 unless otherwise specified. The rate shall include the cost of cutting holes in walls & floors & making good the same. This shall not however include concealed pipe work.

- 1.1.7a GI PIPES & FITTINGS: The pipes shall be of the class specified in the Schedule of Quantities & shall be of galvanized steel, welded or seamless, screwed & socketed shall conform to IS: 1239. & they shall be manufactured by a firm of repute. All fittings shall be malleable iron galvanized fittings of approved best Indian make. The detail of the pipes regarding nominal bore thickness & weight are given below:

APP. OUT SIDE DIA.	NOMINAL BORE		SCREWED & SOCKETED Wt/Mtr		SCREWED & SOCKETED METERS / 1000 KG.			
	MM	NEAREST inch	LIGHT Kg.	MEDIUM Kg.	HEAVY Kg.	HEAVY Kg.	MEDIUM Kg.	LIGHT Kg.
10.2	6	1/8	0.364	0.41	0.496	2747	2439	2016
13.5	8	¼	0.521	0.65	0.773	1919	1529	1294
17.2	10	3/8	0.680	0.85	1.030	1470	1166	971
17.3	15	½	0.961	1.23	1.460	1040	813	685
26.9	20	¾	1.42	1.59	1.910	704	629	524
33.7	25	1	2.03	2.46	2.990	493	407	334
42.4	32	1 ¼	2.61	3.17	3.870	383	316	258
48.3	40	1 ½	3.21	3.65	4.470	304	274	224
60.3	50	2	4.18	5.17	6.240	239	193	160
76.1	65	2 ½	5.92	6.63	8.020	169	151	125
88.1	75	3	6.98	8.64	10.300	143	116	98

APP. OUT SIDE DIA.	NOMINAL BORE		SCREWED & SOCKETED Wt/Mtr		SCREWED & SOCKETED METERS / 1000 KG.			
	MM	NEAREST inch	LIGHT Kg.	MEDIUM Kg.	HEAVY Kg.	HEAVY Kg.	MEDIUM Kg.	LIGHT Kg.
101.6	90	3 ½	8.92	9.90	11.800	112	101	84.6
114.3	100	4	10.2	12.40	14.700	98	80.6	68
139.7	125	5	-	16.70	18.300	-	59.9	54.6
165.1	150	6	-	19.80	21.800	-	50.5	45.9

NOTE: The above weights are for black pipes & theoretical weights of galvanized pipes are 6% higher.

1.1.7b WATER PRESSURE MAINS: Shall be conform to IS: 1536-11967 Class L A as specified in the schedule. They shall be laid, jointed & tested along with the C.I pipes as described in the specification for C.I.S/S pipes.

1.1.7c FLANGED PRESSURE MAINS: Flanged joints to be made by painting the face of the flanged with red lead freely & bolting up evenly on all sides.

A thin fiber of lead wool shall be used in making the joints water tight where facing of the pipes is not true.

Where packing may be used, it shall be of rubber insertion cloth three ply & of approved thickness. The packing should be of full diameter of the flange with proper pipe hole & bolthole, neat & even at both the inner & outer edges.

Where the flange is not fully faced, the packing may be of the dimension of the facing strip only. Its proper placing should be tested before another pipe is jointed on.

TESTING: After each section of the pipeline has been completed it shall be tested for water tightness before being covered in. This can be done by closing by means of a valve, blank flange, cap or plug & fill the pipe with water. The pressure should be raised by means of a small hand operated pump till it registers 50% above the highest working pressure in the section & the test pressure should be ascertained by means of a reliable gauge. When the pipe is laid on any appreciable gradient, the test should be carried out at the lower end of the section. Any leaking joints should be made good & the above test reapplied until no further leaks are apparent.

1.1.8 EXTERNAL WORK:

The rate for external work shall include the cost of labour & materials in all the operations described above except in para 1.1.4. The rate shall include excavation trenches, painting of pipes & sand filling all around the pipes, unless specified otherwise, for which separate payment shall be made.

1.2 Making connection of GI Distribution Branch with GI Main:

1.2.1 Materials – Pipes & Fittings-para 1.1.1 & 1.1.2 shall apply

1.2.2 Preliminary work - A pit of suitable dimensions shall be dug at the point where the connection is to be made with the main & earth removed up to 15cm below the main. The flow of water in the water main shall also be disconnected by closing the sluice wheel valves on the mains.

1.2.3 Making connections - For cutting & jointing para 1.1.3 shall apply. The G.I main shall be cut. Water if any collected in the pit shall be bailed out & ends of the G.I. pipe threaded. The connection of distribution pipe shall then be made by fixing malleable G.I. Tee of the required size & fitting such jam nuts, G.I. sockets, connecting piece etc.

1.2.4 Testing of joints - Para 1.1.6 shall apply.

1.2.5 The portion of the pipe in the pit shall be painted with bitumastic paint & encased with sand 15cm allround. Pit shall be filled with earth in level with original ground surface watered, rammed & the area dressed.

1.2.6 Measurements – The work of making connections to kitchen & laundry equipment's should be counted in numbers.

1.2.7 Rate – the rate shall include the cost of labour & materials involved in all the operation described above.

1.3 Fixing water meter & stop cock in G.I. Pipe line:

1.3.1 Materials – Pipes & fittings – para 1.1.2 shall apply.

1.3.2 CUTTING G.I. PIPE LINE: The G.I. line shall be cut to the required length at the position where the meter & stopcocks are required to be fixed. The ends of the pipe shall then be threaded. For cutting & threading the pipe, para 1.1.3 shall apply.

Fixing meters & stop cock: The meter & stopcock shall be fixed in position by connection pipes, GI Jam nut, & socket etc. The stopcock shall be fixed near the inlet of the water meter. The paper disc inserted in the nipples of the meter shall be Removed & the meter installed exactly horizontal or vertical in the flow line in the direction shown by the arrow cast on the body of the meter. Care shall be taken that the factory seal of the meter is not disturbed. Wherever the meter shall be fixed to a newly fitted pipeline, the pipeline shall have to be completely washed before fitting the meter. For this purpose a piece of pipe equal to the length of the meter shall be fitted in the proposed position of the meter in the new pipeline. The water shall be allowed to flow completely to wash the pipeline & then the meter installed as described above by replacing the connecting piece.

Testing of joints:

Testing of joints shall be done as described in para 1.1.6.

Measurements: The work of fixing meter & stopcocks shall be counted in numbers separately according to the diameters.

1.4 FITTINGS:

General - The brass or gunmetal fittings shall be heavy quality & approved manufacture & pattern with screwed or flanged ends as specified. The fittings shall in all respects comply with the Indian standard Specifications NO.IS>778-1957 & IS.781- 1959. The standard size of brass gunmetal fittings shall be designated by the nominal bore of the pipe outlet to which the fittings are attached. A sample of each kind of fittings shall be got approved from the Engineer-in-charge & all supplies made according to the approved samples.

1.4.1 All cast fittings shall be sound & free from laps, blowhole's holes & fittings; both internal & external surfaces shall be clean, smooth & free from sand etc. Burning plugging, stopping or patching of the casting shall not be permissible. The bonnets, spindles & other parts shall be truly machined so that when assembles the parts shall be axial, parallel & cylindrical with

surface smoothly finished.

The area of the waterway of the fittings shall not be less than the area of nominal. The fittings shall be fully examined & cleared of all foreign matter before being fixed. The fittings shall be fixed in the line in a workman like manner. The joints between fittings & pipes shall be made leak proof. The joints & fittings shall be leak proof when tested to a pressure of 7KG/SQ.CM as described in para 1.1.6 & the defective fittings & joints shall be replaced or redone.

1.4.2 BRASS BIB COCK & STOP COCK:

A bibcock (bib tap) is a draw off tap with a horizontal inlet & free outlet & stopcock (stop tap) is a valve with a suitable means of connections for insertion in a pipeline for controlling or stopping the flow. They shall be specified size & shall be of screw down type. The closing device should work by means of a disc carrying a renewable non-metallic washer, which shuts against water pressure on seating at right angles to the threaded spindle, which operates it. The handle shall be either crutch or butterfly type securely fixed to the spindle. Valve shall be of the loose leather seated pattern. The cocks taps) shall open in anti-clockwise direction. The bibcocks & stopcock shall be polished brass. The minimum finished weights of the bib tap (cock) & stop tap (cock) as given in the IS.

SIZE	MINIUM FINIEHED WEIGHT	
	BIB TAP	STOP TAP
Mm	Kg.	Kg.
8	0.25	0.25
10	0.30	0.35
15	0.40	0.40
20	0.75	0.75

When the bib cocks or stop cocks are required to be chromium plated, the chromium plating shall be of grade B type conforming to IS: 1068-1958. The chromium shall never be deposited on brass unless coating of nickel is interposed. In case these are required to be nickel plated, the plating shall be of first quality with a good thick deposit of silvery whiteness capable of taking high polish which will not easily tarnish or scale. In finished & appearance, the plated

articles, when inspected shall be free from plating defect such as blisters, pits, roughness & unplated areas & shall not be stained or discoloured. Before a plate is plated the washer plate shall be removed from the fittings. The gland packing shall be protected from the plating solution.

Gun metal bibcocks & stopcock: These shall be of gunmetal screw down pattern of the size as specified. So far as the general requirements of materials are concerned, these shall be similar to those as described in para 1.5.2. The weight of these shall be the same as for brass bibcocks & as described in para 1.5.2.

1.5 BRASS FULL WAY VALVE:

Full way valve is a valve with suitable means of connection for insertion in pipeline for controlling or stopping the flow. The valve shall be of brass fitted with a cast iron wheel & shall be of gate valve type opening full way of the size as specified. Valve shall be of best quality as approved by the Engineer-in-charge & shall have the following approximate weight with a tolerance of 5%

Mm	Flanged ends Kg	Screwed ends Kg
15	1.021 (Provisional)	0.567(Provisional)
20	1.503 („)	0.680(„)
24	2.645 („)	1.077(„)
32	3.232 („)	1.559(„)
40	4.082 („)	2.268(„)
50	6.691 („)	3.232(„)
65	10.149 („)	6.804(„)
75	13.381 („)	8.845(„)

1.6 GUN METAL FULL WAY VALVE WITH WHEEL:

These shall be of the Gunmetal fitted with wheel & shall be of Gate valve type opening full way & of the size as specified. These shall generally conform to IS.778-1957 their approximate weights shall be given in para 1.5.1.

Ball valve: The ball valve shall be of high-pressure class & shall be of sizes as specified. The nominal size of a ball valve shall be that corresponding to the size of the pipe to which it is fixed. The ball shall be of brass or Gun metal as specified, & the float of copper sheet. The minimum gauge of copper sheet used for making the float shall be 45 for float upto 115mm dia. & 55 for float exceeding 115mm dia. This shall be spherical in shape. The jointing of the float shall be made by efficiently burnished, lapped & soldered seam or by bracing. Plastic float may also be used if specified. The body of ball valve when assembled in working conditions with the float immersed to not more than half of its volume shall remain closed against a test pressure of 10.5Kg/sq. Cm. & low pressure shall against a test pressure of 3.5Kg/sq. cm.

The ball valve shall generally conform to ISI Specifications No 1703-1962. The weight of ball cock & the size of ball shall be as per table given below.

1.7 CAST IRON & SPUN IRON PIPES & FITTINGS:

1.7.1 MATERIALS:

Pipes & specials: The cast iron pipes shall conform to ISI 1537-1960 while spun iron pipes shall conform to IS 1536- 1960. They shall be either with spigot & socket ends or flanged ends. The cast iron pipes shall be vertically either class A or B as specified. The spun iron pipes shall be of the cast iron casted centrifugally & shall be of class A, B as specified in the item. These pipes & specials Shall be used for water pressure upto half of the hydraulic test pressure of various pipes as given below:

<u>HYDRAULIC TEST PRESSURE FOR VERTICALLY CAST IRON PIPES:</u>				
Nominal dia.	Test Pressure in Kg/sq. cm (meter head)			
	Socket & spigot pipes		Flanged Pipes	
	Class A	Class B	Class A	Class B
Upto & including 300 mm.	20(200)	25(250)	20(200)	25(250)
Over 300 mm to 600 mm.	20(200)	25(250)	20(200)	25(250)

<u>HYDRAULIC TEST PRESSURE FOR CENTRIFUGALLY CAST IRON PIPES:</u>					
Nominal dia.	Test Pressure in Kg/sq. cm (meter head)				
	Socket & spigot pipes			Flanged Pipes	
	Class LA	Class A	Class B	Class A	Class B

Upto & including 300 mm.	20(200)	25(250)	30(300)	20(200)	25(250)
Over 300 mm to 600 mm.	20(200)	25(250)	30(300)	--	--

Specials: The specials shall conform to IS. 1538-1960 & shall be of medium or heavy class depending on their thickness. The hydraulic test pressure of each class shall be as follows:

Nominal dia.	Test Pressure in Kg/sq. cm (meter head)			
	Specials without branches or with branches. Not greater than half the principal diameter.		Specials with branches greater than half the principal diameter.	
	Medium	Heavy	Medium	Heavy
Up to & including 300 mm.	20(200)	25(250)	20(200)	20(200)
Over 300 mm to 600 mm.	15(150)	20(200)	15(150)	20(200)

All the cast iron pipes shall be capable of easily working a drill or file. Pipes & specials should be sound with smooth inner & outer surface, neatly dressed & carefully fitted free from laps Pinholes, & other imperfections & shall ring clearly when struck with a light hammer. The end of the pipes & the specials shall be reasonably square to their axis.

All pipes & specials before they are affected by rust shall have been coated with approved anti-corrosive treatment or by heating & dipping in Dr. Agnus Smith's solution at the factory.

1.7.1 Stacking:

The pipes & specials shall be handled with sufficient care to avoid damage to them. These shall be lined up on one side of the alignment of the trench, socket facing uphill or in the direction of flow of water.

1.7.2 Trenches for C.I. Pipes & Specials:

The trenches for pipes shall be excavated to lines & levels as directed. The bed of the trench

shall have to be truly & evenly dressed throughout from one change of grade to the next. The gradient is to be set out by means of bending rods & the required depth of excavated at any point to the trench shall be regarded as directed by the Engineer-in-Charge. The depth of the trench shall not be less than meter measured from the top of the pipe to the surface of the ground under road & not less than 0.75m elsewhere. The bed of trench, if soft or made up of earth, shall be well watered and rammed before laying the pipes & the depressions if any shall be properly filled with earth & consolidated. If the rock is met with, it shall be removed to 15 cm. below the level of the pipe & the trench will be refilled with excavated materials & consolidated. The excavated materials shall not be stacked within meter or half of the trench width whichever is greater from edge of the trench. The materials excavated shall be separated & stacked so that in refilling they may be re-laid & compacted in the same order to the satisfaction of the Engineer-in-charge. The trench shall be kept free from water. Shoring & timbering shall be provided wherever required. Excavation below water table shall be done after dewatering the trenches.

After the excavation of the trench is completed, hollows shall be cut at the required positions to receive the socket of the pipes & these hollows shall be sufficient depth to ensure that the barrels of the pipes shall rest throughout their entire length on the solid ground & that sufficient space left for jointing the underside of the pipe joint. These socket holes shall be refilled with sand after jointing the pipe where the pipe line or drain crosses an existing road, the road crossing shall be excavated at a time, the second half being commenced after the pipes have been laid in the first half & the trench refilled. Necessary safety measure for traffic as directed shall be adopted. All types of pipes, water mains, cables, etc. met within the course of excavation shall be carefully protected & supported. Care shall be taken not to disturb the electrical & communication cable removal of which if necessary shall be arranged by the Engineer-in-charge.

1.7.3 LAYING OF PIPES & SPECIALS:

Before being laid the pipes shall be examined to see that there are no cracks or defects as described in para 1.7.1.1 above. Subjected to the approval of the Engineer-in-charge, the damaged portion of the cracked pipe may be cut at a point not less than 15 cm. beyond the visible extremity of the crack. The pipes shall be thoroughly cleaned of all dust & dirt & special care shall be taken to clean the inside of the socket & outside of the spigots.

The pipes shall be lowered into the trench by means of suitable pulley blocks, sheer ropes

etc. In no case the pipes shall be rolled & dropped into the trench. After lowering the pipes shall be arranged so that the spigot of one pipes shall be carefully centered into the socket of the next pipe & pushed to the full distance that it can go. The pipe shall be laid to the levels required. Specials shall also be laid in their proper positions as stated above.

Where so directed, the pipes & specials may be laid on masonry or concrete pillars. The pipe laid on the level ground shall be laid with socket facing the direction of water. In all other cases, the socket shall be laid facing up hill.

Any deviation either in plan or elevation less than 11% shall be effected by laying the straight pipes round a flat curve, of such radius that minimum thickness of lead at the face of the socket shall not be reduced below 6mm or the opening between spigot & socket increased beyond 12mm at any point. A deviation of about 2% can be effected at each joint in this way. At end of each days work, the last pipe laid shall have its open last ends securely closed with a wooden plug to prevent entry of water, soil, rats and any other foreign matter into the pipe.

Cement concrete thrust blocks of suitable design as approval by the Engineer-in-charge shall be provided at 45 & 90 deg. bends of the pipes & also at places where there is likelihood of thrust so as to withstand the dynamic & static forces developed due to water in the pipe line. The thrust blocks shall be made after the joints have been tyton.

1.7.4 TYTON JOINTS:

This type of joint is generally done in providing joints in water lines.

1.7.5 Refilling of excavated earth in trenches:

The excavated earth shall be spread in the layer of 250mm. thickness and shall be compacted by proper watering. This filling shall be done such that the joints remain completely open for working. Rest of the filling shall be done in the manner after the line is satisfactorily tested. The excavated material such as brickbats, asphalt's cracks, shall be properly arranged in the top most layer of 23cm & shall be consolidated thoroughly. The excess material shall be spread over the surrounding ground in the radius of 50M from the point of excavation. If extra earth for complete filling will be necessary, same shall be brought from other places by the contractor at his full cost, & the same shall be filled up into the trench as per the manner shown above.

1.8.1 SLUICE VALVE:

Sluice valves: The sluice valves are used in a pipeline for controlling or stopping flow of water. These shall be specified of size and class and shall be of non-rising screwed type with either double flange or double socket ends & cap or hand wheel. These shall, in all respects, comply with the Indian standard specifications IS.780-1963 for valves upto & including 300mm. size. Classes 1 sluice valve is used for maximum working pressure of 10Kg/cm (100 meter head) & Class 2 sluice valve for 15Kg/cm (150 meter head).

The body, domes, covers, wedge gate stuffing box shall be of good quality cast iron, the spindle of bronze, and the nut & valve seats leaded tin bronze. The bodies spindle & other parts shall be truly machined with surface smoothly finished. The area of the water way of the fittings shall be not less than the area equal to the nominal bore of the pipe.

The valves shall be marked with an arrow to show the direction of turn for closing of the valve.

The valve shall be fully examined & cleared of all foreign matter before being fixed. The fixing of the valve shall be done by means of bolts, nuts & 3mm rubber insertion of chemically treated compressed fibber board 1.5mm minimum thickness & of weight less than 0.183 gm/sq. cm. with flanges of spigot & socketed tail pieces drilled to the same specification in case of S & S pipes & with flanges in case of flanged pipes. The tail pieces shall conform to IS. 1938-1960. These shall be jointed to the pipeline by means of lead caulked joints.

1.8.2 Fire Hydrant:

The hydrants shall be of spindle type with 65-mm outlet combined with sluice valve unless otherwise specified. The hydrant shall conform to IS. 909 – 1958 & shall consist of the following components:

One sluice valve class 1 type conforms to IS 909-1963.

One duck foot band.

One 65 mm male coupling instantaneous Pattern &

One Cast iron cap permanently secured to the duck foot bend by means of a chain. Where the fire services requirement of coupling differs from the above, the requisite coupling shall be provided at no extra coat.

The body & cover shall be of good quality cast iron spindle & bronze & the nut & the valve seal of leaded in tin bronze. The bodies, spindles & other parts shall be truly machined with surface smoothly finished.

The hydrant shall be fully examined and cleared of all foreign matter before being fixed. The

fixing shall be done on the water main, which shall be on minimum 75mm dia. The flanged end of the hydrants shall be fixed to the flanged out let of a tee in the water main by means of bolts, nuts & 3mm rubber insertion of or chemically treated compressed fiber bore 1.5mm minimum thickness & of weight not less than 0.183 gm. Per sq. c.m. This can also be fixed by means of flanged tail piece, which may be connected to the water main by C.I. specials.

1.8.3 Appurtenances:- The other appurtenances of pipe line are mentioned below:-

Air Valves: These are placed at every summit in the pipe line to permit the escape of air when the main is filled, & afterwards if any air is carried into the mains. These are also placed on long stretches of nearly level main.

Scour Valves: These are placed at bottom of the all depressions of pipes for emptying the main or letting out the sediment.

Reflux Valves: These are fixed so as to open in the direction of flow but automatically to close if the water flows back. They are used to diminish the damage done by the escape of water due to a burst or to prevent damage to impellers of Pump.

Safety or Relief Valves: These are fixed at the down stream ends of long lengths of main or where water hammer may take so as to reduce from any excessive pressure to the nominal if it occurs.

1.8.4 Measurements: the valves, fire hydrants & tail pieces shall be enumerated separately unless other wise specified, under relevant items.

1.8.5 Rate: The rate shall include the cost of materials & labour, profit etc. involved in all the operations described above against relevant items of work.

1.9 MASONRY CHAMBERS:

1.9.1 General: All masonry chambers for stopcocks, sluice valves, fire hydrants & meter etc. shall be built as per supplied drawings.

1.9.2 Excavation: The excavation for chambers shall be done true to dimension & level indicated on plans or as directed by the Engineer-in-charge.

1.9.3 Bed concrete: This shall be of cement concrete 1:3:6 (1 cement : 3 fine sand : 6 graded stone aggregate 40 mm nominal size).

1.9.4 Brick work: This shall be in 2nd class bricks in cement mortar 1:5 (1 cement : 5 fine sand)

1.9.5 Plastering: Plastering not less than 12mm thick shall be done in cement mortar 1:3(1 cement : 3 coarse sand) finished with a floating coat of neat cement.

1.9.6 Surface Box: This shall be of cast iron, well made & free from casting & other defects. All sharp edges shall be removed & finished smooth. The clear dimensions for surface boxes for stop cocks sluice valves, fire hydrants, water meters, etc. shall be given in drawing.

C.I. surface boxes shall be coated with black bituminous composition except in the case of fire hydrants where the cover of the surface box shall be painted with two coats of rust resisting bright luminous yellow paint for clear visibility during night. The C.I. surface box shall be fixed on the top of the masonry chamber and provided with plain or reinforced cement concrete 1:2:4 (1 cement: 2 coarse sand: 4 graded stone aggregate 20mm nominal size.)

1.10. U-PVC WATER SUPPLY:

1.10.1 U-PVC THREADED PIPES:

The pipes shall Schedule 120 U-PVC Threaded pipes based on A.S.T.M.D. 1785 specifications & Tested for portability and other properties laid down in IS 4985-81 and IS 7834-75, They shall be of the dia. (Nominal bore) specified in the description of the item. The socket shall be designed by the representative nominal bores of the pipes for which they are intended.

The pipes & sockets shall be clearly finished & free from cracks, surface flaws, & other defects, all screw threads shall be clean & well cut. The end shall be cut clearly & square with axis of the tube.

All screw tubes & sockets shall have pipe threads. Conforming to the requirements of I.S. 544 - 1955 (or Revised) Tubes shall have tapering Threads while the sockets shall have parallel threads.

1.10.2 PIPE FITTINGS:

The fitting shall be of U-PVC High pressure schedule 80 type conforming to the requirement of ASTM D - 2464 threaded U-PVC plastic pipe fitting sch. 80 to IS 554 for thread dimension with a pressure rating of over 16 bar complying with all the appropriate requirements as specified. The fittings shall be designated by the respective nominal bore of the pipes for which they are intended.

The fittings shall have screw threads at the ends conforming to the requirements of IS:544-1955(or revised). Female threads on fitting shall be parallel & male threads (except on running nipples & collars of unions) shall be taper.

1.10.3 CUTTING, LAYING & JOINTING:

The pipes & fittings shall be inspected at site before use to ascertain that they conform the specification given in para 1.1.7 above. The defective pipes shall be rejected. Where the pipes have to be cut or rethreaded, ensure square cut of pipe ends. The ends shall be carefully chamfered with file so that no obstruction to bore is offered. The proper size wooden plug in the end of the pipes shall be inserted then be threaded conforming to the requirements of IS544-1955 with pipe dies & taps carefully in such a manner as will not result in slackness of joints when the two pieces are screwed together. The sharp edges of gripping vice & other handling tools should be muffled with a suitable packing to prevent damage of pipe surface. Non metallic tools should be used for jointing preferably. The taps & dies shall be used only for straightening screw threads which have become bend or damaged & shall not be used for turning of the threads so as to make them slack, as the later procedure may not result in water tight joint.

The screw threads of pipes & fittings shall be protected from damage until they are fitted.

The pipes shall be cleaned & cleared of all foreign matter before being laid. In jointing the pipes, the screwed end of the pipes shall be covered with proper layer of Teflon Tape wrapped round the screwed end of the pipe. The joints shall be made with hand tightening of the fitting over the pipe & one or two turn over. Hand tightened joint shall then be screwed in the socket, Care should be taken that all pipes & fitting are properly jointed so as to make the joints completely water tight & pipes are kept at all time free from dust & dirt during the fixing. Burr from the joint shall be removed after laying, the open ends of the pipes shall be temporarily plugged to prevent access of water, solid or any other foreign matter.

In normal case pipe shall be buried to depth of 450 mm from crown of pipe. where external loading can be expected. The depth shall be 750 mm from crown of pipe crossing RCC Hume pipe or metallic pipe sleeve shall be provided for crossing The roads & driveways.

All exposed horizontal pipes shall be supported at a distance of approximate 800 mm & vertical pipes shall be supported at a distance of 1200 mm with appropriate clips to allow for movement of the pipes during change in temperature. For temperature above 40 D.C. distance for clips shall be 500 mm for horizontal pipe & 900 mm for vertical pipe. for sealing of joints best quality Teflon tape, or pipe joint sealing compound shall be used. Air release valve of $\frac{1}{4}$ th of main line diameter shall be provided at every sharp turn or at every 1000 feet interval in case of plain area. Only Readymade U-PVC fitting shall be used for turn, branch & tap connections. For tap connections standard service saddle shall be used. The pipes should not be subjected to rough handling, it is advisable that during transportation the height of the pipe stack shall not exceed 2 meters. For long time storage in racks the height

of the U-PVC pipes shall not exceed 1 Meter.

1.10.4 EXTERNAL WORK:

The U-PVC schedule 120 pipes & fittings shall be laid in trenches to a safe depth.

At joints the trenches width shall be widened wherever necessary. The work of excavation & refilling shall be done true to line & gradient.

The pipes shall be painted with two coats of Anti-corrosive bitumastic paint of approved quality. The pipe shall be laid on a layer of 7.5 cm sand & filled upto 15 cm above the pipes. The remaining portion of the trench shall then be filled with excavated earth. The surplus earth shall be disposed off as directed.

In case of bigger diameter (65mm & above) pipes where the pressure is very high thrust blocks of cement concrete 1:2:4: (1 cement: 2 coarse sand: 4 grade stone aggregate of 20 mm nominal size) shall be constructed on all bends to transmit the hydraulic thrust without impairing the ground and spreading it over a sufficient area.

- 1.10.5 TESTING THE JOINTS: After jointing, the pipes & the fittings shall be inspected under working conditions of pressure & flow. Any joint found leaking shall be redone & all leaking pipe removed & replaced without extra cost.

DIMENSIONS/WORKING PRESSURE FOR U-PVC HIGH PRESSURE THREADED PIPES AS PER ASTM-D-1785 (THREADED AS PER IS-554)

NOMINAL BORE	OUTSIDE DIAMETER	SCHEMDULE 120 WALL THICKNESS	WORKING PRESSURE	
(inch)	(mm)	(mm)	MPA	PSI
½"	21.34	4.32 + 0.51	1.72	250
¾"	26.67	4.32 + 0.51	1.31	190
1"	33.40	5.08 + 0.61	1.24	180
1 ¼"	42.16	5.46 + 0.66	1.03	150
1 ½"	48.26	5.72 + 0.68	0.90	130
2"	60.32	6.35 + 0.78	0.83	120

2 ½"	73.02	7.62 + 0.91	0.83	120
3"	88.90	8.89 + 1.07	0.76	110
4"	114.30	11.10 + 1.32	0.76	110

The pipe & fittings after they are laid shall be tested to hydraulic pressure of 6 Kg/cm² (60 meter) The pipes shall be slowly & carefully charged with water allowing all air to escape & avoiding all shocks of water hammer. The draw of takes & stop cocks shall then be closed & specified hydraulic pressure shall be applicable gradually. Pressure gauge must be accurate & preferably should have been recalibrated before the test. The test pump having been stopped the test pressure should be maintain without loss for at least half an hour. The pipes & fitting shall be tested in section as the work of laying proceeds, keeping the joints exposed for inspection during the testing.

2.0 **DRAINAGE:**

UPVC Drainage class pipes of Foamcore Astral (SN 8) or equivalent make in solvent cement joint including leveling with cutting the pipe to required length, roughining of pipe for external sewer drain.

2.1 Stoneware pipes with spigot & socket ends shall conform to IS.651-1965 and shall be of grade A or AA as specified. These shall be sound, free from visible defects such as dire cracks or hair cracks. The glaze of the pipe shall be free from crazing. The pipe shall give a sharp clear note when struck with a light hammer. There shall be no broken blisters. The approximate thickness of 600 mm long pipes shall be given in the table.

Internal dia. of the pipe	Thickness of the barrel & of socket	Weight of each Pipe per M.
Mm	mm	Kg.
100	12	14
150	16	22
200	17	33
230	19	44
250	20	52
300	25	79

The length of pipes shall be 60 cm. exclusive of the internal depth of the socket. The pipes shall be handled with sufficient care to avoid damage to them.

2.1.1 Trenches for stone ware pipe drains:

Para 1.7.2 under subhead 'water supply' shall apply. Wherever the drain runs deeper the width of trench in the upper reaches shall be increased as directed by Engineer-in-charge.

2.1.2 Laying of stoneware Pipes:

All pipes shall be laid on a bed of 15cm. Cement or lime concrete as specified projecting on each side of the pipe to the width of the trench specified in para 1.7.2. The pipes with their crown level at 1.20 M. depth & less from ground shall be covered with 15 cm. thick concrete above the crown of the pipe & sloped off to meet the outer edges of the concrete to give a minimum thickness of 15 cm. All around the pipe. Pipes laid at a depth greater than 1.20 M. at crown shall be concerted at the side's upto the level of the center of the pipe & sloped off from the edge to meet the pipe tangentially.

The pipes shall be carefully laid to the alignments, levels & gradients as shown on the plans and sections. Great care shall be taken to prevent sand etc. From entering the pipes. The pipes between two manholes shall be laid truly in a straight line without vertical or horizontal undulation. The pipes shall be laid with socket up the gradient. The body of the pipes shall for its entire length rest on an even bed of concrete.

Where they are not bedded on concrete the trench floor shall be left slight high & carefully bottomed up as pipe laying proceeds. So that the pipe barrels rest on firm & undisturbed ground. If the excavation has been carried out too low, the desired levels shall be made up with concrete 1:5:10 (1 cement: 5 fine sand: 10 graded stone aggregate 40 mm nominal size) for which no extra cost shall be paid. If the floor of the trench consist of rock or very hard ground that cannot easily be made to a smooth surface the pipe shall be laid on a leveling course of concrete as described.

2.1.3 Jointing: Tarred gasket of hemp yarn soaked in thick cement slurry shall first be placed round the spigot of each pipe & the spigot shall then be slipped home well into the socket of the pipe previously laid. The pipe shall then be adjusted & fixed in a correct position & the gasket caulked tightly home so as to fill not more than 1/4 of the total depth of the socket. The remainde of the socket shall be filled with stiff mixture of cement mortar in the proportion of 1:1(1 cement: 1 fine sand) When the socket is filled, a sillet shall be forged round the joint with a trowel forming an angle of 45 deg. with the barrel of the pipe. After a day's work any extraneous material shall be removed from the inside of the pipe. The newly made joints shall be cured.

2.1.4 Testing of joints: Water Test: Stoneware pipes used for sewers shall be subjected to a test

pressure of 1.5 M. head of water at the highest point of the section under test. The test shall be carried out by suitably plugging the low end of the drain and the ends of the branch connection if any and filled the systems with water. A knuckle bend shall be temporarily jointed in at the top end and a sufficient length of vertical pipe jointed to it so as to plugged with a connection to a hose ending in a funnel which could be raised or lowered till the required head is obtained & fixed suitable for observation. Where leakage is visible the defective part of the work shall be got out and made good.

- 2.1.5 Refilling of trenches: Clause 1.7.5 under water supply shall apply. In case where pipes are not bedded on concrete special care shall be taken in refilling trenches to prevent the displacement and subsequent settlement at the surface resulting in uneven street surfaces and dangers to foundations etc. The back-filling materials shall be packed by hand under & around the pipe & rammed with a shovel & light tamper. This method of filling will be continued upto the top of the pipe. The refilling shall rise evenly on both sides of the pipes continued upto 60 cm. Above the top of the pipe so as to not to disturb the pipe. The reminder of the back - filling shall not be done until 7 days have elapsed for brick sewers and 14 days of concrete sewers, unless local condition or materials are suitable for the earlier placing of a load on the pipes. The tamping shall become progressively heavier as the depth of the backfill increases.
- 2.2 S.W.GULLY TRAP: Gully traps shall conform to IS.651-1965. This shall be around, free from visible defects such as fire cracks or hair cracks. The glaze of the traps shall be free from crazing. They shall give a sharp clear note when struck with light hammer. There shall be no broken blisters. The size of the gully trap shall be as specified and all dimensions will be as per drawing. Each gully trap shall have one C.I. grating of square size corresponding to the dimensions of inlet of gully trap. It will also have a watertight C.I. cover with frame inside dimension 300 X 300 mm. the cover weighing not less than 2.72 KG. The grating cover & frame shall be of sound & good casting & shall have square seating faces.
- 2.2.1 Excavation: The excavation for gully traps shall be done true in dimensions & levels as indicated on plans or as directed by the Engineer-in-charge.
- 2.2.2 Fixing: The gully trap shall be fixed on cement concrete foundation 65cm. square & not less than 10 cm. thick. The mix for concrete will be 1:5:10(1 cement: 5 fine sand: 10 aggregate 40mm nominal size). The jointing of gully trap outlet to the branch drain shall be done similar to jointing of S.W. pipe as directed in clause 2.1.3.
- 2.2.3 Brick masonry chamber: After fixing & testing gully & branch drain, a brick masonry

chamber 300 X 300 mm.(inside) in second class bricks in cement mortar 1:5(1 cement : 5 fine sand) shall be built with a 10 cm brick work round the gully trap from the top of the bed concrete upto ground level. The space between the chamber walls & the trap shall be filled in with cement concrete 1:5:10(1 cement: 5 fine sand: 10 grade stone aggregate 40 mm nominal size). The upper portion of the chamber i.e. above the top level of the trap shall be plastered inside with cement mortar 1:3(1 cement: 3 coarse sand) finished with floating coat of neat cement. The cement corners & bottom of the chamber shall be rounded off as to slope towards the grating. C.I. covers with frame 300 X 300mm (inside) shall then be fixed on top the brick masonry with cement concrete 1:2:4(1 cement: 2 coarse sand: 4 graded stone aggregate 20mm. nominal size) & rendered smooth. The finished top of cover shall be built about 4 cm. above the adjoining ground level so as to exclude the surface water from entering the gully trap.

2.3 CEMENT CONCRETE PIPES:

The pipes shall be with or without reinforcement as required & of the class as specified. These shall conform to IS.458-1961. The reinforced cement concrete pipes shall be manufactured by centrifugal (or spun) process. All pipes shall be true to shape, straight, perfectly sound & free from cracks & flaws. The external & internal surface of the pipes shall be smooth & hard. The pipes shall be free from imperfect grading of the aggregate mixing or moulding. The pipes shall be RCC light duty, NP2 type.

Concrete used for the manufacture of reinforced concrete pipes & collar shall not be leaner than 1:2:4 (1 cement: 2 coarse 4 graded stone aggregate). The max. size of aggregate should not exceed 1/3 of the thickness of the pipe or 20 mm whichever is smaller. The reinforcement in the reinforced concrete pipes shall be extended throughout the length of the pipe. The circumferential & longitudinal reinforcements shall be adequate to withstand hydrostatic pressure & further bending stresses due to the weight of water when running full across the span equal to the length of pipe plus 3 times its own weight.

2.3.1 Trenches for concrete pipe: Para 1.7.2 shall apply. Where the pipe shall be bedded directly on soil, the bed shall be suitably rounded to fit the lower part of the pipe.

2.3.2 Laying of pipes: Loading, transportation & unloading of concrete pipes shall be done with care. Handling shall be such as to avoid impact. Gradual unloading by inclined plane or chain block is recommended. All pipe sections & connections shall be inspected carefully before being laid. Broken or defective pipes or connections shall not be used. Pipes shall be lowered into the trenches carefully. Mechanical appliances may be used. Pipes shall be laid true to line & grade as specified. Laying of pipes shall proceed up a slope.

If the pipes have spigot & socket joints, the socket end shall face upstream. In the case of

pipes with joints to be made with loose collars, the collars shall be slipped on before the next pipe is laid. Adequate & proper expansion joints shall be provided where directed. In case where the foundation conditions are unusual such as in the proximity of tress, of holes, under existing or proposed manholes, etc. the pipe shall be encased all-round in 15 cm. thick cement concrete 1:3:6 (1 cement: 3 fine sand: 6 graded stone aggregate 40 mm nominal size) or compacted sand or gravel.

In case where the natural foundation is inadequate the pipe shall be laid either in concrete cradle supported on proper

Foundations or on any other suitably designed structure. If a concrete cradle bedding is used the depth of concrete below the bottom of the pipe shall be least $\frac{1}{4}$ th of the internal dia. of the pipe subjected to the min. of 10 cm. & a max. of 30 cm. The concrete shall be extended upto the sides of the pipe atleast to a distance of $\frac{1}{4}$ th of the outside diameter or pipes 300 mm. & over in dia. The pipes shall be laid in this concrete bedding before the concrete has set. Pipes laid in trenches in earth shall be bedded evenly & firmly & as far as the branches of the pipes as to safely transmit the load excepted from the backfill through the pipe to the bed. This shall be done either by excavating the bottom of the branch to fit the curve of the pipe or by connecting the earth around the curve of the pipe to form an even bed. Necessary provision shall be made for joints wherever required. When the pipe is laid in trench in rock hard clay, shale or other hard material the space below the pipe shall be excavated & replaced with an equalizing bed of concrete sand or compacted earth.

When the pipes are laid completely above the ground the foundation shall be made even & sufficiently compacted to support the pipeline without any material settlement. Alternatively the pipeline shall be supported on rigid foundations at intervals. Suitable arrangements shall be made to retain the pipeline in the proper alignment such as by shaping the top of the supports to fit the lower parts of the pipe. The distance between the supports shall in no case exceed the length of the pipe. The pipe shall be supported as far as possible close to the joints. In no case shall the joint come in center of the span. Care shall be taken to see that super imposed loads greater than the total load equivalent to the weight of the pipe when running full shall not be permitted.

Suitable designed anchor blocks at change of direction & grade for pressure lines shall be provided where required.

2.3.3 Jointing of pipes: Joints are generally of rigid type. Where specified flexible type joints may also be provided.

Spigot & Socket joint (rigid): The spigot of each pipe shall be slipped home well into the

socket of the pipe previously laid & adjusted in the correct position. The opening of the joint shall be filled with stiff mixture of cement mortar in proportion of 1:2(1 cement: 2 fine sand) which shall be rammed with caulking tool. After a days work any extraneous material shall be removed from inside of the pipe & the newly made joint shall be cured.

Collar joint (rigid): The adjoining pipes shall be butted against each other in correct position. The collar shall then be slipped over the joint, covering equally both the pipes. The angular space shall be filled with stiff mixture of cement mortar 1:2 (1 cement: 2 fine sand) which shall be rammed with caulking tool. After a days work any extraneous materials shall be removed from the inside of the pipe & the newly made joint shall be cured.

- 2.3.4 Testing of joints, refilling of trenches: Clause 2.1.4 and 2.1.5 shall apply for stoneware & concrete sewers.

2.4 MANHOLES, VENT SHAFTS, GULLY CHAMBERS, ETC.:

- 2.4.1 Manholes: Manholes of different types & sizes as specified shall be constructed in the sewer line at such places & to such levels & dimensions as directed by the engineer-in-charge. The size specified shall indicate the inside dimensions of the manholes. Typical drawings of various types of manholes shall be supplied.

Manholes 1.4M internal diameter at bottom is generally constructed for drainage works where depth is 2.45M or more. When manholes are constructed on foot path, they shall be provided with cover of medium duty casting & when built within the width of the road under vehicular traffic, these shall be provided with cover of heavy duty casting.

Excavation: The manholes shall be excavated true to dimensions & levels shown on the plans or as directed by the Engineer-in-charge.

Bed concrete: The manholes shall be built on a bed of cement concrete 1:4:8(1 cement: 4 coarse sand: 8 graded stone aggregate 40mm nominal size). The thickness of the bed concrete shall be of 20cm. For manholes upto 4.25 M depth & 30 cm. for depths beyond 4.25M manholes otherwise specified or directed by Engineer-in-charge.

Cement block work shall be within mortar 1:5 (1 cement: 5 fine sand). The external joints of the pipe with the masonry shall be made perfectly leak-proof for circular manholes. Masonry in arches & arching over the pipes shall be in cement mortar 1:3(1 cement: 3 fine sand). The coarse of manholes of circular type the excess shaft shall be corbelled inwardly on three sides at the top to reduce it's size to that the cover frame to be fitted. The walls shall be built of 20cm. Brick work for depth upto 4.25 M below depth 4.25 M in ordinary sub soil wall thickness shall be increased to 30 cm. & at 9.75 M below ground 40 cm. shall be built.

Plaster & painting: The walls of the manholes shall be plastered inside with 12mm. thick cement plaster 1:3 (1 cement: 3 coarse sand) finished smooth. In the case of arched type manhole the walls of the manhole shall be plastered inside all around only upto the crown level, & flush pointed for the shaft with cement mortar 1:2(1 cement: 2 fine sand). Where the saturated soil is met with, also the external surface of the walls of the manhole shall be plastered with 12 mm. thick cement plaster 1:3(1 cement: 3 coarse sand) finished smooth upto 30 cm. above the highest sub-soil water level, with the approval of the Engineer-in-charge where required. The plaster shall further be water proofed, with addition of approved water proofing compound in a Quantity as per manufacturer specifications and Instructions.

Benching: The channels and benching shall be done in cement concrete 1:2:4(1 cement: 2coarse sand: 4 graded stone aggregate 20 mm nominal size) and rendered smooth with neat cement.

The depth of channels & benching shall be as in the table given below:

Size of drain in mm.	Top of channel at the center in cm. above bed concrete	Depth of benching at side wall in cm. above bed concrete
100	15	29
150	20	30
200	25	35
250	30	40
300	35	45

RCC Work: RCC work for slabs & lintels shall be in cement concrete 1:2:4 (1cement: 2coarse sand: 4graded stone aggregate 20mm. nominal size) with steel reinforcement. Plain concrete where for fixing the frame of manholes covers shall be of 1:2:4 mix (1cement: 2coarse sand: 4graded stone aggregate 20 mm nominal size). This concrete shall be laid in one operation integral with RCC slab underneath.

Foot rests: All manholes deeper than 1.2M shall be provided with M.S. foot rests. Footrests shall be of 20mm. M.S. Square or round bars as specified. These shall be embedded 20 cm. deep with 20 X 20 X 10 cm. blocks of cement concrete 1:3:6(1 cement: 3coarse sand: 6graded stone aggregate 20cm. nominal size). The block with M.S. footrest placed its center shall be cast in site along the masonry & surface finished with 12 mm. thick cement plaster 1:3 (1cement: 3coarse sand) finished smooth.

Footrests shall be fixed 30cm. apart vertically & shall project 10cm. beyond the surface of the wall. The top footrests shall be 45 cm. below the manhole cover. Foot rests shall be painted with coal tar, the portion embedded in the masonry or cement concrete block being painted with thick cement slurry before fixing.

Manhole covers & frames: The covers & frames shall conform to IS: 1726-1960 & shall be of the following grade and types:

Heavy duty: These shall be denoted by the letters 'HD' circular solid type for use under heavy vehicular traffic conditions.

Medium duty: These shall be denoted by the letters 'MD' circular or rectangular solid type for use under light traffic conditions such as foot paths, carriage drives & cycle tracks.

b. Light duty: These shall be denoted by the letters 'LD'

Or rectangular size for use in domestic premises of

Where they are not subjected to wheeled traffic loads.

The covers & frames shall be neatly cast & they shall be free from air & sand holes & from cold shuts. They shall be nearly dressed & carefully trimmed. All castings shall be free from voids whether due to shrinkage gas inclusion or other causes. Covers shall have a raised checkered design on the top surface to provide an adequate non-slip grip.

The covers shall be capable of easy opening & closing & it shall be fitted in the frame in workmanship like manner. The cover shall be gas tight & watertight.

The size of covers specified shall be taken as the clear internal dimensions of the frame.

The approximate weights of the various types of manhole covers & frames shall be as in table given below:

Description of CI. Manhole cover	Weights of cover Kg.	Weights of cover Kg.	Total weight of cover & frame Kg.
LD. Rectangular 455 x 610 mm (single seat)	23	15	38

MD 500 mm Dia.	58	58	116

1/2% variation in weight shall be permissible on either side.

Covers and frame shall be coated with a black bituminous composition. The coating shall be smooth tenacious. It shall not flow when exposed to a temperature of 63 deg. & shall not be brittle as to chip off at temperature of 0 deg. C.

The frame of manhole cover shall be firmly embedded to correct alignment & levels in RCC slab or plain concrete, as the case may be on the top of the masonry.

After completion of the work, manhole covers shall be sealed by means of thick grease.

2.4.1.1 Filling Earth: The excavated earth shall be back filled around the manhole as the brickwork proceeds. The surplus earth shall be disposed off as directed by the Engineer-in-charge or as specified.

2.4.2 Drop Connection: In case where branch pipe sewer enters the manhole of main sewer, a drop connection should be provided. S.C.J pipes & specials conforming to IS.1729-1964 as revised from time to time shall be of the size same as of the branch pipe sewer.

For 150 & 250 mm. main line. The difference in level between the water line (peak-flow-level) & the invert level of branch line is less than 60 cm. a drop connection may be provided within the manhole by giving ramp. If the difference in level is more than 60 cm. the drop should be provided externally.

Excavation: The excavation shall be done for the drop connection at the place where the branch line meets the manhole. The excavation shall be carried upto the bed concrete of the manhole & to the full width of the branch line.

Laying: At the ends of branch sewer line S.C.I. tee shall be fixed to the line, which shall be extended through wall of the manhole by horizontal piece of S.C.I. pipe form an inspection on cleaning eye. The open end shall be provided with chain & lid. The S.C.I. drop pipe shall be connected to the tee at the top & to the S.C.I. bend at the bottom. The end shall be extended through the wall of the manhole by a piece of C.I. pipe, which shall discharge into

the channel. Necessary channel shall be made with cement concrete 1:2:4 (1 cement: 2 coarse sand: 4 graded stone aggregate to 20 mm nominal size) & finished smooth to connect the main channel. The joint between S.C.I. pipe & fittings shall be lead caulked. The joint between S.C.I. tee & S.W. branch line shall be made with cement mortar 1:1 (1 cement: 1 fine sand) as per para 2.1.3 for SW pipes. The exposed portion of the drop connection shall be encased allround with minimum 15cm. Thick concrete 1:3:6 (1 cement: 3 fine sand: 6 graded stone aggregate 40 mm nominal size) & cured. For encasing the concrete around the drop connection, necessary centering & shuttering shall be provided. The holes made in the walls of manholes shall be made good with brick work in cement mortar 1:5 (1 cement: 5 fine sand) & plastered with cement mortar 1:3 (1 cement: 3 coats sands) on the inside of the manhole wall. The excavated earth to be backfilled in the trench in level with the original ground level.

2.5 SOIL, WASTE, RAIN WATER, VENT & ANTI-SIPHONAGE PIPE & FITTINGS:

2.5.1 All soil, waste, vent and anti-siphonage pipes & fittings used within plumbing shafts (vertical run) shall be sand cast iron socket & spigot conforming to IS. 1729-1964 or its subsequent revision. All cast iron pipes & fittings shall be of the best approved Indian make or soil variety preferably of spun quality & hot dipped in Dr. Agnus Smith Solution & free from flaws. Air bubbles, cracks, sandholes & other defects and shall be truly cylindrical & uniform in thickness. They shall not be brittle but shall allow for heavy cutting, chipping & drilling & shall not be less than 6mm thick & the diameter mentioned in the schedule of qualities & shall be of the largest length available & shall be fixed against the wall on special 'U' clamps 25mm wide, 3mm thick & hot dip galvanised by means of round headed flat nail of 75mm long on brickwall. In case of hollow block wall 50 X 50 X 75mm long wooden gutties soaked in solignum should be first fixed & then flat nails should be based & nails painted with two coats of paint.

2.5.2 Jointing shall be carried out with Drip seal. The spigot of the pipe must be forced well home into its socket & must be entered, so that the joint may be of even thickness all round. Atleast, one complete lap of clean white hemp spun yarn shall be drawn into the socket without being forced through the joints into. As many laps as may be needed to leave the space of not less than 25 for the drip seal shall then be poured into the joint. The joints shall then be run with drip seal in sufficient quantity so that after being caulked solid, the drip seal may project 3mm beyond the face of the socket against the outside of the spigot but must be flush with the outside edge of the socket.

- 2.5.3 Cleanouts at the head of CI SS horizontal pipes running under the floor shall be of cast brass screwed in type. Floor & wall clean outs shall be of cast brass screwed type. The connecting pieces shall be of G.I. threaded to suit the Clean out with lead caulked joint.
- 2.5.4 Inspection chambers, gully traps, etc. within the building shall be of 'Patel Pattern' cast iron with bolts, nuts to close the cover, all to be fabricated as per actual requirements.
- 2.5.5 Supports, pedestals & base for inspection chambers, gully traps & pipes shall be in 1:2:4 cement concrete mixes.
- 2.5.6 Pipe sleeves & inserts, etc. through RCC walls either external or internal shall be C.I. or M. S. provided with water bar flange.
- 2.5.7 During installation open end of pipes shall be plugged with wood cut into required shape of gunny bags & to be maintained free from dirt.
- 2.5.8 G.I waste pipes & fittings shall be of 'C' class I.T.C. or equivalent with G.I. unions, tail piece reducers & connections to be provided between joints to either lead or C.I. Pipes.
- 2.5.9 The sizes of branch waste pipe for different fittings shall be as follows :
- | | |
|--------------------|----------------------------|
| Lavatory Basin | - 1 1/2" & 1 1/4" dia. |
| Urinal | - 1 1/2" dia. (40 mm) |
| Sink | - 1 1/2" dia. (40 mm) |
| Nahni Trap | - 3" dia. (75 mm) |
| Special floor Trap | - 75 or 100 mm as required |
| | with bolted aluminum |
| | grating in 25 X 25 mm |
| | M.S. angle. |
- 2.5.10 W.C. pan connectors shall be to suit the requirements as per drawing, with 40mm vent born for connections to he anti-siphonage pipe with pan connector of C.I. lead.
- 2.5.11 Connection to the sewage or storm water collection sumps to be perfectly water tight & as specified in the drawing.
- 2.5.12 Rain water flashing shall be of 150mm X 100mm or 225mm X 150mm with C.I. dome shape grating & extension piece.
- 2.5.13 All rain water pipes & fittings shall be soil pipe variety conforming to IS. 1729-1964 or equivalent. This shall apply to pipe outside buildings or within the building or separate shafts.
- 2.5.14 The floor trap for toilet blocks shall be cast iron with C.I. brass grating, bolted down design.
- 2.5.15 Where toilet shafts are sunk, the floor trap shall be of 100 mm X 75 mm heavy type C.I. 'P' Trap, with C.I. brass grating, bolted down design.

- 2.5.16 Bathroom C.P. grating shall be of bolted down design out of heavy cast brass with the chromium plating of the best approved standard.
- 2.5.17 Cast iron gratings shall be flat with perfect edge of the quality procurable of the specified width & thickness & the available lengths.
- 2.5.18 Spigotted & socketed 75 mm, 100 mm & 150 mm C.I. pipes shall be of heavy pattern for the portion below the floor & embedded & laid over 150 mm cement concrete 1:3:6, the width of the concrete being :
- 75 mm dia
100 mm dia
150 mm dia
200 mm dia
- The pipes shall be laid to a slope & connected to the drain. On no account should lime or lime concrete come in direct contact.

2.6 PVC PIPES FOR DRAINAGE:

- 2.6.1 Agricultural PVC Class 3, 6 Kg/Sq. Cm. shall be used for Drainage All pipes & Coupler sockets shall conform to IS 4985-81 & 7834-75. Pipes shall be smoother, free from visible defects such as dire cracks or hair cracks. The approximate thickness of pipes shall be given in the table:

Internal dia. of the pipe	Thickness of the pipe class 3,	6 Kg / Sq. cm
mm	Minimum	Maximum
110	3.7 mm	4.3 mm
160	5.4 mm	6.2 mm
180	6.1 mm	7.0 mm

The pipes shall be handled with sufficient care to avoid damage to them.

2.6.2 Trenches for stone ware pipe drains:

Para 1.7.2 under sub-head 'water supply' shall apply. Wherever the drain runs deeper the width of trench in the upper reaches shall be increased as directed by Engineer-in-charge.

- 2.6.3 Laying of P.V.C. Pipes: All pipes shall be laid on a bed of 15cm. cement or lime concrete as specified projecting on each side of the pipe to the width of the trench specified in para 1.7.2. The pipes with their crown level at 1.20 M. depth & less from ground shall be covered with 15 cm. thick concrete above the crown of the pipe & sloped off to meet the outer edges of the concrete to give a minimum thickness of 15 cm. all around the pipe. Pipes laid at a depth greater than 1.20 M. at crown shall be concerted at the side's upto the level of the center of the pipe & sloped off from the edge to meet the pipe tangentially.

The pipes shall be carefully laid to the alignments, levels & gradients shown on the plans & sections. Great care shall be taken to prevent sand etc. from entering the pipes. The pipes between two manholes shall be laid truly in a straight line without vertical or horizontal undulation. The pipes shall be laid with socket up the gradient. The body of the pipes shall for its entire rest on an even bed of concrete & places shall be excavated in the concrete to receive the socket of the pipe. RCC Hume pipe sleeve shall be provided for crossing the roads & drainage.

Where they are not bedded on concrete the trench floor shall be left slight high & carefully bottomed up as pipe laying proceeds. So that the pipe barrels rest on firm & undisturbed ground. If the excavation has been carried out too low, the desired levels shall be made up with concrete 1:5:10(1 cement: 5 fine sand: 10 graded stone aggregate 40 mm nominal size) for which no extra cost shall be paid. If the floor of the trench consist of rock or very hard ground that cannot easily be made to a smooth surface the pipe shall be laid on a leveling course of concrete as described.

- 2.6.4 Cut the pipes as square as possible. The pipe & the socket should be clean & dry. Clean the surface with emery paper before jointing.

Apply a thick coat of solvent cement on the outer surface of the pipe & also on the inner surface of the socket.

Insert the pipe into the socket & turn it through a 90 d. angle for even distribution of cement.

Hold the joint for 2 minutes & ensure that pipe does not slip out of fitting. Clean off extra cement. Let it dry.

- 2.6.5 Testing of joints: Water Test: PVC pipes used for sewers shall be subjected to a test pressure of 1.5 M. head of water at the highest point of the section under test. The test shall be carried out by suitable plugging the low end of the drain & the ends of the connecting if any & filled the systems with water. A bend shall be temporarily jointed in at the top end & a sufficient length of vertical pipe jointed to it so as to plug with a connection to a hose ending in a funnel which could be raised or lowered till the required head is obtained & fixed suitable for observation.

Where leakage will be visible the defective part of the work shall be got out & made good.

2.6.6 Refilling of trenches: 1.7.5 under water supply shall apply. In case where pipes are not bedded on concrete special care shall be taken in refilling trenches to prevent the displacement & subsequent at the surface resulting in uneven street surfaces & dangers to foundations etc. The backfilling materials shall be packed by band under & round the pipe & rammed with a shovel & light tamper. This method of filling will be continued upto the top of the pipe. The refilling shall rise evenly on both sides of the pipes continued upto 60 cm. Above the top of the pipe so as to not to disturb the pipe. The reminder of the backfilling shall not be done until 7 days have elapsed for bricksewers & 14 days of concrete sewers, unless local condition or materials are suitable for the earlier placing of a load on the pipes. The tamping shall become progressively heavier as the depth of the backfill increases.

2.7 PVC (SWR) SOIL, WASTE, RAIN WATER, VENT & ANTI-SIPHONAGE PIPE & FITTINGS:

2.7.1 All Vent pipes and fittings used horizontal & vertical run shall be PVC (SWR) type Supreme / Prince make smooth & free from air bubbles, cracks, & other defects truly cylindrical & uniform in thickness. Pipe shall be of the largest length available & shall be fixed against the wall with PVC clips nail of 75mm long on brick wall and suspended from ceiling by MS hangers & Anchor fasteners or by welding to embedded plates. In case of hollow block wall 50 X 50 X 75mm long wooden gutties soaked in coligum should be first fixed & then flat nails should be based & nails painted with two coats of paint.

2.7.2 Jointing of PVC Pipes shall be carried out with lubricated in Rubber lubricant) 'T' shaped Rubber rings as follows :

Make sure the spigot end & inside of socket is clean, & the Sealing ring is placed evenly in the socket.

When cutting pipes make sure they are cut straight. Chamfer the end cut to a angle of 15% with a medium file.

A correct depth of entry of the spigot into the socket is required to allow thermal movement. To achieve this, push spigot fully into the socket (remove sealing ring at this time) & make a mark on the spigot. Withdraw the spigot by 100 mm & mark the spigot with a bold line. This bold mark indicates the correct depth of entry to allow the Necessary expansion gap.

Smear rubber lubricant evenly on the chamfered spigot & the sealing ring. Then insert the spigot into socket with light twisting motion. (Ensure the 10 mm expansion gap is allowed)

Joining to CI pipes shall be in 1:1 cement sand joint after roughening the surface of PVC pipes for proper hold.

3.0 HANGERS & SUPPORTS :**3.1 GENERAL:**

Provide proper solid angle iron/channel section, supports for all pipes complete with clamps. wherever insulation comes, to provide wooden guide to support pipe on the angle iron hangers/supports. For attachment in concrete, use Dash" fasteners or anchor plug type inserts or equivalents. Provide hangers within 0.9 meter of all hangers in direction of mains & a minimum of three hangers per expansion bend wherever shown in drawing. Provide all additional structural steel angles, channels or other members not specifically shown but are required for proper support. Do not expose concrete reinforcement to hang pipes.

3.2 Where necessary additional hangers to be provided to arrest water hammers or hydraulic resonance with proper rubber padding.

3.3 Space hangers, as noted below, except on all soil pipe which shall have a hanger or multiple fittings, sufficient hangers shall be provided to maintain proper slop without sagging, in case of slopping suspended line, the following is suggested.

A	Pipe Sizes.	Hanger Rod Dia.
	20 mm through 50 mm	9 mm.
	65 mm through 125 mm	12 mm.
	150 mm and over	16 mm.
B	Pipe sizes	Spacing of Supports
	12 mm to 20 mm	1.5 M apart
	25 mm to 40 mm	1.8 M apart
	50 mm & above	1.8 M apart or as per IS.

3.4 Provided floor stands, wall brackets of masonry piers, etc. for all lines running near the floor or near walls for those lines can be properly supported from the walls or floors. Pipe line near concrete or masonry walls may be hung also by hangers carried from wall brackets at a higher level than pipes. Hanging of any pipe from another is prohibited.

3.5 HANGERS : Clevis or band type hangers shall be provided. Hot water piping is to be provided with suspended supports as far as possible. Note that strap hangers are not permitted & clamps should be of removable type.

3.6 INSULATED HOT WATER PIPING : A 40 mm thick timber support for direct support of hot water line is required. Timber supports are to rest in brackets.

4.0 VALVES & PRESSURE GAUGES :

- 4.1 Pressure gauges shall have not less than 112 mm dia brass body siphon & gauge cock of 9 mm size. Dial ranges shall be adequate for the pressure encountered & as specified.
- 4.2 Provided valves on branch pipe connection to mains & at connection to equipment where indicated. All valves are to be located for easy access & are to be full bore of pipe connected together. Support all valves wherever necessary. Valves are to be as per IS. 780 (class 1) for G.I. sluice valve & to IS. 778 for valves & tested & approved.
- 4.3 VALVE SCHEDULE:

SERVICE	TYPE	SIZE	RATING	ENDS	MATERIALS
Water, Oil, air steam (low pressure)	Gate	65 mm & under	300 psi/20 Kg./sq.cm.	screwed	Bronze
Water	Gate	75 mm & over	300 psi WOG	flanged	CI body bronze trim
Gas	Gate	65 mm & under	600 psi	flanged	Bronze/SS spindle & trim
Water, Oil, air, Gas, steam (low pressure)	Globe & angle	65 mm & under	300 psi.	Screwed	Bronze
Water	Globe & Angle	65 mm & under	300 psi. water	Screwed	Bronze
Water	Globe & Angle	65 mm & over	300 psi.	Flanged	Iron body bronze trim
Water	Horizontal & vertical check	65 mm & under	300 psi.	Screwed	Bronze
Water	Horizontal & vertical check	65 mm & over	300 psi.	Flanged	Iron body bronze trim

- 4.4 All globe & check valve shall have working parts suitable for hot & cold water, oil or gas as required. Valves shall be tagged with permanent label under band wheel indicating type of duty.

5.0 SANITARY FIXTURE & FITTINGS :

Unless otherwise specified, the sanitary fixtures shall be of the following specifications:

- 5.1.1 WATER CLOSETS : (European type) shall be of vitreous china of approved pattern, quality & colour. The closet shall be fixed with C.P. brass screws in floor for floor mounted type & mounted on C.I. chair brackets with bolts for wall mounted type & shall be provided with solid plastic seat & cover with chrome plated pillar brass hangers as specified.
- 5.1.2 Indian Pattern shall be of similar quality as specified above. The pan shall be 675/575 mm in length with 'S' or 'P' trap of the same material of the pan. The W.C. with the trap shall be fitted & fixed in position & built round solid with brick & cement to required level after all connections are made. The finished floor of the water closet shall be of 25 mm below the level of the room or passage in front of it.
- 5.1.3 Both type of closets should conform to the requirements of I.S. 771-1963 for glazed vitreous china sanitary appliances.
- 5.1.4 The flushing cisterns shall conform to the requirements of I.S. 774-1971. High level cisterns shall be of cast iron unless otherwise specified. Low level cisterns shall be of the same material as the water closet. The cisterns shall be mosquito proof & shall fulfil the requirements of the local Authority.
- 5.1.5 The flush pipe shall be 32 mm dia. PVC if concealed & if exposed brass C.P. as specified.
- 5.1.6 Where flush valves are specified, this shall be of the best approved quality procurable with C.P. control valve & C.P. flush pipe.

5.2 URINALS:

- 5.2.1 Urinals shall be of glazed fire clay earthenware or Vitreous china as specified & shall conform the requirements of I.S. 771-1963. Bowl type urinals with a lipped basin & flushing main shall be fixed to wall by screws. A 40 mm trap shall be provided & outlet shall be connected to soil pipes.
- 5.2.2 One gallon flushing cistern shall be provided unless otherwise specified. In case of such urinals in range one 3 gallons flushing cistern for 3 urinals shall be provided. All exposed pipe work shall be heavy brass C.P. with C.P. wall supports.

5.3 LAVATORY BASIN:

- 5.3.1 They shall be of vitreous china of approved pattern & shall conform to the requirements of Indian standard Specifications. The basin shall be provided with 32 mm heavy cast brass C.P. trap & waste shall be connected to the waste pipe with a C.P. extension & wall flange.

5.4 SINKS:

- 5.4.1 They shall be of Vitreous china & shall strictly be in conformation with I.S. 771-1963 for

white glazed earthenware sanitary appliances or in stainless steel where required of oriental Metal & pressing works or equivalent.

5.4.2 The sink shall be provided with 40 mm trap & shall be connected to the waste pipes.

6. **INSULATION:**

1. SCOPE:

Scope of this section comprises supply & installation of insulation for pipes, tanks & heat exchangers as herein specified.

2. The insulation material shall be resin bounded fibber glass having following :-

- a) Minimum density - 32 KG./C.M.
- b) Thermal Conductivity - 0.04 KCAL/MH 0C
- c) Minimum fiber dia. - 7 micrometer.

It shall be non-hygroscopic, Vermin proof & should not settle due to vibration over a period of time.

3. The thickness of insulation shall be :-

25 mm for pipes 15 mm to 40 mm.

40 mm for pipes 50 mm to 150 mm.

Hot water tanks shall be insulated with 40 mm thick insulation.

4. APPLICATION:

The pipe, tank or heat exchanger surface shall be thoroughly cleaned with wire brush & surface rendered free from rust. The cleaned surface shall be painted with one coat of bitumen 85/40 or 85/25 conforming to IS 702. The insulation shall then be applied with staggered joints. The joints shall then be sealed with adhesive tape. The insulation shall be held in position with 1mm G.I. wire at 600 mm center.

5. FINISH:

The insulated surface of all pipes in shafts & above false ceiling shall be finished clad with 24 gauge aluminum sheet with 50 mm overlap at joints. The cladding shall be held in position using self-tapping screws. Cladding shall be formed to required shapes, tightly bound for all pipes bends & valves.

Insulated hot water tanks shall be either provided with two coats of hard setting compound each

of 6 mm thick or clad with 24-gauge aluminum sheet, as required by Engineer – in - charge. Insulated heat exchangers shall be clad with 24 `G A1. sheets.

All flanges valves & union shall be insulated & clad separately & distinctly for easy identification & location.

6. Insulation of small dia. embedded pipes:

Small dia pipes carrying hot water & embedded in walls shall be insulated with 6mm thick asbestos rope closely.

7 **CUTTING, PATCHING, REPAIRING & MAKING GOOD:**

- 7.1 Cutting, patching & repairing required for the proper installation & completion of the work, specified in each division, including chasing, plastering, masonry work, concrete work, etc. & making good shall be carried out by the contractor wherever required. Holes, which are cut oversize, shall be refilled, so that a tight fit is obtained around the pipe or other object passing through. Any damages to water proofed location should not be patched up, without rectification by the water proofing agency(specialist contractor) to ensure his guarantee.

8 **EQUIPMENT PROTECTION:**

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- 8.1 Keep all the pipe & conduit openings closed by means of plugs or caps to prevent the entrance of foreign matter. Protect all piping, conduit, fixtures, equipment or apparatus. Any such items damaged prior to final completion or work shall be restored to its original conditions or replaced at no expenses to the Owner.

8.2 **ACCESSIBILITY:**

The installation of valves, thermometers, cleanout fittings & other including equipment or specialties requiring frequent reading, adjustments, inspections, repairs, removal or replacement, shall be conveniently & accessibly located with reference to the finished buildings. hermometers & gauges shall be installed so as to be easily read from the floor.

8.3 **INSERTS & SLEEVES:**

- a) General: Layout work in advance of placing of concrete slabs or construction of walls, furnish & set inserts & sleeves necessary to complete the work, cost of cutting or patching made necessary as a result of this operation shall be at no expense to the Owner. Openings shall be as per

Structural Consultants/Engineer-in-charge approval.

b) Pipe sleeves:

Wall Sleeves: G.I. wall sleeves in cold store & black pipe 'A' class for cable, conduits, gas pipes, etc. are to be inside flush with wall on both sides. Sleeves shall be large enough in diameter to provide 12mm clearance around pipe for insulation. Exterior wall sleeves for cable entry/pipe/earthing strips, etc. shall be cast-iron flush with wall on both sides. Sleeves shall be large to allow caulking from outside using lead wool.

Floor Sleeves: Interior floor sleeves for general areas shall be of C.I. extending 50mm(2") more above finished floor. All pipes passing through sleeves shall be caulked with asbestos rope & finish with cement mortar. Insulated pipe shall have insulation butted to floor sleeve & sealed with insulating cement in both sides.

Exception: Chilled water or refrigerant suction piping insulation shall be run continuous through the sleeves & caulked. Interior floor sleeves for kitchen areas shall be C.I. steel pipe extending 50mm(2") above finished floor. Caulking shall be the same for general areas. Floor co grade sleeves, caulked & made water tight.

9. EQUIPMENT, MATERIAL & WORKMANSHIP:

- 9.1 Determine that each piece of equipment meet the detailed requirements of the contract documents & that it is suitable for the installation shown. Notify the Architect of any shortcoming found during the tendering period. Each piece of equipment furnished shall meet all detailed requirements of the contract documents. Equipment's not meeting all requirements will not be acceptable, even though specified by name along with other manufacturers.
- 9.2 Where two or more units of the same class of equipment are furnished use product of the same manufacture, component parts of entire system need not be product of the same manufacturer. Furnish all materials & equipment's, new & free from defects & of size, make, type, & quality herein specified or approved by the Architect. All shall be installed in a neat & mark manlike manner.

10. CLEANING, OPERATION & TESTS:

- 10.1 Plumbing equipment fixtures, piping etc. shall be free of stampings, makings (except those required by codes) iron cuttings & other foreign materials.
- 10.2 Hot,Cold & drinking water system shall be cleaned thoroughly filled & flushed with water.
- 10.3 The entire mechanical apparatus shall operate at full capacity without objectionable noise or vibrations.
- 10.4 Test all plumbing system in the presence of the site Engineer/Supervisor/Engineer-in-charge & ample advance notice to test dates. Provide all equipment materials & labour necessary for inspection & tests & repair all work, not passing the tests. After repairs are made, repeat tests until units system is found satisfactory, to the authorities. Carry out tests prior to concealing, insulating or back filling over any piping No exceptions will be made.
- 10.5 Test entire system of soil, waste & vent piping by water after the roughing in is completed & before the fixtures are set. After setting the fixtures, providing smoke test, after sealing all traps.
- 10.6 Water test: Test entire system or section of system by closing all opening in piping except the highest opening & filling system with water to the point of overflow. If the system is tested in sections, plug each opening except the highest opening of the section filled with water. Keep the water in system or in portion under test of or atleast 45minutes before inspection starts with test pressure/head lasting for two hours. The system must be tight at all joints.
- 10.7 Final Test: After fixture are set, test system with smoke as follows:-
- 10.8 Smoke Test : Fill traps with water, then introduce into system a pungent thick smoke produced by one or more smoke machines. Then smoke appears at stacks on the roof, plug stacks & allow pressure of 25mm water column to build up in system. Maintain pressure of 15 minutes before inspection starts. The system shall be tight at all joints.
- 10.9 Test all down spouts or rain headers & their branches within the building by water as described for the above soil, waste & vent system.
- 10.10 All water piping: Hydro-static test 150 PSI for a minimum of 2 hours without drop in pressure as required.
- 10.11 All tests on below grade lines shall be continued until backfilling on such lines is completed to disclose any damage caused by backfilling.
- 10.12 All system shall be tested in sections as required to expedite the work on other trades & meet construction schedules & final test on completion.

11. TOOLS, MATERIALS & STORAGE:

- 11.1 The contractor at his own cost & charge shall provide all materials, tools tackle measure,

scaffolding labour & water necessary for the completion of the whole work in all respects.

The contractor shall pay the fees for testing the material if directed by the architects & Local Authorities or other statutory authorities.

The Contractor will obtain, from time to time, various permission & the completion certificates as per rules of all local & statutory authorities.

The Counter shall arrange for the material & storage facility with the building contractor.

Any materials, brought at site, shall not be removed without the written authority of the Architect/Consulting Engineer/ Engineer-in-charge & when the Contractor shall have received payment in respect of any unfixed materials on the work has been taken into account, such materials, shall become the property of Employer/Corporation & the Contractor shall be liable for any loss or damage hereto.

The Contractor shall insure the work against damages, for such sum as the Architects/Consulting Engineers/Engineer-in -charge may from time to time direct. All insurance policies are to be taken out in the joint name of Employer/Corporation & the Contractor in an office selected by the Architect/ Consulting Engineer/Engineer-in-charge & all policies & receipts shall be deposited with Architect/Consulting Engineers/Engineer-in-charge.

All the brackets & hangers for pipes shall be fixed to the wall or RCC slab using 'Dash' fasteners wherever necessary.

The amount shown against the provision item or / and contingencies in the schedule are provisional & for estimating purposes only the Contractor is neither concerned for its execution nor to change any commission on these items. The Owner reserves the right to get the work done for these items through a separate & independent Contractor.

Surplus material from the site shall be carted away by the Contractor without any cost to the Employer / Corporation & the Storage shall be handed over to Employer /Engineer-in-charge clean & ready for occupation.

12. SAFETY CODE:

There shall be maintained in a readily accessible place first aid appliance including adequate supply of sterilized dressing & cotton wool.

All injured persons shall be taken to a public hospital without loss of time, in case where the injury necessitates hospitalisation.

Suitable & strong scaffolds should be provide for workman for all works that cannot safely be done from ground.

No portable single ladder shall be over 8 M in length. The width between the side rails shall be not less than 30cm. (clear) & the distance between two adjacent rungs shall not be more than 30cm. When a ladder is used or extra mazdoor shall be engaged for holding the ladder.

The excavated material shall not be placed within 1.5 M of the edge of the trench or half of the depth of trench whichever is more. All trenches & excavation shall be provide with necessary fencing & lighting.

Every opening in the floor of a building or in working platform be provided with suitable means to prevent the fall of person or materials by providing suitable fencing or railing whose minimum height shall be one meter.

No floor or other part of the structure shall be so overloaded with debris or materials as to render it unsafe.

Workers employed on mixing & handling material such asphalt cement mortar or concrete & lime mortar shall be provided with protective footwear & rubber hand gloves.

Those engaged in welding works shall be provided with welder's protective eye-shields & gloves.

No paint containing lead or products shall be used except in the form of paste or readymade paint.

Suitable face masks should be supplied for use by the workers when the paint is applied in the form of spray or surface having lead paint dry rubbed & scrapped.

Overalls shall be supplied by the Contractor to the painter & adequate facilities shall be provided to enable the working painters to wash during the periods of cessation of work.

Hoisting machines & tackle used in the works. including their attachments, anchorage & supports shall be perfect condition.

The rope used in hoisting or lowering material or as a means of suspension shall be of durable quality & adequate strength & free from defect.

13. SPECIFICATION FOR PUMPS:

- 13.1 The pumps shall confirm to IS 1520-1960 (latest revision) and shall be of following construction.

	<u>PUMP</u>	<u>HORIZONTAL SPLITCASE</u>
	1. Casing	Cast Iron/Cast Steel
	2. Impeller	Bronze
	3. Shaft	High Tensile Steel
	4. Bearings	Heavy Duty Ball/Roller Bearings
	5. Base Plate	Cast Iron/Fabricated M.S.
	6. Flanges	To I.S.S. 1536/1960
	7. Packing	Graphited Asbestos
	8. Max. Speed	1500 R.P.M/970 RPM
	9. Driver	Drip proof Induction Motor TEFC
13.2	Driver rating shall be at least 1.3 times the maximum BHP of the pump. Refer equipment schedule for the rating of motors and diesel engine.	
13.3	The pump and the driver shall be mounted on common foundation and common bed plate. The following accessories and fittings shall be provided with each pump over and above the standard accessories.	
	a. Coupling guard for coupled set.	
	b. Lubrication fittings and seal piping.	
	c. Pressure gauges as suction and delivery side.	
	d. Test and/or air vent cock.	
13.4.0	Installation	
13.4.1	Pumps shall be installed as per manufacture's recommendations. Pump set shall be mounted on concrete block, which in turn mounted on machinery isolation cork or any other equivalent vibration isolation fitting. Concrete foundation will be made by the owner to the drawings and specifications of the contractor and the isolation pad shall be supplied by the contractor. Contractor shall however ensure that the foundation bolts are currently embedded.	
13.4.2	Pump sets shall preferably be factory aligned. Whenever necessary site alignment shall be done by competent persons. Before the foundation bolts are grouted and the couplings bolted, the bed plate levels and alignment results shall be submitted to the Engineer.	
13.5.0	Testing:	
13.5.1	Tenders shall submit the performance curves of the pumps supplied by them. (They shall also check the capacity and total head requirements of each pump to match his own piping and equipment layout.)	
13.5.2	On completion of the entire installation, pumps shall be tested, wherever possible, for their	

discharge head, flow and B.H.P. Where it is not possible, at least the discharge and B.H.P as measured on the input side shall be field-tested. Test results shall correspond to the performance curves.

13.5.3 Tenders shall furnish the required testing instrument and arrange for their connection as required.

13.6.0 Painting:

After complete installation and testing, pumps accessories and fittings shall be given two coats three mills each, of approved finishing paint.

13.7.0 Bill of Material:

13.7.1 The bill of material given here are only for the pump sets and diesel engines. The contractor shall include all ancillary item given in the specification and also these items which are essential for efficient operation of the equipments.

13.8.0 Diesel Operated Pump sets:

13.8.1 General: The diesel engine and pump shall be a factory assembled and tested set, the product of one manufacturer only as follows:

a) Ashok Leyland, Kirloskar or Kirloskar Cummins or approved quality. Provide the necessary controls and accessories for a complete system.

13.8.2 Rating: Rating of the diesel engine set shall be based on operation of the set when equipped with all necessary operating accessories such as air cleaners, lubricating oil pump, fuel transfer pump, fuel injection pump, jacket water pump governor, etc.

13.8.3 Engine Specifications:

Type: Engine shall have compression ignition. It shall be a two or four stroke cycle, coiled injection engine of either vertical inline or V types.

Horse Power: B.H.P shall be as per bill of quantities at 1000 rpm. Submit certified engine horsepower curve showing the manufacturer's approval of the engine rating for standby application.

Speed: The engine speed shall not exceed 1000 rpm at full load operation.

Fuel: The engine shall be capable of satisfactory performance on a commercial grade of distilled petroleum fuel oil (such as No.2 fuel oil)

Governor: The engine speed shall be governed by a full hydraulic governor, woodward SS or equal to maintain governed speed.

Fuel System: Per manufacturer's normally used system, including a fuel pump to lift the fuel from the main tank and a replicable element fuel filter conveniently located for servicing. Build a fuel tank of sufficient capacity into the engine base to provide an immediate fuel supply to the pump upon engine start up. An engine-driven fuel pump shall

supply fuel to the engine.

Lubricating: The engine shall have a gear type lubricating oil pump for supplying oil under pressure to main bearings, crank-pins bearings pistons, piston pins, timing gears, camshaft bearings and valve rocker mechanism. Provide full flow oil filters, conveniently located for servicing, equipment such with a spring loaded bye-pass valve to ensure oil circulation if filters are clogged.

Cylinder Liners: Provide engine with removable wet or dry type cylinder liners of close grained alloy iron.

Air Cleaners: Provide engine with one or more dry type air cleaners.

Starting: Equip engine with a 24 volt electric starting system of sufficient capacity to crank the engine at a speed, which will allow full diesel starting of the engine. Provide lead acid batteries having sufficient capacity for cranking the engine for atleast 60 seconds at firing speed, with capacity for starting the diesel engine a minimum of our times. Provide a suitable battery trickle charger with sufficient capacity to re-charge batteries back to normal starting requirements quickly. Provide an automatic battery trickle charger (6-amp capacity) to maintain batteries at full capacity.

14. SPECIFICATION FOR CPVC PIPES

14.1 Concealed Plumbing:

“All internal concealed plumbing for water supply shall be done with **CPVC**. The pipes & fittings shall conform to CTS (Copper Tube Size) SDR-11 as per ASTM D2846. All pipes and fittings from ½” upto 2” shall come under this category. A medium body CPVC solvent cement conforming to ASTM F493 should be used for joining pipes to fittings.

14.2 External Plumbing :

“All external plumbing for water supply and distribution shall be done with **CPVC**. The CPVC pipes above 2” for external water supply lines shall conform to ASTM F441 CPVC Schedule 40 & 80 pipe and will be the **Corzan™ CPVC** brand. The fittings above 2” size shall conform to ASTM F438 (Schedule 40 CPVC fittings) or ASTM F 439 (Schedule 80 CPVC fittings). All threaded CPVC fittings shall conform to ASTM F437 (threaded CPVC fittings schedule). A heavy bodied CPVC solvent cement shall be used along with a primer. IPS brand primer and heavy bodied CPVC solvent cement only should be used conforming to ASTM F493. All external CPVC pipes shall be coated with a water based acrylic paint emulsion for enhanced UV protection.

14.3 Threading of CPVC pipes:

pipes conforming to ASTM F441 Schedule 80 shall be threaded. No threading of CPVC pipes Schedule 40 will be allowed.

14.4 CPVC Solvent Cement Specifications:

“The CPVC solvent cement used for installing CPVC piping systems shall conform to ASTM F493. For FlowGuard™ pipes from ½” upto 2” pipes and fittings, a single step medium bodied CPVC solvent cement should be used. For Corzan™ CPVC pipes and fittings upwards of 2”, a primer shall be used followed by a heavy bodied solvent cement conforming to ASTM F493. PVC solvent cement should not be used.

14.5 Installation procedure:

“All parameters pertaining to the installation of **CPVC** plumbing system such as cutting, joining, support spacing, expansion loops, insulation, type of support, special connections, etc. shall be as per the manufacturer’s specifications. For special considerations, Noveon technical cell to be contacted for further details.”

14.6 Special fittings :

“ All special fittings and accessories like internally or externally threaded brass adaptors, ball valves, globe valves, unions shall be of **CPVC**.

14.8 Treatment for external exposed piping :

All external **CPVC** pipes shall be coated with an acrylic water based paint.

14.9 Insulation :

Insulation for the concealed CPVC pipes shall be glass wool, asbestos rope or nitrile rubber based

15 SPECIFICATION FOR PP-R (PP-RANDOM COPOLYMER) PIPES

15.1 MATERIAL: Pipe manufactured as per DIN 8079 & 8077 And fittings as per DIN 16893. Green colour for concealed application & Sky blue colour with UV protection for outdoor application.

15.2 POLYFUSION WELDING : Joints of the indo green pipes & fittings are usually jointed together by poly-fusion welding which is a fundamental property of this system. This process consists of mixing of melted material of external surface of the pipe & internal surface of the fitting, after heating them up to $260^{\circ}\text{C} \pm 10^{\circ}\text{C}$ on the small welding machine called poly-fusion device. Fusion process gives homogeneous, integral, long lasting, leak proof joints.

15.3 CUTTING: Cut the pipe square to the required length by cutter. Debur the cut end if necessary. Pipe ends must be clean cut at right angles.

15.4 CLEANING: Prior to welding, the pipe & fitting should be dried & properly cleaned.

- 15.5 **MARKING:** Mark the required insertion depth on the pipe with the help of suitable marker. This depth varies with the diameter of pipe & given in the table.
- 15.6 **HEATING:** Ensure that temperature of fusion device 270⁰C, this is indicated by switched off green LED. First weld can be made 2-3 minutes after green LED goes OFF. Heat the pipe & fitting times given on the polyfusion device as per the recommended heating times given in the table below. While heating the pipe & fitting in the matrices, apply light pressure from both sides. For diameters over 63mm you need scraper & assembly jig for welding.
- 15.7 **WELDING:** After specified heating time remove the pipe & fitting out of the matrices. Heated end of the pipe should be pushed into the flared end of the hot fitting down to the previously marked depth. Do not turn or twist the pipe or fitting while pushing in to the matrices & pulling out of the matrices.
- 15.8 **COOLING:** After the specified cooling time, the joint gets a first stiffness, after this phase next joint can be made. A double uniform ring of melted material around entire perimeter of the joints confirms good quality of the weld.
- 15.9 Pressure test must be carried out before concealing the pipe work.
- 15.10 PIPES [S] WALL THICKNESS

Diameter	PN 16		PN 20	
	Wall thickness	Internal diameter	Wall thickness	Internal diameter
16	2.3	11.4	2.7	10.6
20	2.8	14.4	3.4	13.2
25	3.5	18.0	4.2	16.6
32	4.5	23.0	5.4	21.2
40	5.6	28.8	6.7	26.6
50	6.9	36.2	8.4	33.2
63	8.7	45.6	10.5	42
75	10.4	54.2	12.5	50
90	12.5	65.0	15.0	60
110	15.2	79.6	18.4	73.2

16 EXCAVATION :

- 16.1 The width of excavation for sewers unless stated, shall be calculated by adding 250 mm. on

either side of the pipes. The excavation shall be carried out in such length as directed by the EIC. No permanent work shall be begun, until the Engineer has approved the excavation

16.2 Fencing, Lighting and Watching :

The contractor shall make proper provisions for protecting the work by providing appropriate fencing and by providing watching and lighting (at nights) arrangements as directed by the EIC.

The fencing posts of timber not be less than 75mm in diameter or 1.2 M above ground surface. Two horizontal rails, sufficiently long to run from post to post and 50 to 70mm. in dia., shall be fixed to these vertical posts, one near the top and the other 450mm. above ground.

Proper provision shall be made for lighting at night and watchman shall be kept to see that this is properly done. In the event of the contractor not fully complying with the provision of these clause, the EIC. may with or without notice to the contractors, put up a fence or improve the fence already put up or provide or improve the lighting or adopt such measures as he may deem necessary and all the cost of such procedure as may be adopted by the EIC. shall be borne by the contractors.

In addition to the normal lighting arrangements, the contractor shall provide, wherever a sewer work is in progress, battery operated blinking lights (6 volts) in the beginning and end of a trench with a view to provide suitable indication to the vehicular traffic. The contractor shall also provide and display special boards as per directions of EIC.

16.3 SHORING :

Wherever shoring may be deemed necessary by the EIC the Contractor shall provide the same in the best possible manner with the best material and to the satisfaction of the EIC. The contractor shall employ such kind or kinds of shoring as the EIC may consider the exigencies of the work to require and it is to be distinctly understood that the work 'shoring' is to comprise of such work and all appliances and appurtenances including polling boards, sheet piling and runners (whether the joints be butt, groove and tongue feather edge and groove, birds mouth and double splay, rebated or otherwise), together with walling struts props, point blank shores, raking shores, blocks, wedges, iron dogs, bolts, screws, nails and everything that may be required for due execution of the work.

Contractor's responsibility for secure shoring and or all damages :

The contractors will be held responsible for providing secure shoring and for adopting

every other precaution which may be necessary or proper for protecting any building which may be damaged or be liable to damage by the excavation of any trench or otherwise by the execution of the works in the vicinity of such building. If the EIC shall require the adoption of any special or extra measures or precautions, the contractors shall forthwith adopt and supply the same but this provision is not to be read or understood as in any degree of relieving the contractors from responsibility or from liability under clause 53 of General Condition of Contract, in respect of Claims made against the corporation by the execution of any of the works or otherwise. After the work is completed near buildings, the contractors shall remove any shoring and make good any cutting out or other damage that may have been done.

16.4 Ventilation :

The contractor shall provide adequate ventilation and efficient apparatus to keep all excavations, trenches, sewers and manholes free from all gases and he shall take precautions to ascertain that they are in a safe condition before allowing workmen to proceed.

16.5 Pumping Out Water :

The contractors shall provide and work at their own cost all pumps, engines and machinery requisite to keep the trenches for the sewers, drains or foundations and all other excavations clear of water, whether sub-soil water, storm water, leakage from tanks, well drains, sewers, water mains, tide water etc. so that there may be no accumulations of such water and that no setting out may be done, no masonry may be laid, no concrete deposited, no joints made and no measurements taken in water. The pumping shall be continued so long after execution of any portion of work and repeated so after as the EIC may consider as necessary. The pumps and power applied must be such as the EIC may determine to be sufficient at any particular time, or he may himself supply pumps and power at contractor's expenses, so he may stop the work altogether until he is satisfied and also impose a fine upon the contractors. The rate excavation includes pumping out any quantities of water as mentioned above by using any number of pumps and for any length of time singly or in combination, Nothing extra, whatsoever, will be payable on account of this.

16.6 Keep excavation clear of water :

Where ground water is encountered or anticipated, the contractor shall provide sufficient pumps to handle the ingress to water and must provide and maintain in working order

standby pumping units to be available and employed in the event of mechanical failure. The contractor must also arrange for night and day manning and operating of the pumps wherever necessary to ensure that at all times and whether the work may proceed.

The Contractors shall not allow any accumulation of water either from the discharge of their dewatering pumps or their water connection on the site of their work. If an accumulation is unavoidable, it shall be treated with insecticides to the satisfaction of the Consultant. In case of failures to do this on the part of the Contractors, such accumulation shall be treated by Consultants at the cost of contractors.

16.7 Cleaning of the Pipes :

It shall also be ascertained by the contractors that each stretch from manhole to manhole is absolute clear and without any obstruction on visual examination of the interior of the pipe line suitably enlightened by projected sunlight or otherwise

16.8 Fracture of Pipes :

Any pipe or length of pipe found to be defective shall be immediately removed and replaced at the contractors expenses, and leakage joints shall be remade, the inspection tests shall then be repeated as often as necessary, until the whole line under inspection or test is accepted by the EIC.

16.9 All works to be cleared, clean and perfect :

The contractors, shall after completion or whenever required by the EIC, prove all pipes and fittings to be clear, clean and perfect, and for this purpose shall, at their own expense and in the presence of the Engineer, or his appointee provide suitable instruments and appliances and pass them through the pipes and shall if required, throw in water and show that it passed freely through every portion of the work. Bricks, mortar and rubbish shall not be allowed to fall in into the manholes or sewer lines while fixing or if allowed shall be removed by the Contractor at their own expense.

17 WATER TREATMENT PLANT:

- 17.1 The supply of equipment's & their erection including electrification & inter - connecting pipe work shall be complete in all respects & any equipment not covered in this specification but considered essential by the contractor in order to guarantee the proper operation of the plant shall be include in the quotation. The necessary equipment's, their expected performance & their disposition in the plant are all indicated in the

specification & the drawing. However, if the contractor desires he may suggest alternative equipment's & their layout capable of meeting the requirements of final water quality as well as the area & head room restrictions within the plant room.

17.2 Standards:

The components of all equipment's shall be designed, assembled & tested in accordance with the latest standards of the ISI. The component of all plants & equipment's shall conform to the latest relevant standards published by the ISI in order that specific aspects under the Indian Condition are taken care of.

17.3 Inlet quality TDS 1000 ppm, Hardness 750ppm, Calcium 200ppm.

17.4 Outlet quality TDS 250ppm, Hardness 100ppm, Calcium 20ppm.

17.5 EQUIPMENT:

17.5.1 The equipment's to be supplied & erected for the plant shall be constructed from first class material with first class workmanship to the satisfaction of the architects & consulting engineers. The equipment shall be shop assembled as far as possible, except where the assembly is required to be done at site.

17.5.2 The Items listed below are for the general guidance of the contractor. The contractor shall include all items essential for the complete water filtration plant & shall revise or modify the list & submit his tender on the list which he considers suitable for guaranteeing the Performance of the plant.

Filter vessel & pumps.

Alum & chlorine dosing tanks.

Alum & chlorine dosing pumps.

A set of external control valve should be provided on all piping for raw water inlet, water outlet, backwash inlet & backwash outlet indicating pressure gauge for the inlet & outlet pressure pipes with cocks & connecting piping.

LIST OF APPROVED MAKES

SR.NO.	DESCRIPTION	MATERIAL SPECIFICATION
1	EXTERNAL DRAINAGE LINE	UPVC DRAINAGE CLASS FOAMCORE ASTRAL SN 8
2	GULLY TRAP TO CHAMBER CONNECTION PIPE	STONEWARE FIRST CLASS

SR.NO.	DESCRIPTION	MATERIAL SPECIFICATION
3	MANHOLE & GULLY TRAP COVERS	CAST IRON DOUBLE SEAL MEDIUM DUTY
4	SEWER TRAP	STONEWARE FIRST CLASS
5	STORMWATER DRAIN	RCC HUME PIPE OF NP2 CLASS
6	CATCH BASIN COVERS	CAST IRON MEDIUM DUTY
7	SW CHANNEL COVERS	DI MEDIUM DUTY
8	RAIN WATER PIPES	CAST IRON CENTRY PIPES
9	SOIL, WASTE & VENT PIPES	CAST IRON CENTRY PIPES
10	ANTI PIPES	CAST IRON CENTRY PIPES
11	FLUSHING & DOMESTIC WATER SUPPLY PIPE	CPVC PIPES WITH CPVC FITTINGS
12	CP FITTING	AS PER CLIENT APPROVED MAKES
13	SANITARY WARE	AS PER CLIENT APPROVED MAKES
14	KITCHEN SINK	STAINLESS STEEL

NO.	LIST OF MATERIALS	NAME OF MANUFACTURER
1	Sanitary ware	1. Hindware
		2. Parryware
		3. KOLHAR
2	C.P fittings	1. Jaquar
		2. TOTO
		3. KOLHAR
3	Flush tanks	1. VIEGA
		2. GEBERIT
4	WATER HEATER	1. SPHERE HOT
		2. RACLOD
5	S S SINK	1. NIRALI
		2. FRANKI
6	S.S. Pipes	1) VIEGA
		2) SATYAM
7	G.I./M.S. Pipes	1) TATA
		2) ZENITH
		3) JINDAL
8	G. I. Fittings SCREWED	1) ZOLOTO
		2) `R' Marked
		3) ISI marked KIRITI
9	G. I. Fittings WELDED	1) ZOLOTO
		2) `R' Marked
		3) ISI marked KIRITI
10	PVC Pipes & Fittings	1. ASTRAL
		2. Supreme

11	Stoneware Pipes	1. Gorco
		2. Rajura ceramics
		3. Bharat ceramics
12	C.I. LA Class Pipes & Fittings	1. NECO
		2. Kesoram
		3. Electro Steel
13	R.C.C. Hume Pipe	1. K. K. Industries
		2. Pranali
		3. INDIAN HUME PIPE CO
14	C.I. soil variety pipes & fittings	1. NECO.
		2. KAPILANSH
15	SS PIPES	1. SATYAM
		2. VIEGA
16	SS PIPES FITTINGS	1. SATYAM
		2. VIEGA
17	CPVC PIPE & FITTINGS	1. Astral MAKE
		2. Ashirwad
18	Sluice Valve	1. Kirloskar
		2. Indian Valve Co.
19	BRASS BALL VALVE	1. RB MAKE
		2. Zoloto
20	Gate valve (All ISI Mark)	1. Zoloto
		2. Leader

21	PRESSURE REDUCING VALVE	1. TATA HONEYWELL
		2. RB MAKE (ITELY)
		3. VERIE MAKE
22	NON RETURN VALVE GM	1. ZOLOTO
		2. LEADER
23	Insulation	1. THERMAFLEX
		2. ARMAFLEX
24	CI STRAINER (BUCKET Type)	1. ZOLOTO
		2. VIKING
		3. SANT
25	BUTTERFLY VALVE	1) Audco India
		2) Honeywell
		3) ZOLOTO
26	SENSOR AUTO Urinal Flash valves & Basin mixers	1. Geberit
		2. ASKON
		3. JAQUAR

27	Fire Pumps, Hydro Pumps, Sump Pumps, Sewage pumps, Water Transfer Pumps, Their Panels & connecting equipemnts.	1. H.B.D. (DP)
		2. Grundfoss
28	Motor	1. Kirloskar
		2. Bharat Bijlee
		3. ABB
29	Air blower	1. Kay
		2. Avrest
30	Air compressor	1. Elgi
		2. Ingersol Rand
31	Dosing pump	1. Asia LMI
		2. Rototek
32	Sewage treatment plant & WATER Filtration systems	1. Thermax
		2. KAWN
		3. EUREKA FORBS
		4. ION Exchange

7.0 FIRE DETECTION ALARM SYSTEM

Following codes and standards are made part of this specification:

Table 9: Codes for Fire Detection Alarm System

Codes	Description
BIS 15908 -	Selection, Installation and Maintenance of Control and Indicating Equipments for Fire Detection and Alarm System--Code of Practice (2011)
IS:2189:1988	- Code of practice for selection, installation and maintenance of Automatic Fire Detection and alarm system (second revision)

A. Codes & Standards

UL-50	Cabinets and Boxes
UL-268	Smoke Detectors for Fire Protective Signaling Systems
UL-864	Control Units for Fire Protective Signaling Systems
UL-268A	Smoke Detectors for Duct Applications
UL-521	Heat Detectors for Fire Protective
UL-228	Door Closers-Holders for Fire Protective Signaling Systems
UL- 464	Audible Signaling Appliances
UL-38	Manually Actuated Signaling Boxes
UL-346	Water-flow Indicators for Fire Protective Signaling Systems
UL-1481	Power supplies for Fire Protective Signaling Systems.
UL-1076	Control Units for Burglar Alarm
UL-1971	Visual Notification Appliances
UL-318	Clean Room Application (9th Edition)

NFPA-72, 2013 Edition: General System Design Guideline

NBC, 2005: National Building Code of India

Local AHJ: All requirements of Authorities Having Jurisdiction.

B. Mandatory Approvals

- UL listing
- ULC listing
- FM approval

C. Approved Makes

- Simplex (Tyco) (UL & FM Approved)
- Notifier (Honeywell) (UL & FM Approved)

D. Generic System Capabilities

- i. Analogue addressable microprocessor-based fire alarm system with initiating devices, notification appliances, monitoring and control devices as indicated on the drawings and as specified herein.
- ii. The system shall be capable of on-site programming to accommodate system expansion and facilitate changes in operation.
- iii. All software operations shall be stored in a non-volatile programmable memory within the fire alarm control unit. Loss of primary and secondary power shall not erase the instructions stored in memory.
- iv. Panels shall be capable of full system operation during new site specific configuration download.
- v. Remote panel site-specific software and executive firmware downloads shall be capable of being performed over proprietary fire alarm network communications and via TCP/IP Ethernet network communications. Ethernet access to any fire alarm panel shall be capable of providing access only to authenticated users through a cryptographically authenticated and secure SSL tunnel.
- vi. Panels shall automatically store all program changes to the panel's non-volatile memory each time a new program is downloaded. Panels shall be capable of storing the active site-specific configuration program and no less than 9 previous revisions in reserve. A compare utility program shall also be available to authorized users to compare any two of the saved programs. The compare utility shall provide a deviation report highlighting the changes between the two compared programs.
- vii. Panels shall provide electronic file storage with a means to retrieve a record copy of the site-specific software and up to 9 previous revisions. Sufficient file storage shall be provided for other related system documentation such as record drawings, record of completion, owner's manuals, testing and maintenance records, etc.
- viii. The media used to store the record copy of site-specific software and other related system documentation shall be electrically supervised. If the media is removed a trouble shall be reported on the fire alarm control panel.
- ix. The system shall provide a means to recall alarms and trouble conditions in chronological order for the purpose of recreating an event history. A separate alarm and trouble log shall be provided.

E. Wiring & Signal Transmission

- i. Transmission shall be hard-wired using separate individual circuits for each zone of alarm operation, as required or addressable signal transmission, dedicated to fire alarm service only.
- ii. System connections for initiating device circuits shall be Class A.
- iii. Initiating device circuits/detection loop shall be wired with 2-core, Copper Conductor, 1.5 sqmm (16 AWG), twisted pair FRLS cable of approved makes.
- iv. Notification Appliance Circuits shall be wired with 2-core, Copper Conductor, 1.5 sqmm (16 AWG), twisted pair FRLS cable of approved makes.
- v. Speaker Circuit shall be wired with audio cable.
- vi. The Fire Fighter Telephone line, Notification Appliance Circuit and Voice Evacuation cum Public Address Pathway shall be wired with 2 hour fire rated shielded cable of mentioned specification & approved make.
- vii. Terminations shall be done with proper ATC lugs with insulated sleeves.
- viii. Circuit faults shall be indicated by a trouble signal at the FACP. The system shall provide a distinctive indicating audible tone and alphanumeric annunciation.
- ix. Addressable Short-Circuit Isolators shall be provided at an interval of every 20 devices on a detection loop as a general thumb rule. However, it shall be ensured that a single short circuit or open-circuit fault on an automatic fire detector circuit/detection loop shall neither disable protection within an area of more than 2,000m², nor on more than one floor of the building plus a maximum of five devices (automatic detection, manual call points, sounders or a combination of these) on the floor immediately above and five devices on the floor immediately below that floor.
- x. Circuit faults shall be indicated by a trouble signal at the FACP. The system shall provide a distinctive indicating audible tone and alphanumeric annunciation.
- xi. When provided, audio notification appliance circuits shall be supervised during standby by monitoring for DC continuity to end-of-line resistors.

F. Remote Access

- i. Fire Alarm Control Panel (FACP) shall have the capability to provide a remote service access feature using Ethernet and TCP/IP communications protocol. The Remote Access feature shall provide automatic notification of system faults and remote diagnostics of system status for responding technicians prior to arrival on site.
- ii. The internet remote access service function shall provide automated real time off-site reporting of discrete system events to a remote service support center with details of internal FACP fault conditions allowing a pre-site visit analysis of repair requirements.
- iii. Existing FACP controls shall be capable of retrofitting the Remote Service module as a plug-in

upgrade feature.

- iv. The remote service network shall work on the customers Ethernet infrastructure and be Fire-Wall friendly for two-way communications for off-site reporting. The feature shall be compatible with existing proxy servers and firewalls shall not require any special changes or modifications.
- v. The remote service system shall be a non-Windows based application to protect against conventional virus attacks.
- vi. The remote service system shall be compatible with virtual LANS (VLAN).
- vii. The remote service system shall work on an outbound communication premise (panel calls home) in order to eliminate the possibility of any inbound connection into the network (from trusted or non-trusted sites).
- viii. The remote service system shall have capability to provide an audit trail of all events and service connections.
- ix. The FAS shall be compatible to Remote Service program that provides the following requirements if asked for:
- x. 24/7 recording of FACP service activity

Off-site diagnostics by a technical specialist to provide repair and parts guidance to the service technician prior to a site visit.

- i. Network Communication
- ii. Network node communication shall be through a token ring, hub, or star topology configuration, or combination thereof.
- iii. A single open, ground or short on the network communication loop shall not degrade network communications. Token shall be passed in opposite direction to maintain communications throughout all network nodes. At the same time the status of the communication link shall be reported.
- iv. If a group of nodes becomes isolated from the rest of the network due to multiple fault conditions, that group shall automatically form a sub-network with all common interaction of monitoring and control remaining intact. The network shall be notified with the exact details of the lost communications.
- v. Fiber optics communication shall be provided as an option via a fiber optics modem. Modem shall multiplex audio signals and digital communication via full duplex transmission over a single fiber optic cable, either single mode or multi-mode.
- vi. The communication method shall be in accordance to NFPA 72 style 7.
- vii. Network communication shall be "Peer-to-Peer" and the complete or filtered event indication shall

be possible in keeping with the system architecture and requirements of this document.

- viii. Initiating device signals, voice signals and cause-n-effect logic shall travel in seamless and hassle-free manner over the FDA network communication channel and even the worst condition load / full load shall keep the response time within the limit specified by NFPA-72 / 2013 edition.

G. Required Functions

- i. Operator Console/HMI: The operator console/HMI shall offer the means to display, monitor and control all the ALARM, TROUBLE and SUPERVISORY signals from the initiating devices connected to the FACP. The operator console/HMI shall meet the specifications mentioned for it under “Product Specification” part of this document.
- ii. Annunciation: Operation of ALARM, TROUBLE and SUPERVISORY initiating devices shall be annunciated at the FACP and the Remote Annunciator indicating the type of device, the operational state of the device (Alarm, Trouble or Supervisory) and shall display the custom label associated with the device.
- iii. Priority of Signals: Fire Alarm events shall have highest priority. Subsequent alarm events are queued in the order received and do not affect existing alarm conditions. Priority Two, Supervisory and Trouble events have second, third, and fourth-level priority, respectively. Signals of a higher-level priority take precedence over signals of lower priority even though the lower-priority condition occurred first. However, all the events shall be annunciated regardless of priority or order received.
- iv. Non interfering signals: An event on one zone does not prevent the receipt of signals from any other zone. All zones are manually resettable from the FACP after the initiating device or devices are restored to normal. The activation of an addressable device does not prevent the receipt of signals from subsequent addressable device activations.
- v. Alarm: A system alarm shall include:
 1. Indication of alarm condition at the FACP and at the annunciators.
 2. Identification of the device / zone triggering alarm at the FACP and the annunciators.
 3. Operation of audible and visible notification appliances until silenced at FACP.
 4. Selectively closing doors normally held open by magnetic door holders on the fire floor, floor above and floor below.
 5. Unlocking designated doors.
 6. Shutting down supply and return fans serving zone where alarm is initiated.
 7. Closing smoke dampers on system serving zone where alarm is initiated.
 8. Initiation of smoke control sequence as defined.
 9. Transmission of signal to the supervising station.

- vi. Alarm Silencing: If the "Alarm Silence" button is pressed, all audible signals shall cease operation. The visible signals shall be off at Panel Reset.
- vii. System Reset: System Reset shall do the following
 - 10. The "System Reset" button shall be used to return the system to its normal state. Display messages shall provide operator assurance of the sequential steps ("IN PROGRESS", "RESET COMPLETED") as they occur. The system shall verify all circuits or devices are restored prior to resetting the system to avoid the potential for re-arming the system. The display message shall indicate "ALARM PRESENT, SYSTEM RESET ABORTED."
 - 11. Should an alarm condition continue, the system will remain in an alarmed state.
- viii. Supervisory Operations: Upon activation of a supervisory device such as a fire pump power failure, low air pressure switch, and tamper switch, the system shall operate as follows
 - 12. Activate the system supervisory service audible signal and illuminate the LED at the control unit and the remote annunciator.
 - 13. Pressing the Supervisory Acknowledge Key will silence the supervisory audible signal while maintaining the Supervisory LED "on" indicating off-normal condition.
 - 14. Record the event in the FACP historical log.
 - 15. Transmission of supervisory signal to the supervising station.
 - 16. Restoring the condition shall cause the Supervisory LED to clear and restore the system to normal.
- ix. Evacuation (Drill) Switch: Evacuation / Drill Switch shall be provided to operate the notification appliances without causing other control circuits to be activated.
- x. Walk Test: The system shall have the capacity of 8 programmable pass-code protected one person testing groups, such that only a portion of the system need be disabled during testing. The actuation of the "enable one person test" program at the control unit shall activate the "One Person Testing" mode of the system as follows:
 - 17. The city circuit connection and any suppression release circuits shall be bypassed for the testing group.
 - 18. Control relay functions associated with one of the 8 testing groups shall be bypassed.
 - 19. The control unit shall indicate a trouble condition.
 - 20. The alarm activation of any initiating device in the testing group shall cause the audible notification appliances assigned only to that group to sound a code to identify the device or zone.
 - 21. The unit shall automatically reset itself after signaling is complete.
 - 22. Any opening of an initiating device or notification appliance circuit wiring shall cause the audible signals to sound for 4 seconds indicating the trouble condition.
- xi. Spoken Walk Test: In case the system is equipped with Integrated Voice Evacuation and Public

Address System, the Walk Test shall have an option to notify the findings of each device through voice notification.

- xii. Install Mode: The system shall provide the capability to group all non-commissioned points and devices into a single "Install Mode" trouble condition allowing an operator to clearly identify event activations from commissioned points and devices in occupied areas.
- 23. It shall be possible to individually remove points from Install Mode as required for phased system commissioning.
- 24. It shall be possible to retrieve an Install Mode report listing that includes a list of all points assigned to the Install Mode. Panels not having an install mode shall be reprogrammed to remove any non-commissioned points and devices.
- xiii. Service Gateway: The system shall be compatible to a service gateway as described. If asked for a Service Gateway software application shall be provided that allows an authorized service person to remotely query panel status during testing, commissioning, and service without the need to return to the panel using standard email / Instant Messaging Tools / Smart Phones / Tablets / I Pads etc.

Product Specification

1. Fire Alarm Control Panel (FACP)

- 1.1. Microprocessor based Fire Alarm Control Panel (FACP) with 80 character displaying at least 600 or more characters in multiple lines at a time and shall accommodate the no. of detection loops and the quantity of field devices mentioned in the commercial BOQ. The HMI shall have at least 5 or more customer programmable buttons with LED indication in order to freely configure its programmed response as per project requirement.
- 1.1. Each Detection Loop of FACP shall accommodate, monitor and control a minimum of 250 intelligent addressable devices in any combination. The exact combination of the field devices in a detection loop shall be at the discretion of the design consultant based on the project requirement & System Design. However, the System Proposed by the Solution Provider / System Integrator shall accommodate all the field devices / components and shall meet all the requirements mentioned in the commercial BOQ.
- 1.2. FACP shall connect all the field devices (Detectors, MCPs, Control Modules, Monitor Modules, Hooter cum Strobes etc.), shall fully monitor them and communicate to them for their status and shall be able to take intelligent decision of ALARM, TROUBLE, SUPERVISORY based on the programmed cause-n-effect logic. It should have an interactive HMI (display cum operation interface), with status monitoring LEDs for AC Power, Fire Alarm, System Trouble, System

Supervisory, Ground Fault and shall have at least 5 programmable switch with LED for seamless operation & maintenance.

- 1.1. FACP shall be UL and ULC listed and FM approved.
- 1.2. FACP shall comply to UL-864 9th edition.
- 1.3. FACP shall have a dedicated mass storage memory to store project related critical back-up like Auto-CAD as-built drawings, reports, logs, customer-text files etc in line with NFPA-72, 2013 requirements. The memory shall be fully monitored by the FACP CPU and shall be password-protected.
- 1.4. FACP shall support multiple System Power Supplies and Expansion Power Supplies in cascade to ensure the optimum power as required by the system load and system design.
- 1.5. Each power supply shall provide total of 9 Amp current out of which 2 Amp per NAC shall be dedicated to the current requirement of Notification Appliance Circuit.
- 1.6. FACP shall house 2 nos. of 50 AH batteries in its own housing and shall have the proper, trouble-free charging capacity for them. However, the FACP shall be able to charge up to 110AH of batteries if required by the system design and system load.
- 1.1. FACP shall have the networking capability with the other control panels of same family by adding a network module.
- 1.2. FACP shall be compatible to Modbus over RS-232, Modbus over RS-485, Modbus over IP and Bacnet over IP as different open protocol variants for 3rd party Integration. Exact variant and module shall be considered as mentioned in commercial BOQ. The selection of exact protocol variant shall be at sole discretion of the design consultant based on the project & system requirement. Any deviation in this regard needs a prior formal approval of the design consultant.
- 1.3. FACP shall be compatible to seamless integration of aspiration system via application specific interface module. The FACP shall be able to view, monitor and control the aspiration system from its HMI.
- 1.4. FACP shall have peak value logging capability and shall be able to analyse the peak value of individual sensors for individual sensitivity selection.
- 1.5. FACP shall provide min 5 or more RS-232 ports for printers and other serial port utilities.
- 1.6. FACP shall have IP communication capability.
- 1.7. FACP shall have battery brackets for seismic area protection.
- 1.8. FACP shall support the intelligent Cause-n-Effect programming based on the Boolean logic or equivalent to ensure the achievement of complete system functionality as required by this document.
- 1.9. FACP shall be capable of indicating different events of varying priority and shall be able to map those events in intelligent cause-n-effect logic to achieve “Positive Alarm Sequence” and

notification activation & deactivation as required by “Cause-n-Effect” programming. The exact requirement of cause-n-effect will depend at sole discretion of design consultant in line with the code requirement and protected premise requirement.

- 1.10. FACP shall be capable of delivering all the functionalities mentioned under “Required Functions” of this document in “General Specification” part.
- 1.11. FACP shall support Integrated Voice Evacuation cum Public Address System and Integrated Fire Fighter Telephone system as an integral part of the FDA system. The Integrate Voice Evacuation System and Integrated PA system shall be of same make as that for FDA system and shall be configured with the same software tool that is used for the FDA (Fire Detection & Alarm) system configuration to ensure seamless, effective and hassle-free “ALERT” & “EVACUATION” announcement.
- 1.12. FACP shall support priority setting of various events.
- 1.13. FACP shall support the password protected authority level & assignment.
- 1.14. FACP shall have forward and backward compatibility with various generations of devices in its family to protect client’s investment.
- 1.15. FACP shall support distributed architecture / arrangement for the components of the same control panel / Network Node where it shall allow the mounting of various components like analogue addressable detection loop interfaces, amplifiers, fire fighter telephones, power supplies and other accessories in multiple remote enclosures at different locations away from the main FACP to facilitate effective and efficient field wiring terminations, avoid unnecessary cable runs. However, the functionality of the FACP shall be intact. A single communication failure between FACP and remote enclosures shall not affect any system performance (but report the trouble condition at FACP) and complete communication failure (by multiple discontinuities or short-circuits) of a remote enclosure shall enable it to operate as a conventional system and report the complete status of the trouble at the FACP.
- 1.16. FACP shall be UL & ULC listed and FM approved.

2. Photoelectric Optical Smoke Detector

- 2.1. Photoelectric Smoke Detector shall offer multiple selectable sensitivity levels from 0.2% Obs/ft to 3.7% Obs/ft in order to customize the sensitivity settings.
- 2.2. Optical Smoke Detector shall have automatic drift compensation or environmental compensation capability for different contamination level of different areas in order to counter nuisance alarm.
- 2.3. Optical Smoke detector shall have selectable bases with Response Indicator, Isolator, Sounder, Relay and CO detection capability as an option so that the best fit solution is selected depending on the requirement.

- 2.4. Optical Smoke detector shall have manual DIP switch addressing method that does not require any special tool from manufacturer and commissioning activity for replacing the detector in case the detector goes faulty.
- 2.5. Optical Smoke Detector shall have an operating temperature range of -9°C to 50°C and humidity range up to 95% RH non-condensing.
- 2.6. Optical Smoke Detector shall be UL & ULC listed and FM approved.

3. Multi Sensor Detector

- 3.1. The multi sensor detector shall be an intelligent digital photoelectric detector with a programmable heat detector
- 3.2. Multi Sensor Detector shall offer multiple selectable sensitivity levels from 0.2% Obs/ft to 3.7% Obs/ft in order to customize the sensitivity settings.
- 3.3. Heat Detection shall have two selectable rate of temperature rise thresholds of 8°C per minute & 11°C per minute (or close to this value not deviating by more than 1°C) selectable from the FACP.
- 3.4. Heat Detection shall have two fixed temperature alarm thresholds of 57°C and 68°C (or close to this value not deviating by more than 1°C) configurable from the FACP.
- 3.5. Multi Sensor Detector shall have automatic drift compensation or environmental compensation capability for different contamination level of different areas in order to counter nuisance alarm.
- 3.6. Multi Sensor detector shall have selectable bases with Response Indicator, Isolator, Sounder, Relay and CO detection capability as an option so that the best fit solution is selected depending on the requirement.
- 3.7. Multi Sensor detector shall have manual DIP switch addressing method that does not require any special tool from manufacturer and commissioning activity for replacing the detector in case the detector goes faulty.
- 3.8. Multi Sensor Detector shall have an operating temperature range of -9°C to 50°C and humidity range up to 95% RH non-condensing.
- 3.9. Multi Sensor Detector shall be UL & ULC listed and FM approved.

4. Rate of Rise cum Fixed Temperature Heat Detector

- 4.1. Heat Detector shall have both Rate of Rise Temperature operation and Fixed Temperature operation freely configurable as per requirement of site.
- 4.2. Heat Detector shall have two selectable rate of temperature rise thresholds of 8°C per minute & 11°C per minute (or close to this value not deviating by more than 1°C) selectable from the FACP.
- 4.3. Heat Detector shall have two fixed temperature alarm thresholds of 57°C and 68°C (or close to this value not deviating by more than 1°C) configurable from the FACP.

- 4.4. Heat Detector shall have selectable bases with Response Indicator, Isolator, Sounder, Relay and CO detection capability as an option so that the best fit solution is selected depending on the requirement.
- 4.5. Heat Detector shall have manual DIP switch addressing method that does not require any special tool from manufacturer and commissioning activity for replacing the detector in case the detector goes faulty.
- 4.6. Heat Detector shall have an operating temperature range of 0°C to 50°C and humidity range up to 95% RH non-condensing.
- 4.7. Heat Detector shall be UL & ULC listed and FM approved.

5. Manual Pull Station

- 5.1. Manual Pull Station shall be addressable and shall sit on the detection loop of the FACP and shall communicate to the FACP to report its status.
- 5.2. Manual Pull Station shall require dual action to generate a manual fire alarm.
- 5.3. Manual Pull Station shall have an operating temperature range of 0°C to 49°C and humidity range up to 93% RH non-condensing.
- 5.4. Manual Pull Station shall have manual DIP switch addressing method that does not require any special tool from manufacturer and commissioning activity for replacing the Manual Pull Station in case it goes faulty.
- 5.5. Manual Pull Station shall be UL and ULC listed and FM approved.

6. Addressable Hooter with Strobe

- 6.1. Hooter with strobe should be true addressable system.
- 6.2. Hooter with Strobe unit shall have both audible and visual output units housed within the same device. The audible output shall be multi-tone horn output up to 98DB and strobe output shall have selectable intensity of 15, 30, 75 and 110 candela.
- 6.3. Strobe unit shall have a flash rate of 1Hz synchronized throughout the Fire Alarm Network.
- 6.4. Hooter with Strobe unit shall be connected to the NAC of FACP and it shall be fully monitored by FACP.
- 6.5. Hooter with Strobe unit shall report its status with configured parameters of each unit (hooter and strobe) to FACP.
- 6.6. Hooter with Strobe unit shall support individual field testing in “Silent Mode” and “Non-Silent Mode” (full operational mode).
- 6.7. If asked for, it shall be possible for FDA system to generate, print and e-mail the diagnostic report of notification devices with tested and verified parameters.

- 6.8. Hooter with Strobe unit shall be controlled independently on the same 2-Core NAC as per programmed activation and deactivation criteria or from the FACP. Audible (hooter) and Visible (strobe) outputs shall be independently configurable from FACP for its activation and deactivation criteria as required.
- 6.9. In absence of any specific mention of activation and deactivation criteria, the hooter shall stop at “Alarm Acknowledge” or “Alarm Silence” and the strobe shall stop at “System Reset” or “Panel Reset”. This requirement shall not be deviated from unless otherwise stated cause-n-effect configuration or unless a formal written approval is taken from the design consultant.
- 6.10. It shall be possible to poll each and every hooter with strobe unit from the HMI / Display / Operator Console at FACP, isolate and include in the circuit (NAC), activate and deactivate, view the voltage received by it from the HMI / Display / Operator Console at the FACP & Network Repeater.
- 6.11. It shall be ensured that the last notification device at respective NAC receives at least 20Vdc (or 3 V above the min operating voltage) to ensure the desired performance. There shall be a provision to verify the same either from FACP or a hand-held testing device.
- 6.12. Hooter with Strobe unit shall support individual performance check by a hand-held testing tool during in “Silent-Mode” or “Sound-Mode” to facilitate performance check during normal working hour.
- 6.13. Hooter cum Strobe shall have an operating temperature range of 0°C to 50°C and humidity range up to 93% RH non-condensing.
- 6.14. Hooter with Strobe unit shall be UL and ULC listed and FM approved.

7. Addressable Hooter / Horn

- 7.1. Hooter/Horn should be true addressable system.
- 7.2. The audible output shall be multi-tone selectable horn output from 85 DB up to 98DB.
- 7.3. Hooter shall be connected to the NAC of FACP and it shall be fully monitored by FACP.
- 7.4. Hooters shall be controlled independently on the same 2-Core NAC as per programmed activation and deactivation criteria or from the FACP.
- 7.5. It shall be possible to poll each and every hooter from the HMI / Display / Operator Console at FACP, isolate and include in the circuit (NAC), activate and deactivate, view the voltage received by it from the HMI / Display / Operator Console at the FACP & Network Repeater.
- 7.6. Hooter shall report its status with configured parameters to FACP.
- 7.7. Hooter shall support individual field testing in “Silent Mode” and “Non-Silent Mode” (full operational mode).

- 7.8. If asked for, it shall be possible for FDA system to generate, print and e-mail the diagnostic report of notification devices with tested and verified parameters.
- 7.9. It shall be ensured that the last notification device at respective NAC receives at least 20Vdc (or 3 V above the min operating voltage) to ensure the desired performance. There shall be a provision to verify the same either from FACP or a hand-held testing device.
- 7.10. Hooter shall have an operating temperature range of 0°C to 50°C.
- 7.11. Hooter shall have humidity tolerance range up to 93% RH non-condensing.
- 7.12. Hooter shall be UL and ULC listed and FM approved.

8. Addressable Strobe

- 8.1. Strobe should be true addressable system.
- 8.2. Strobe shall have selectable intensity levels of 15, 30, 75 & 110 cd and shall be configured and selected from FACP.
- 8.3. Strobe shall be connected to the NAC of FACP and it shall be fully monitored by FACP.
- 8.4. Strobe shall be controlled independently on the same 2-Core NAC as per programmed activation and deactivation criteria or from the FACP.
- 8.5. It shall be possible to poll each and every strobe from the HMI / Display / Operator Console at FACP, isolate and include in the circuit (NAC), activate and deactivate, view the voltage received by it from the HMI / Display / Operator Console at the FACP & Network Repeater.
- 8.6. Strobe shall report its status with configured parameters to FACP.
- 8.7. Strobe unit shall support individual field testing with indication of configured and measurable intensity level.
- 8.8. If asked for, it shall be possible for FDA system to generate, print and e-mail the diagnostic report of notification devices with tested and verified parameters.
- 8.9. It shall be ensured that the last notification device at respective NAC receives at least 20Vdc (or 3 V above the min operating voltage) to ensure the desired performance. There shall be a provision to verify the same either from FACP or a hand-held testing device.
- 8.10. Strobe shall have an operating temperature range of 0°C to 50°C.
- 8.11. Strobe shall have humidity tolerance range up to 93% RH non-condensing.
- 8.12. Strobe shall be UL and ULC listed and FM approved.

9. Programmable Control Module

- 9.1. Control Module shall be addressable and shall sit on the detection loop of the FACP and shall communicate to the FACP to report its status.

- 9.2. Control Module shall provide programmable, power limited, potential-free, Form-C, SPDT Relay to control external 3rd party utilities in case of fire alarm.
- 9.3. Control Module shall have the contact rating of 2A@24Vdc (resistive) and 1A@24Vdc (inductive).
- 9.4. Control Module shall have an operating temperature range of 0°C to 49°C and humidity range up to 93% RH non-condensing.
- 9.5. Control Module shall have manual DIP switch addressing method that does not require any special tool from manufacturer and commissioning activity for replacing the control module in case it goes faulty.
- 9.6. Control Module shall be UL and ULC listed and FM approved.

10. Programmable Monitor Module

- 10.1. Monitor Module shall be addressable and shall sit on the detection loop of the FACP and shall communicate to the FACP to report its status.
- 10.2. Monitor Module shall supervise potential-free, NO (Normally Open) dry contacts in order to monitor the status of an external 3rd party device.
- 10.3. Monitor Module shall be configurable to report supervisory signal and alarm signal.
- 10.4. Monitor Module shall have an operating temperature range of 0°C to 70°C and humidity range up to 93% RH non-condensing.
- 10.5. Monitor Module shall have manual DIP switch addressing method that does not require any special tool from manufacturer and commissioning activity for replacing the monitor module in case it goes faulty.
- 10.6. Monitor Module shall be UL and ULC listed and FM approved.

11. Addressable Fault Isolator Module

- 11.1. Fault Isolators shall be addressable and shall sit on the detection loop of the FACP and shall communicate to the FACP to report its status.
- 11.2. Fault Isolators shall be dual port, bidirectional communication isolator so that it isolates the short-circuited wire of any side (left side or right side).
- 11.3. Fault Isolators shall be compatible to isolation from the FACP for the field diagnostic purposes.
- 11.4. Fault Isolator shall power up in isolated mode and shall be directed by FACP to connect the detection loop segment. It shall connect the detection loop segment only if the segment is short-circuit free and acceptable else shall remain in isolated mode to impart short-circuit survivability and tolerance to the remaining detection loop.

- 11.5. Fault Isolator shall be fully monitored and addressable by FACP. It shall report its status to the FACP and shall be controlled from FACP.
- 11.6. Fault Isolator shall have an operating temperature range of 0°C to 49°C and humidity range up to 90% RH non-condensing.
- 11.7. Fault Isolator shall have manual DIP switch addressing method that does not require any special tool from manufacturer and commissioning activity for replacing the fault isolator in case it goes faulty.
- 11.8. Fault Isolator shall be UL and ULC listed and FM approved.

12. Active Repeater Panel

- 12.1. Repeater panel should be active type where control switches should be available for system acknowledge, Alarm silence & system reset.
- 12.2. Lamp/LCD test should be possible.
- 12.3. Active Repeater panel should be UL and ULC listed and FM approved.

13. Fire Graphic Software

- 13.1. The proposed software should be from the same manufacture of fire alarm system & should be UL & FM approved.
- 13.2. To provide Annunciation, Status display, Monitoring & Control of each and every element connected to Fire Alarm System and Networks.
- 13.3. The software should have a capacity of 62,500 points or point lists.
- 13.4. Should be able to store 5,00,000 event logs.
- 13.5. Quad Monitor supports. Should support multiple active windows such as putting alarm list window in one monitor and the graphic window in another monitor.
- 13.6. Should be able to customize alarm & messages.
- 13.7. Pan & Zoom features within a graphic screen for rapid & convenient selection.
- 13.8. Multiple password option should be available in the software.
- 13.9. Should operate on Windows 7 32 bit Operating system.

14. Digital Voice Command Station

- 1.1. Digital Voice Command Station shall either be located at the FACP.
- 1.2. Digital Voice Command shall contain all equipments required for automatic voice evacuation, Public Address system, Two-way Fire Fighter Telephone communication, Audio Control, Audio Message configuration, Recorded Message storage, Back up for Audio files, Time bound Cause-n-Effect configuration, Audio Zone Selection & Annunciation, Fire Fighter Telephone Zone

selection & annunciation, Microphone, Telephone Handset and all other necessary accessories to complete the system requirements specified in this tender document.

- 1.3. Digital Voice Command Station shall operate as fully supervised multi-channel emergency voice communication system capable automatically announce “ALERT” & “EVACUATION” pre-recorded messages triggered via programmed Cause-n-Effect logic.
- 1.4. Digital Voice Command shall have a provision of manual paging in selected audio-zone / channel overriding any ongoing “ALERT” or “EVACUATION” message.
- 1.5. Digital Voice Command shall have provision of cause-n-effect logic controlled message selection, automatic announcement of the selected message in the selected zone and time-bound escalation of the voice evacuation with priority setting for different voice messages.
- 1.6. Digital Voice Command Station shall annunciate TROUBLE condition of individual speaker circuits, fire fighter telephone circuit, digital voice controllers, fire-fighter telephone controllers and of all other controllers, modules and accessories that are connected to it for proper functioning of the system.
- 1.7. Digital Voice Command Station shall have a provision of library of factory recorded voice messages, phrases and words to facilitate the flexible configuration of voice messages for automatic “ALERT” & “EVACUATION” announcement.
- 1.8. Digital Voice Command Station shall be modular in nature with regard to hardware and software features in order to facilitate the customized system configuration and customized voice evacuation cum manual paging.
- 1.9. Digital Voice Command Station shall provide “Ready to Talk” main microphone with zone selection capability.
- 1.10. Digital Voice Command Station shall support min 5 supervised remote microphone inputs.
- 1.11. Digital Voice Command Station shall be capable to either house the required no. of amplifiers in its own housing / enclosure or shall support a distributed amplifier assembly structure of customized power capacity. It shall not limit the location and capacity of amplifier-assembly as a system limitation.
- 1.12. Digital Voice Command Station shall support “Spoken Walk Test” which gives voice confirmation of the status of the tested devices under walk test.
- 1.13. Digital Voice Command Station shall be UL & ULC listed and FM approved.

15. Audio Amplifier

- 1.1. Audio Amplifier shall have capacity of min 50W (or more) with min 2 (or more) speaker circuits.

- 1.2. Audio Amplifier shall provide min 2 or more freely selectable audio channels to facilitate the announcement of min two simultaneous different messages controlled by cause-n-effect programming.
- 1.3. Multiple amplifiers of stated capacity and specification shall be mounted in a single enclosure/amplifier assembly which can either be at FACP location or away from it. The exact power capacity of amplifier assembly shall be configured as per the commercial BOQ which will be decided at sole discretion of the design consultant. Any deviation from commercial BOQ and System architecture shall have a prior formal approval of the design consultant. However, achieving the complete functionality as required in this document shall be binding on the solution provider in terms of responsibility.
- 1.4. Audio amplifier shall have the necessary power supply, monitoring mechanism, over-voltage and over-current protection, short-circuit detection & tolerance, earth fault detection and tolerance, primary and secondary power supply failure indication and other detection, monitoring and protection mechanism to ensure the complete, proper and trouble-free functionality as required by this document.
- 1.5. Audio amplifier shall offer multiple combinations of capacity distribution between 2-channels such as 0W & 50W, 25W & 25W, 10W & 40W or any other combination that totals to 50W.
- 1.6. Audio amplifier shall provide 70.7Vrms to the speaker circuit.
- 1.7. Audio amplifiers shall be UL & ULC listed and FM approved.

16. Speakers

- 1.1. Speakers shall have different variants for ceiling mount and wall mount and separate variants for red colour and white colour.
- 1.2. Speakers shall have multiple tapping options of 0.25W, 0.5W, 1W and 2W which shall be field selectable.
- 1.3. Speakers shall be compatible to the audio amplifier at 70.7Vrms line.
- 1.4. Speakers shall be capable of reliably and efficiently handling the frequency response from 400Hz to 4000Hz.
- 1.5. Speaker shall be capable to generate audio message up to 89 DB at 3 m (10 ft) from it.
- 1.6. Speaker shall have the operating temperature range of 0°C to 38°C.
- 1.7. Speaker shall have the humidity tolerance range from 10% to 95% RH, non-condensing.
- 1.8. Speaker shall be UL & ULC listed and FM approved.

17. Fire Fighter Telephone Station

- 1.1. Fire Fighter Telephone Station shall be complete with Telephone Jack, Handset and required accessories housed in a red coloured enclosure equipped with Magnetic Latch or Lock. The door of this unit shall indicate “FIRE WARDEN STATION” or equivalent message prominently.
- 1.2. Fire Fighter Telephone station shall be capable of two-way communication with the operator at command centre at FACP.
- 1.3. Operator at Command Centre shall be able to connect or disconnect to multiple simultaneous fire fighters / callers from the field with unambiguous addressability / identification of each caller.
- 1.4. It shall be possible for the operator at main command centre to set up a conference call among 5 or more fire fighters trying to speak to the operator at the main command centre.
- 1.5. The Fire Fighter Telephone Station / Fire Warden Station shall be UL & ULC listed and FM approved.

PA SYSTEM

1. General Description

The contractor shall supply, install, test, connect and commission a high quality fast-acting **Public Address and Voice Alarm System** complying strictly with BS 5839 part8 and EN60849 and shall be TUV or Equivalent Agency approved. The Public Address and Voice Evacuation System shall comprise of Audio Matrix Units, High quality speakers, Audio rack all mounted on a 19” Rack and fully connected and **integrated on the fire alarm loop**. The system shall be used for Professional Sound Reproduction for all the areas where possible special events take place.

Prior to placing order for any equipment, the contractor shall submit comprehensive document comprising working drawings, catalogues and descriptive literature of components, acoustic calculation to meet with BS5839 part8 RASTI (Room Acoustic Speech Transmission Index) requirements of 0.5 on the STI scale and 0,7 on the CIS scale. The contractor shall be required to train and instruct client's personnel in the correct use, operation and supervision of the system, preferably prior to the handing over of the project.

In order to ensure whole site integration capability, the fire and voice alarm system will be awarded to a single specialist local supplier who will be responsible for the design, global operation, management and interfacing of the system. The contractor shall make sure that all power tapping of the speakers must be carried out as specified, even if the acoustic calculations indicates less power tapings. The contractor must endure minimum of 10dB above the ambient noise levels are achieved.

The system shall be fully programmed to accommodate fire alarm and voice communication zones as indicated on the drawings and schematics. The system shall be configured to allow on site modifications

with the minimum of disruption using the PC based software to facilitate future changes or alterations to the buildings.

APPLICABLE STANDARD:

EVAC Compliant with IEC/EN60849
Loudspeakers -Rated power IEC 60286-Part 5
Tested in accordance with BSEN60268-5
Acoustic models ready for CATT, ULYSSES & EASE
Compliant with BS5839 Part 8
Battery backup/charger compliant with EN54 part 4

Scope of Work

The scope of work under this head shall include designing supplying and installing of Public Address System. The work under this system shall consist of furnishing all materials, equipment's and appliances and labour necessary to install the said system, complete with Speakers, Amplifiers, Microphone, Zone Selection Panel for interfacing with other systems.

The PA system is designed to serve the dual purpose of making general announcement and Voice Evacuation at the time of Fire alarm activation.

System Design

The PAVA system shall be connected on the same Fire Alarm loop with in-built isolators to protect the system in case of any cable faults. The system shall be de-centralized in nature, each distributed rack DAU (Distributed Amplifier Unit) shall have all the DSP (Digital Signal Processing), messages, amplifiers, monitoring in such a way that can work in a standalone mode in case the master rack is faulty or down.

The Man Machine Interface (MMI) shall be connected back to the control room, to monitor and control the entire PAVA system. The MMI shall be fully BS5839 part 8 and EN60849 compliant and TUV approved. The DAU shall play background / Foreground music and in case of Fire Alarm / Paging announcement, the system shall go to full power as programmed to provide the enough SPL (Sound Pressure Level) levels to comply with BS5839 part8, with minimum of 10dB above the noise levels.

All system components shall be digitally monitored including and not limited to, Messages, Amplifiers, and back up amplifiers, Speaker Circuits, Audio Matrix units, Paging Microphone, Battery Charger and the

230VAC line. Each amplifier / line circuit shall be monitored individually and shall report any faults back to the Master Audio Matrix Unit as well as the Paging Microphone.

The system shall be capable of sending messages automatically to any zone at any time interval, without affecting the music in the other areas. Each Zone and circuit speaker shall have separate amplifier, system sharing two amplifiers to multiple circuit speakers are not acceptable. There shall be one back up amplifier for every eight amplifiers, the system shall automatically change over to the back up in case of any amplifier failure, and the backup amplifiers shall be monitored as well. In case of any system component failure, the paging microphone shall override any defective unit and provide paging to the required zone. The System can provide any Cause & Effect programs after integrating with the Fire Alarm System, thus Alert/Evacuate messages can be programmed and delayed as well as played on any zone / floor as per the Cause & Effect approved by the Engineer.

The Battery Backup shall provide 24 hours of back up and 30 min of alarm operation. The power supply / charger must comply with EN54 part 4 and shall be 19" rack mounted. Battery calculation must strictly comply with BS5839 part 8 and shall be based on the amplifier size and not the speaker circuit load.

The PAVA system shall be properly integrated with the fire alarm system. The integrated PAVA system shall cover all normally accessible areas including the car parks. All stair cases shall have dedicated zone riser. The system shall be capable of being used for everyday background music and public announcement duties with the fire alarm initiated emergency announcements overriding all other facilities. Initiation of voice alarm shall take immediate priority and shall cancel all other PA operations.

In addition a FIRE DRILL, BOMB ALERT, EARTHQUAKE ALERT and an ALL CLEAR message shall be incorporated into the operation. A fire alarm broadcast signal shall cancel any public address operation and shall override it. When a fireman's microphone is operated, this shall override any automatic voice alarm signal being transmitted to the zone selected. The Alert and Evacuate pre-recorded messages will be maintained in other zones while live voice fire announcements are being broadcast to selected loudspeaker zones.

All amplifier gain shall be monitored and measured for open, short or earth faults. The Entertainment Rack shall be located in the Control/Security Room enabling the operator to select music from the CD player, FM tuner or the double cassette deck to transmit music to selected zones or all the zones in the building from the touch screen paging microphone. A public address announcement shall override the music transmission to selected zones or all zones. Paging any zone shall not interrupt music in other zones. The

Speakers shall be distributed in the entire floor and shall be configured in different zones. The announcement can be made in zone wise or to all the speakers simultaneously in ALL CALL mode. Fire Alarm shall be announced immediately on receipt of Fire signal from the panel to all zones or group of Zones.

System shall have following functions:

Voice Evacuation and Public Address system integration includes paging system and background music system.

Monitoring of microphone, controller, amplifier, fireman microphone, source modular, and amplifier changeover, AC&DC power Supply, Loudspeaker Line and Volume Control.

The Amplifier shall be used only Class-D with Digital switching power technology

System shall have facility for Backup amplifier for at least one backup amplifier over Working Amplifier.

Amplifiers

All amplifiers shall be power amplifier with High quality speech and Music broadcast. The power amplifiers shall have adequate continuous (RMS) power output to meet the requirement of the configuration. The unit shall be capable of delivering the rated output power with less than 0.1% harmonic distortion in the design bandwidth. The amplifier shall have a broad band frequency response of 40 Hz to 20 KHz. The output voltage and impedance shall meet with the system requirements. Amplifiers shall be protected against over loads and output shorts and a special thermal overload on the heat sink.

The Amplifier shall be Class –D Amplifier have one channel, Two Channel, Three Channel and four channel's each channel have rated power 120/240 or 500W. The Amplifier shall have switch power technology for power electricity saving, Separate PFC design for highest reliability, separate power supply system for each channel, Separate cooling system, sleep mode is automatically enabled when no signal input is detected.

Amplifier shall have AC 100V or 230V power supply and DC 24V input, having separate fuse for each channel. The Amplifier shall be connected through balanced audio input and shall work on 100V Speaker Line.

Technical Specifications

- Rated Output Voltage(RMS) 120/240/500W or 2x120/2x240/2x500
4x120/4x240/4x500W
- Amplification Class-D

➤ Battery Voltage	24VDC (max 10% déviation)
➤ Frequency Response	40Hz to 20KHz
➤ S/N Ratio	>90 dB
➤ Total Harmonic Distortion	<0.1% @ 1kHz
➤ Power Efficiency	>80%
➤ Approval	EN

Speakers

1. Speakers shall be especially designed for broadcasting high quality, integrated emergency fire alarm signals and voice communications and approved by an appropriate authority for use in such situations.
2. Speakers shall be ceiling, wall mounted or Horn Speaker as shown in the schedule of work and shall be completed with mounting brackets accessories etc. Speakers shall be in metal enclosures only.
3. Speakers shall be of high efficiency providing maximum output at minimum power across 120 – 14000 Hz frequency range for Indoor Speakers. Speakers shall have a line matching transformer for direct connection to amplifiers with multiple taps.
4. Speaker external appearance shall be approved by the Architects.
5. Speakers shall be interconnected in the zone configuration.

6W Ceiling Mounted Speaker

The ceiling mounted 6 W 3''speakers shall be installed as depicted in the drawing. The speakers support EASE, CATT or ULYSSES models for acoustic studies. This mean the acoustic model can be designed to simulate the sound quality and distortion prior to installation. The Speaker should be in compliance BS/EN 60065, 2003 and EMC (BS EN 61000-6-Part 1/2/3/4). The Ceiling speaker shall work on 100V line so that it can reduce line losses over long distance and allow easy parallel connection of multiple loudspeakers. The Speaker shall have multiple tapping for different application according to room size and ambient noise environment. The Speaker shall have aluminum grille and metal baffle and shall have spring clip clamp for easy installation.

Technical Specifications

➤ Rated power	6 W
➤ Tapings 100V line	6/3/1.5W
➤ Operation Voltage	100V or 70V
➤ Effective frequency range	120 ~ 14kHz (10% Variation allowed)

➤ SPL @ 1W/m	>91 dB
➤ S.P.L. ,@Full power/ 1m, dB	>100 dB
➤ Color	White
➤ Ceiling Cut-out	170mm
➤ Dimensions	200 mm x 55 mm (10% Variation allowed)

6W Wall Mount Speaker

The Wall mounted 6 W speakers shall be installed as depicted in the drawing. The speakers support EASE, CATT or ULYSSES models for acoustic studies. This mean the acoustic model can be designed to simulate the sound quality and distortion prior to installation. The Speaker should be in compliance BS/EN 60065, 2003 and EMC (BS EN 61000-6-Part 1/2/3/4). The speaker shall work on 100V line so that it can reduce line losses over long distance and allow easy parallel connection of multiple loudspeakers. The Speaker shall have multiple tapping for different application according to room size and ambient noise environment. The Speaker shall have Metal grille and ABS Enclosure and shall be closed cabinet.

Technical Specifications

➤ Rated power	6 W
➤ Tapings 100V line	6/3/1.5W
➤ Operation Voltage	100V or 70V
➤ Effective frequency range	90 ~ 18kHz (10% Variation allowed)
➤ SPL @ 1W/m	>90 dB
➤ S.P.L. ,@Full power/ 1m, dB	>98 dB
➤ Color	White
➤ Dimensions	285mm x 200mm x 85mm (10% Variation allowed)

15W Horn Speaker

The Horn speakers with 15W Output shall be installed as depicted in the drawing. The speakers support EASE, CATT or ULYSSES models for acoustic studies. This mean the acoustic model can be designed to simulate the sound quality and distortion prior to installation. The Speaker should be in compliance BS/EN 60065, 2003 and EMC (BS EN 61000-6-Part 1/2/3/4). The Horn speaker shall work on 100V line so that it can reduce line losses over long distance and allow easy parallel connection of multiple loudspeakers. The Speaker shall have multiple tapping for different application according to room size and ambient noise environment. The Speaker shall have aluminium grille and metal baffle and shall have spring clip clamp for easy installation.

Technical Specifications

➤ Rated power	15 W
➤ Tapings 100V line	15W/7.5/3.75W
➤ Operation Voltage	100V or 70V
➤ Effective frequency range	250 ~ 8kHz (10% Variation allowed)
➤ SPL @ 1W/m	>103 dB
➤ S.P.L. ,@Full power/ 1m, dB	>115 dB
➤ Color	White
➤ IP Rate	IP 66
➤ Dimensions	221 x 165 x 235mm (10% Variation allowed)

Remote Paging Microphone

1. Digital voice evacuation system remote paging microphone.
2. Each microphone of 8 zone capacity.
3. Zone expansion by connection with expansion unit.
4. .System indicators of AC, DC, fault, Mic status and test.
5. 6 inputs & mic/line selection buttons.
6. 8 zone selection buttons with three-colored indicators
7. Reset/Cancel, All Call & Call buttons.
8. Two RJ45 ports for input and link output.
9. CAT5 or CAT6 cable communication up to 600 meters.
10. AC 230V and DC24V battery inputs.
11. Built-in monitor speaker.

Voice Alarm Controller

1. Digital voice evacuation system all in one amplifier.
2. Specifications meet the standards of BS EN54-32 & EN608409.
3. EN54-16 standards certificate is under taken.
4. Built-in 240W & 500 8 zone class-D amplifier.
5. Integration of EVAC system, paging system, PA system & BGM system together.
6. Built-in two separate players for EVAC and alert voice message by SD card.
7. Built-in 8 zone AB speaker line low impedance supervision.
8. Built-in amplifier auto changeover into standby when fault.
9. With external amplifier input to expansion the power.
10. Capacity of connection 8 unit's remote microphone.

11. Red button EVAC message push to activate with priority except fireman mic.
12. 8 zone speaker outputs with separate zone volume control.
13. 8 zone separate indicator for EVAC, fault, music/paging & select.
14. System indicators of AC, DC, fault and indicators for EVAC, alert & fireman mic.
15. Zone capacity of 96 zones by cascaded 11 unit's router.
16. With 8 programmable control inputs and 8 programmable control outputs for voice evacuation system.
17. With Fault, EVAC outputs and Reset input for third party system integration.
18. With fireman microphone of highest priority.
19. Priority level: fireman mic, EVAC, input 1, remote microphone, timer & BGM.
20. Two combo inputs for mic/line, 4 line inputs and one REC output.
21. Two RJ45 for cascade router, two RJ45 for remote microphone input and two RJ45 for LAN/WAN/Internet network.
22. IP network module for optional to buy. The IP network
23. AC 230V and DC24V battery input. Auto switch into the battery backup when AC fails.

Technical Specification:

Description	8 Zone Voice Evacuation Amplifier
Rated Power Output	500W
Fireman Microphone	5Mv, 600Ω
Line 1-2 Inputs	385mV, 10kΩbalanced Combo
Line 3-6 Inputs	350mV, 10kΩ, RCA
Frequency Response	80Hz~20kHz
THD	<1% at RMS,1KHz
S/N Ratio	>70dB
Speaker Output	100V AB 8 zone speaker outputs
REC Output	200mV
Control Input & Output	8 programmable control inputs: Max 3.3V (voltage mode) or 0V closed contact 8 programmable control outputs: 0V closed contact Control output for fault & EVAC: 0V closed contact Reset control input: 0V closed contact
Voice Message	MP3 or WMA format, two separate players of SD card with protection cover, programmable voice message up to 255, 10 years valid
Event Record	HEX format, Hard Flash memory, events up to 1000 records, 10 years valid

Operation Environment	Operation Temp: +5°C ~ +40°C Store Temp: -20°C ~ +70°C Operation Humidity: <95%
Power Consumption	600W
Power Supply	AC230V or 115V & DC24V battery inputs, 50-60HZ
AC Fuse	250V/6.3A, slow type and restorable fuse
Dimension	484(W)×132(H)×449(D) mm
Weight	24kg

Software

PAVA Software with following Features: Should be connected with CAT5 Cable, Shall provide Zone control, status monitor, Offline Program, Event Recording, System Configuration, User Management. Software shall allow automatically playing and timing function to achieve timing programmed playing in the designated zones for unattended operation, Built-in Automatic Timing Corrector. Support Export and Import easily to save Data.

Digital AM/FM Tuner

The digital AM/FM tabletop and rack mount design with aluminum alloy panel. It shall have clearly visible LDC display, microcomputer control and touch-button operation. FM/AM two band receive option, FM receiving frequency 76MHz – 108MHz, AM receiving frequency 520Hz – 1708 KHz. Radio frequency automatic search and memory function, memory up to 99 bands and a power off memory functions. Using vehicle dedicated digital radio module, integrated radio tuner module, with a small size good performance and strong anti – interference etc.

Built in High fidelity wideband monitor Speaker, Sound full and clear, and a monitor with adjustable volume knob

Technical Specifications:

- Power Supply 220V/50Hz
- Power Consumption 8W
- 1 Channel audio signal left and right channel output

CD/DVD Player

The CD/DVD player shall be capable playing MP3 audio tracks from USD or DVD or CD.

Technical Specifications:

- D/A converter 24 bit, 192 kHz
- Frequency response 30-20000 Hz
- Signal to noise ratio > 90
- Distortion and Noise (1kHz) > 65 dB
- Crosstalk (1kHz) > 70 dB
- Dynamic Range (1kHz) > 80 dB
- Sound System Dolby Digital
- Playback Media
 - CD
 - MP3-CD
 - MP3-DVD
 - WMA-CD
 - CD-R/RW
 - Audio CD
- Compression format
 - MP3
 - Dolby Digital
 - PCM
 - WMA
- MP3 bit rates
 - 32 - 320 kbps

Rack

The equipment shall be housed in a standard rack of suitable height, with Plexiglas door or metal mesh and lock. Ventilation panels of 1U height shall be provided between each item of equipment.

Details of the proposed equipment shall be forwarded to the Consultant with performance specifications, dimensions, construction and finish for approval.

Rack should comply with ANSI/EIA RS-310-D; DIN41491; DIN41494; IEC297-2; and GB/T3047.2-92.

The Rack should have DIN Rail Mounted Terminal Blocks for termination of Speaker Zone cables on the rear.

All cables coming from Speaker zones, Call Stations, Power supply should enter from Bottom.

Rack should be installed at location which has minimum 600mm space from front & back for accessing it easily.

Rack should be installed in well ventilated room preferable Air conditioned. The unit should have Fans from top.

The unit should have Lockable Glass door at front

Dimensions

- Height as per the Quantity of PA Processor & Amplifiers
- Depth 600mm Deep
- Width 19"

Speaker Cables

All cables associated with PA system shall be of following specifications:

The 2 core speaker cable will be connected to the speakers by screw terminals before which it shall be crimped using 1.5 sq. mm. bootlace lugs. Care has to be taken for avoiding any single strand of wire shall not come out of Lug & screw terminals to avoid noise & leakage.

Speaker cables used should be Multi-conductor Stranded type

Flexible Copper Conductor of cross section 1.5 Sq. mm / 2.5 Sq. mm insulated, PVCFRLS sheathed control Cable as per IS 694.

These Cables shall be laid in G.I. Conduits concealed/surface.

Call Station Cables

Call station cables should be 4pair CAT6 STP (Shielded Twisted Pair) type, It should be crimped by RJ45 Shielded Male Connectors.

Approved Makes

- ATEIS – IDA8
- BOSCH Presideo
- HEINRICH DVA8/6

Testing PAVA System

Sr. No.	Description	Visual	Test Readings	Documentation
1	All cables are tested for continuity, insulation, resistance etc.			√
2	System installation proper as per drawing	√		
3	Carry out visual checks on all speakers & Processors are free from any mechanical damage, cables, inter phase modules etc.to ensure they are properly installed.	√		
4	Check for proper termination of bootlace lugs & feruling	√		
5	Check Input A/C Supply Voltage		√	
6	Check location / spacing of loudspeakers as in drawing.	√		√
7	Check Distribution of Zones as per Drawing.	√		√
8	Check full load speaker sound quality & measure Sound pressure level (SPL) in dB.	√	√	
9	Check if local loudspeakers overrides by voice messages in case of emergency evacuation.	√		√
10	If power fails, whether Voice evacuation system is working on battery supply if yes for what time		√	
11	Check if recorder messages are CLEAR, free from any noise distortion & easy to understand with Room acoustic speech transmission Index (RaSTI) value >0.5.	√	√	
12	Processor LED's and all keys are working properly	√		
13	Check for Microphone locations & the sensitivity by paging	√		√

Sr. No.	Description	Visual	Test Readings	Documentation
14	Play a soft music & check sound quality	√		

IP Based CCTV system shall be provided for the entire premises for the purpose of security surveillance, and shall be broadly divided in to

- **Internal surveillance** for the Monitoring the Server Aisles, Entrance to Critical Spaces, and Corridors leading to critical spaces; and also for general surveillance in the office floors.
- **External Surveillance** for monitoring the External Periphery of the Data Centre Building Premises, and utility areas such as the DG Area, the Fuel Unloading area, the Terrace floor with Chiller Plant area, the Main and the Material entry Gates, rear side Material and Service Gates etc.

1. General Specifications

The CCTV Vendor shall supply install and commission an IP Camera based CCTV system with the objective shall be to provide High degree of Electronic surveillance system to the entire premises.

The purpose is to monitor & supervise the entire area for security purposes, as well as the record and inform officials on unwanted, untoward incidents. It is also essential to have recorded images to be stored at least for 90 days of all critical areas to facilitate investigations of a reported case.

The Hardware required for the System including servers, workstations, monitors, networking components, cables, connectors, conduits, power supplies etc. shall be in vendor's scope.

Development of independent LAN network for IP CCTV shall be Scope CCTV vendor.

Further, the CCTV system shall provide the direct interface with the Access Control Systems. This shall be achieved either by offering a unified database for the IBMS, or by suitable SDK/API's middleware solution to enable the seamless transfer of data between disparate systems.

Should the Bidder need IT or Networking hardware more than what is provided for in the tender Bill of quantities, then the Bidder needs to inform the tender committee / Consultants in writing on the same along with the Tender BID and include the same in his/her bid price.

Any additions to the Takeoff Quantities given in the tender, if required by the Bidder at the tender Stage shall need to be spelt out by the Bidder at the time of the Bid itself.

It is expected that the Bidder provides a system configuration wherein Main Directory shall be loaded on the Main Server hardware located in the Security/ CCTV Monitoring Room at Ground Floor; and the Failover directory shall be loaded on the failover Servers, again kept at the same location.

2. Power Quality at Site:

- i. Note that AC Power Quality Available on the Site shall be 230 V AC +/- 5%, 50 Hz +/- 5%.
- ii. While there are Main UPS and Redundant UPS should be considered if required, the Electrical system shall deliver this power after switchover to the CCTV Equipment.

For the internal and external surveillance of the Data centre Premises, Strategically placed video surveillance cameras shall provide continuous monitoring of all parts of the premises.

- A. All equipment and materials used shall be standard components that are regularly manufactured and used in the system.
- B. All systems and components shall have been thoroughly tested and proven in actual use.

A minimum of 20 cameras shall be configurable with video analytics, of which, approx 7-8 shall be for external surveillance analytics, and rest for other critical areas, reception area etc., within the premises.

Offered analytics shall have the flexibility to be deployed on any of the cameras across the complete system as per directions from the customer/consultant during the execution/operations phase of the project without any additional hardware/software requirement.

3. Technical Specifications:

1) 2MP Fixed IR DOME	
Parameters	Specification
Image Sensor	1/2.8" Progressive CMOS
Maximum Resolution	1920x1080 (2MP)
Lens Type	Fixed-focal
Focal Length	f = 2.8 mm
Aperture	F1.8
Field of View	110° (Horizontal)

1) 2MP Fixed IR DOME	
Parameters	Specification
	64° (Vertical)
	135° (Diagonal)
Shutter Time	1/5 sec. to 1/32,000 sec.
WDR Technology	WDR
Day/Night	Removable IR-cut filter for day & night function
Minimum Illumination	0.06 Lux @ F1.8 (Color)
	0.001 Lux @ F1.8 (B/W)
Pan/tilt/zoom Functionalities	ePTZ:
	48x digital zoom (4x on IE plug-in, 12x built in)
IR Illuminators	Built-in IR illuminators, effective up to 30 meters
	with Smart IR
	IR LED*8
On-board Storage	Slot type: MicroSD/SDHC/SDXC card slot
	Seamless Recording
Video Compression	H.264 & MJPEG
Maximum Frame Rate	30 fps @ 1920x1080
	In both compression modes
Maximum Streams	4 simultaneous streams
S/N Ratio	58dB
Dynamic Range	100dB
Video Streaming	Adjustable resolution, quality and bitrate, Smart Stream
Image Settings	Adjustable image size, quality and bit rate, Time stamp, text overlay, flip & mirror, Configurable brightness, contrast, saturation, sharpness, white balance, exposure control, gain, backlight compensation, privacy masks, Scheduled profile settings, 3D Noise Reduction, Video Rotation, Defog
Audio Capability	Two-way audio (full duplex)
Compression	G.711, G.726
Interface	Internal microphone input
	External line output
	Live viewing for up to 10 clients

1) 2MP Fixed IR DOME	
Parameters	Specification
Users	
Protocols	IPv4, IPv6, TCP/IP, HTTP, HTTPS, UPnP, RTSP/RTP/RTCP, IGMP, SMTP, FTP, DHCP, NTP, DNS, DDNS, PPPoE, CoS, QoS, SNMP, 802.1X, UDP, ICMP, ARP, SSL, TLS
Interface	10 Base-T/100 BaseTX Ethernet (RJ-45)
ONVIF	ONVIF supported
Video Motion Detection	Five-window video motion detection
Alarm Triggers	Video motion detection, manual trigger, digital input, periodical trigger, system boot, recording notification, camera tampering detection, audio detection
Alarm Events	Event notification using digital output, HTTP, SMTP, FTP and NAS server, SD Card
	File upload via HTTP, SMTP, FTP, NAS server and SD card
Connectors	RJ-45 cable connector for Network/PoE connection
	Audio input
	Audio output
	DC 12V power input
	Digital input*1
	Digital output*1
LED Indicator	System power and status indicator
Power Input	DC 12V
	IEEE 802.3af/at PoE Class 0
Power Consumption	Max. 9 W
Safety Certifications	CE, LVD, FCC Class B, VCCI, C-Tick
Operating Temperature	Starting Temperature: 0°C ~ 50°C (32°F~ 122°F)
	Working Temperature: -10°C ~ 50°C (14°F~ 122°F)

2) 2MP Varifocal IR DOME	
Parameters	Specification (FD816B-HT)

2) 2MP Varifocal IR DOME	
Parameters	Specification (FD816B-HT)
Image Sensor	1/2.8" Progressive CMOS
Maximum Resolution	1920x1080 (2MP)
Lens Type	Vari-focal
Focal Length	f = 2.8 ~ 12 mm
Aperture	F1.8 ~ F2.85
Auto-iris	P-iris
	42° ~ 105° (Horizontal)
Field of View	24° ~ 57° (Vertical)
	49° ~ 131° (Diagonal)
Shutter Time	1/5 sec. to 1/32,000 sec.
WDR Technology	WDR
Day/Night	Removable IR-cut filter for day & night function
Minimum Illumination	0.03 Lux @ F1.8 (Color)
	0.001 Lux @ F1.8 (B/W)
Pan/tilt/zoom Functionalities	ePTZ:
	48x digital zoom (4x on IE plug-in, 12x built in)
IR Illuminators	Built-in IR illuminators, effective up to 30 meters
	with Smart IR
	IR LED*8
On-board Storage	Slot type: MicroSD/SDHC/SDXC card slot
	Seamless Recording
Video Compression	H.264 & MJPEG
Maximum Frame Rate	30 fps @ 1920x1080
	In both compression modes
Maximum Streams	4 simultaneous streams
S/N Ratio	58dB
Dynamic Range	100dB
Video Streaming	Adjustable resolution, quality and bitrate, Smart Stream

2) 2MP Varifocal IR DOME	
Parameters	Specification (FD816B-HT)
Image Settings	Adjustable image size, quality and bit rate, Time stamp, text overlay, flip & mirror, Configurable brightness, contrast, saturation, sharpness, white balance, exposure control, gain, backlight compensation, privacy masks, Scheduled profile settings, 3D Noise Reduction, Video Rotation, Defog
Audio Capability	Two-way audio (full duplex)
Compression	G.711, G.726
Interface	Internal microphone input
	External line output
Users	Live viewing for up to 10 clients
Protocols	IPv4, IPv6, TCP/IP, HTTP, HTTPS, UPnP, RTSP/RTP/RTCP, IGMP, SMTP, FTP, DHCP, NTP, DNS, DDNS, PPPoE, CoS, QoS, SNMP, 802.1X, UDP, ICMP, ARP, SSL, TLS
Interface	10 Base-T/100 BaseTX Ethernet (RJ-45)
ONVIF	ONVIF supported
Video Motion Detection	Five-window video motion detection
Alarm Triggers	Video motion detection, manual trigger, digital input, periodical trigger, system boot, recording notification, camera tampering detection, audio detection
Alarm Events	Event notification using digital output, HTTP, SMTP, FTP and NAS server, SD Card
	File upload via HTTP, SMTP, FTP, NAS server and SD card
Smart Focus System	Remote Focus
	RJ-45 cable connector for Network/PoE connection
Connectors	Audio input
	Audio output
	DC 12V power input
	Digital input*1
	Digital output*1

2) 2MP Varifocal IR DOME	
Parameters	Specification (FD816B-HT)
LED Indicator	System power and status indicator
Power Input	DC 12V
	IEEE 802.3af/at PoE Class 0
Power Consumption	Max. 13 W
Safety Certifications	CE, LVD, FCC Class B, VCCI, C-Tick, UL
Operating Temperature	Starting Temperature: 0°C ~ 50°C (32°F~ 122°F)
	Working Temperature: -10°C ~ 50°C (14°F~ 122°F)

3) 2MP Fixed IR BULLET	
Parameters	Specification
Image Sensor	1/2.8" Progressive CMOS
Maximum Resolution	1920x1080 (2MP)
Lens Type	Fixed-focal
Focal Length	f = 3.6 mm
Aperture	F2.1
Field of View	83° (Horizontal)
	53° (Vertical)
	91° (Diagonal)
Shutter Time	1/5 sec. to 1/32,000 sec.
WDR Technology	WDR
Day/Night	Removable IR-cut filter for day & night function
Minimum Illumination	0.06 Lux @ F2.1 (Color)
	0.001 Lux @ F2.1 (B/W)
Pan/tilt/zoom Functionalities	ePTZ:
	48x digital zoom (4x on IE plug-in, 12x built in)
IR Illuminators	Built-in IR illuminators, effective up to 30 meters
	with Smart IR
	IR LED*8
On-board Storage	Slot type: SD/SDHC/SDXC card slot
	Seamless Recording
Video Compression	H.264 & MJPEG

3) 2MP Fixed IR BULLET	
Parameters	Specification
Maximum Frame Rate	30 fps @ 1920x1080
	In both compression modes
Maximum Streams	4 simultaneous streams
S/N Ratio	Above 58 dB
Dynamic Range	100 dB
Video Streaming	Adjustable resolution, quality and bitrate, Smart Stream
Image Settings	Adjustable image size, quality and bit rate, Time stamp, text overlay, flip & mirror, Configurable brightness, contrast, saturation, sharpness, white balance, exposure control, gain, backlight compensation, privacy masks, Scheduled profile settings, 3D Noise Reduction, Video Rotation, Defog
Audio Capability	Two-way audio (full duplex)
Compression	G.711, G.726
Interface	External microphone input
	Audio output
Users	Live viewing for up to 10 clients
Protocols	IPv4, IPv6, TCP/IP, HTTP, HTTPS, UPnP, RTSP/RTP/RTCP, IGMP, SMTP, FTP, DHCP, NTP, DNS, DDNS, PPPoE, CoS, QoS, SNMP, 802.1X, UDP, ICMP, ARP, SSL, TLS
Interface	10 Base-T/100 BaseTX Ethernet (RJ-45)
	*It is highly recommended to use standard Cat. 5e & Cat. 6 cables which are compliant with the 3P/ETL standard.
ONVIF	ONVIF supported
Video Motion Detection	Five-window video motion detection
Alarm Triggers	Video motion detection, manual trigger, digital input, periodical trigger, system boot, recording notification, camera tampering detection, audio detection
Alarm Events	Event notification using digital output, HTTP, SMTP, FTP

3) 2MP Fixed IR BULLET	
Parameters	Specification
	and NAS server, SD Card
	File upload via HTTP, SMTP, FTP, NAS server and SD card
Smart Focus System	Fixed Focus
Connectors	RJ-45 cable connector for Network/PoE connection
	Audio input
	Audio output
	DC 12V power input
	Digital input*1
	Digital output*1
LED Indicator	System power and status indicator
Power Input	DC 12V
	IEEE 802.3af/at PoE Class 0
Power Consumption	Max. 9 W
Casing	Weather-proof IP66-rated housing
	Vandal-proof IK10-rated metal housing (Casing Only)
Safety Certifications	CE, LVD, FCC Class A, VCCI, C-Tick
Operating Temperature	Starting Temperature: -10°C ~ 50°C (14°F~ 122°F)
	Working Temperature: -20°C ~ 50°C (-4°F~ 122°F)

4) 2MP Varifocal IR BULLET	
Parameters	Specification
Image Sensor	1/2.8" Progressive CMOS
Maximum Resolution	1920x1080 (2MP)
Lens Type	Vari-focal, Remote Focus
Focal Length	f = 2.8 ~ 12 mm
Aperture	F1.8 ~ F2.85
Auto-iris	P-iris
Field of View	39° ~ 92° (Horizontal)
	22° ~ 49° (Vertical)
	45° ~ 122° (Diagonal)
Shutter Time	1/5 sec. to 1/32,000 sec.

4) 2MP Varifocal IR BULLET	
Parameters	Specification
WDR Technology	WDR
Day/Night	Removable IR-cut filter for day & night function
Minimum Illumination	0.03 Lux @ F1.8 (Color)
	0.001 Lux @ F1.8 (B/W)
Pan/tilt/zoom Functionalities	ePTZ:
	48x digital zoom (4x on IE plug-in, 12x built in)
IR Illuminators	Built-in IR illuminators, effective up to 30 meters
	with Smart IR
	IR LED*8
On-board Storage	Slot type: SD/SDHC/SDXC card slot
	Seamless Recording
Video Compression	H.264 & MJPEG
Maximum Frame Rate	30 fps @ 1920x1080
	In both compression modes
Maximum Streams	4 simultaneous streams
S/N Ratio	Above 58 dB
Dynamic Range	100 dB
Video Streaming	Adjustable resolution, quality and bitrate, Smart Stream
Image Settings	Adjustable image size, quality and bit rate, Time stamp, text overlay, flip & mirror, Configurable brightness, contrast, saturation, sharpness, white balance, exposure control, gain, backlight compensation, privacy masks, Scheduled profile settings, 3D Noise Reduction, Video Rotation, Defog
Audio Capability	Two-way audio (full duplex)
Compression	G.711, G.726
Interface	External microphone input
	Audio output
Users	Live viewing for up to 10 clients
Protocols	IPv4, IPv6, TCP/IP, HTTP, HTTPS, UPnP, RTSP/RTP/RTCP, IGMP, SMTP, FTP, DHCP, NTP, DNS, DDNS, PPPoE, CoS, QoS,

4) 2MP Varifocal IR BULLET	
Parameters	Specification
	SNMP, 802.1X, UDP, ICMP, ARP, SSL, TLS
Interface	10 Base-T/100 BaseTX Ethernet (RJ-45)
	*It is highly recommended to use standard Cat. 5e & Cat. 6 cables which are compliant with the 3P/ETL standard.
ONVIF	ONVIF supported
Video Motion Detection	Five-window video motion detection
Alarm Triggers	Video motion detection, manual trigger, digital input, periodical trigger, system boot, recording notification, camera tampering detection, audio detection
Alarm Events	Event notification using digital output, HTTP, SMTP, FTP and NAS server, SD Card
	File upload via HTTP, SMTP, FTP, NAS server and SD card
Smart Focus System	Remote Focus
Connectors	RJ-45 cable connector for Network/PoE connection
	Audio input
	Audio output
	DC 12V power input
	Digital input*1
	Digital output*1
LED Indicator	System power and status indicator
Power Input	DC 12V
	IEEE 802.3af/at PoE Class 0
Power Consumption	Max. 13 W
Casing	Weather-proof IP66-rated housing
	Vandal-proof IK10-rated metal housing (Casing Only)
Safety Certifications	CE, LVD, FCC Class A, VCCI, C-Tick, UL
Operating Temperature	Starting Temperature: -10°C ~ 50°C (14°F~ 122°F)
	Working Temperature: -20°C ~ 50°C (-4°F~ 122°F)

5) 2MP 30x IR Speed Dome PTZ Camera	
Parameters	Specification
Image sensor	1/2.8" Progressive CMOS
Maximum Resolution	60 fps @ 1080p Full HD
Lens Type	30x optical zoom, auto focus
Focal Length	4.3 ~ 129 mm
Aperture	F1.2 (Maximum)
Auto-iris	DC-Iris
Field of View	2.3° ~ 64° (Horizontal)
	1.3° ~ 36° (Vertical)
	2.6° ~ 73° (Diagonal)
Shutter Time	1/1 sec. to 1/10,000 sec.
WDR Technology	WDR
Day & Night	Yes
Minimum Illumination	0.4 lux in Color
	0.03 lux in B/W
Pan speed	0.05° – 320°/s
Pan range	360 degree
Tilt speed	0.05° – 240°/s
Tilt range	220 degree
Preset Locations	256 preset locations
Pan / Tilt / Zoom	48x digital zoom (4x on IE plug-in, 12x built in)
	Auto pan mode
	Auto patrol mode
On-board Storage	SD/SDHC/SDXC card slot
Video Compression	H265, H.264, MJPEG
Maximum Frame Rate	H.265 : 60 fps @ 1920x1080
	H.264 : 60 fps @ 1920x1080
Maximum Streams	3 simultaneous streams
S/N Ratio	Above 60 db With adjustable 2DNR & 3DNR
Dynamic Range	Above 100db
IR Illuminators	Recognition: 150M
	Detection: 200M
Video Streaming	Adjustable resolution, quality and constant bit rate control

5) 2MP 30x IR Speed Dome PTZ Camera	
Parameters	Specification
Image Settings	Time stamp, text overlay, flip & mirror
	Adjustable image size, quality and bit rate
	Configurable brightness, contrast, saturation, sharpness, white balance, exposure control, gain, backlight compensation, privacy masks (Up to 24)
	Scheduled profile settings
	Defog
Audio Capability	External microphone input, audio output (Full Duplex)
Compression	AAC
	G.711
	G.726
Interface	External microphone input
	External line output
Users	Live viewing for up to 10 clients
Network Protocols	IPv4, IPv6, TCP/IP, HTTP, HTTPS, UPnP, RTSP/RTP/RTCP, IGMP, SMTP, FTP, DHCP, NTP, DNS, DDNS, PPPoE, CoS, QoS, SNMP, 802.1X
Interface	10 Base-T / 100BaseTX Ethernet (RJ-45)
ONVIF	Supported, specification available at www.onvif.org
Video Motion Detection	Triple-window video motion detection
Auto-Tracking	Auto-tracking on moving object
Alarm Triggers	Video motion detection, manual trigger, digital input, periodical trigger, system boot, recording notification, camera tampering detection ,audio detection, advanced motion detection
Alarm Events	Event notification using digital output, HTTP, SMTP, FTP and NAS server
	File upload via HTTP, SMTP, FTP and NAS server
Connectors	RJ-45 cable connector for Network/PoE connection
	Audio input
	Audio output
	DC 48V
	Digital input*4

5) 2MP 30x IR Speed Dome PTZ Camera	
Parameters	Specification
	Digital output*2
	RS485
LED Indicator	System power and status indicator
Power input	DC 48V
	95W UPoE
Casing	IK10, IP67, NEMA 4X
Safety Certifications	CE, LVD, FCC Class A, VCCI, C-Tick, UL,
Operating Temperature	Wide Temperature:
	Working Temperature: -40°C ~ 55°C

6) 5MP IR FISH EYE Camera	
Parameters	Specification (FE8174)
Image sensor	1/2.5" Progressive CMOS sensor in 2560 x 1920 resolution
Maximum Resolution	1920x1920
Lens Type	Fixed-focal
Focal Length	f = 1.5 mm
Aperture	2.8
Field of View	180° (horizontal)
	180° (vertical)
	180° (diagonal)
Shutter Time	1/5 sec. to 1/32,000 sec.
WDR Technology	WDR enhanced, 57 dB
Day & Night	Removable IR-cut filter for day & night function
Minimum Illumination	0.03 Lux @ F2.8 (Color)
	0.01 Lux @ F2.8 (B/W)
Pan / Tilt / Zoom	ePTZ
	12x digital zoom (12x on IE plug-in)
On-board Storage	MicroSD/SDHC/SDXC card slot
Video Compression	H.264, MPEG-4 & MJPEG
Maximum Frame Rate	In all compression modes:
	15 fps at 1920x1920
	30 fps at 1920x1080

6) 5MP IR FISH EYE Camera	
Parameters	Specification (FE8174)
Maximum Streams	3 simultaneous streams
S/N Ratio	Above 62 dB
Dynamic Range	57 dB
Video Streaming	Adjustable resolution, quality and bitrate
	Configurable video cropping for bandwidth saving
Image Settings	Time stamp, text overlay, flip & mirror, scheduled profile settings, configurable brightness/contrast/saturation/sharpness,
	white balance, exposure control, gain, backlight compensation, privacy masks, pixel calculator, 3D-Noise reduction
Audio Capability	Audio input / output (full duplex)
Compression	AAC
	G.711
	G.726
Interface	Built-in microphone
	External microphone input
	External line output
Auido Audio Effective Range	5 meters
Users	Live viewing for up to 10 clients
Network Protocols	IPv4, IPv6, TCP/IP, HTTP, HTTPS, UPnP, RTSP/RTP/RTCP, IGMP, SMTP, FTP, DHCP, NTP, DNS, DDNS, PPPoE, CoS, QoS, SNMP, 802.1X, UDP, ICMP
Interface	10 Base-T / 100BaseTX Ethernet (RJ-45)
ONVIF	Supported, specification available at www.onvif.org
Video Motion Detection	Five-window video motion detection
Alarm Triggers	Video motion detection, manual trigger, digital input, periodical trigger, system boot, recording notification, camera tampering detection
Alarm Events	Event notification using digital output, HTTP, SMTP, FTP and NAS server
	File upload via HTTP, SMTP, FTP and NAS server
Connectors	RJ-45 cable connector for Network/PoE connection

6) 5MP IR FISH EYE Camera	
Parameters	Specification (FE8174)
	Audio input
	Audio output
	DC 12V power input
	Digital input*1
	Digital output*1
LED Indicator	System power and status indicator
Power input	12V DC
	IEEE 802.3at PoE Class 4
Power consumption	Max. 22 W (DC 12V)
	Max. 23 W (PoE+)
Safety Certifications	CE / UL
Operating Temperature	Starting Temperature: -25°C ~ 50°C (-13°F ~ 122°F)
	Working Temperature: -40°C ~ 50°C (-40°F ~ 122°F)

7) 2MP 1080P 30X PTZ Indoor Camera	
Parameters	Specification
Image sensor	1/2.8" Progressive CMOS
Maximum Resolution	1920x1080 (2MP)
Lens Type	30x optical zoom, auto focus
Focal Length	f = 4.3 ~ 129 mm (30x zoom)
Aperture	F1.6 ~ F4.7
Auto-iris	DC-iris
Field of View	2.3° ~ 64° (horizontal)
	1.3° ~ 36° (vertical)
	2.6° ~ 73° (diagonal)
Shutter Time	1/1 sec. to 1/10,000 sec.
Day & Night	Removable IR-cut filter for day & night function
Minimum Illumination	0.5 Lux @ F1.6, 30 IRE (Color), 1/30s
	0.03 Lux @ F1.6, 30 IRE (B/W), 1/30s
	0.14 Lux @ F1.6, 50 IRE (Color), 1/5s
	0.01 Lux @ F1.6, 50 IRE (B/W), 1/5s
Pan speed	0.05° ~ 450° / sec.

7) 2MP 1080P 30X PTZ Indoor Camera	
Parameters	Specification
Pan range	360° endless
Tilt speed	0.05° ~ 450° / sec.
Tilt range	220° (-110° ~ +110°)
Preset Locations	256 preset locations, 40 presets per tour
Pan / Tilt / Zoom	48x digital zoom (4x on IE plug-in, 12x built-in)
	Auto pan mode
	Auto patrol mode
On-board Storage	SD/SDHC/SDXC card slot
Video Compression	H.264, MJPEG & MPEG-4
Maximum Frame Rate	H.264: 30 fps @ 1920x1080, 60 fps @ 1280x720
	MPEG-4: 30 fps @ 1920x1080, 60 fps @ 1280x720
	MJPEG: 30 fps @ 1920x1080, 60 fps @ 1280x720
	(Up to 30/60 fps in WDR mode)
Maximum Streams	4 simultaneous streams
S/N Ratio	Above 50 dB
Dynamic Range	Above 90 dB
Video Streaming	Adjustable resolution, quality and bit rate
	Zoom enhancement for better image quality under limited bandwidth
	Adjustable image size, quality and bit rate
	Time stamp, text overlay, flip & mirror
Image Settings	Configurable brightness, contrast, saturation, sharpness, white balance, exposure control, gain, backlight compensation, privacy masks (Up to 24)
	Scheduled profile settings
	Defog
Audio Capability	Audio input / Audio output (Full duplex)
Compression	AAC
	G.711
	G.726
Interface	External microphone input
	External line output

7) 2MP 1080P 30X PTZ Indoor Camera	
Parameters	Specification
Users	Live viewing for up to 10 clients
Network Protocols	IPv4, IPv6, TCP/IP, HTTP, HTTPS, UPnP, RTSP/RTP/RTCP, IGMP, SMTP, FTP, DHCP, NTP, DNS, DDNS, PPPoE, CoS, QoS, SNMP, 802.1X
Interface	10 Base-T / 100BaseTX Ethernet (RJ-45)
ONVIF	Supported, specification available at www.onvif.org
Video Motion Detection	Triple-window video motion detection
Auto-Tracking	Auto-tracking on moving object
Alarm Triggers	Video motion detection, manual trigger, periodical trigger, system boot, recording notification, camera tampering detection, audio detection
Alarm Events	Event notification using digital output, HTTP, SMTP, FTP and NAS server
	File upload via HTTP, SMTP, FTP and NAS server
Connectors	RJ-45 cable connector for Network/PoE connection
	Audio input
	Audio output
	DC 12V power input
	Digital input*4
	Digital output*2
	RS-485 for PTZ control (PelcoD protocol, Baud rate 2400)
LED Indicator	System power and status indicator
Power input	PoE plus (IEEE 802.3at compliant)
	High Power PoE
	AC 24V
Power consumption	PoE plus:
	Max. 19W
	AC 24V:
	Max. 48W (heater on)

7) 2MP 1080P 30X PTZ Indoor Camera	
Parameters	Specification
	Max. 19W (heater off)
	High Power PoE:
	Max. 48W (heater on)
	Max. 19W (heater off)
Casing	Weather-proof IP66- and NEMA 4X-rated metal housing
Safety Certifications	CE / UL
Operating Temperature	5°C ~ 55°C (PoE Plus)
	-40°C ~ 50°C (AC 24V / High Power PoE)

8) 2MP 30x IR Speed Dome Outdoor PTZ Camera	
Parameters	Specification
Image sensor	1/2.8" Progressive CMOS
Maximum Resolution	60 fps @ 1080p Full HD
Lens Type	30x optical zoom, auto focus
Focal Length	4.3 ~ 129 mm
Aperture	F1.2 (Maximum)
Auto-iris	DC-Iris
Field of View	2.3° ~ 64° (Horizontal)
	1.3° ~ 36° (Vertical)
	2.6° ~ 73° (Diagonal)
Shutter Time	1/1 sec. to 1/10,000 sec.
WDR Technology	WDR
Day & Night	Yes
Minimum Illumination	0.4 lux in Color
	0.03 lux in B/W
Pan speed	0.05° – 320°/s
Pan range	360 degree
Tilt speed	0.05° – 240°/s
Tilt range	220 degree
Preset Locations	256 preset locations
Pan / Tilt / Zoom	48x digital zoom (4x on IE plug-in,12x built in)

8) 2MP 30x IR Speed Dome Outdoor PTZ Camera	
Parameters	Specification
	Auto pan mode
	Auto patrol mode
On-board Storage	SD/SDHC/SDXC card slot
Video Compression	H265,H.264 ,MJPEG
Maximum Frame Rate	H.265 : 60 fps @ 1920x1080
	H.264 : 60 fps @ 1920x1080
Maximum Streams	3 simultaneous streams
S/N Ratio	Above 60 db With adjustable 2DNR & 3DNR
Dynamic Range	Above 100db
IR Illuminators	Recognition: 150M
	Detection: 200M
Video Streaming	Adjustable resolution, quality and constant bit rate control
Image Settings	Time stamp, text overlay, flip & mirror
	Adjustable image size, quality and bit rate
	Configurable brightness, contrast, saturation, sharpness, white balance, exposure control, gain, backlight compensation, privacy masks (Up to 24)
	Scheduled profile settings
	Defog
Audio Capability	External microphone input, audio output (Full Duplex)
Compression	AAC
	G.711
	G.726
Interface	External microphone input
	External line output
Users	Live viewing for up to 10 clients
Network Protocols	IPv4, IPv6, TCP/IP, HTTP, HTTPS, UPnP, RTSP/RTP/RTCP, IGMP, SMTP, FTP, DHCP, NTP, DNS, DDNS, PPPoE, CoS, QoS, SNMP, 802.1X
Interface	10 Base-T / 100BaseTX Ethernet (RJ-45)
ONVIF	Supported, specification available at www.onvif.org
Video Motion Detection	Triple-window video motion detection

8) 2MP 30x IR Speed Dome Outdoor PTZ Camera	
Parameters	Specification
Auto-Tracking	Auto-tracking on moving object
Alarm Triggers	Video motion detection, manual trigger, digital input, periodical trigger, system boot, recording notification, camera tampering detection ,audio detection, advanced motion detection
Alarm Events	Event notification using digital output, HTTP, SMTP, FTP and NAS server
	File upload via HTTP, SMTP, FTP and NAS server
Connectors	RJ-45 cable connector for Network/PoE connection
	Audio input
	Audio output
	DC 48V
	Digital input*4
	Digital output*2
	RS485
LED Indicator	System power and status indicator
Power input	DC 48V
	95W UPoE
Casing	IK10, IP67, NEMA 4X
Safety Certifications	CE, LVD, FCC Class A, VCCI, C-Tick, UL,
Operating Temperature	Wide Temperature:
	Working Temperature: -40°C ~ 55°C

1. High Configuration Network Video Storage Servers

Server shall be of 19" rack mounting or any of the branded with CCTV OEM make.

Quad core Intel Processor at 2.4 GHz 12M Cache,

8GB or more RAM, Microsoft Windows 2008 R2 64 bit pre-installed embedded OS.

SQL Express 2008 or better as required by the application

Minimum 12 hot swappable drive slots.

10 X 2.5TB = 25TB raw RAID 5 configured storage for 30 days of storage. Complete with one spare drive.

Calculated @ H.264 Compression, 15fps @ 720p, 40 days of recording.

DVI Graphics Card to support minimum 3 multiplexed monitors, with different possibility on each of the monitor i.e. Multiplexed, Alarm, Maps, sequence or any combination. Also support Drag-n-Drop of images by using connected mouse device.

Embedded Gigabit network cards with fault tolerant configuration,

Redundant Power Supply, Standard video display adapter,

Minimum 3 Years Next Day Business Day on Site Warranty from OEM.

2. Applicable Standards

Original Equipment Manufacturer Standard

APPROVALS

All the cameras should be

A. CE Compliant and

B. UL Listed and

C. FCCB

3. NETWORK FOR IP CCTV SYSTEM:

The IP CCTV Vendor shall setup an independent IP Network for the use of IP CCTV system.

EDGE SWITCHES:

- i. All networking equipment shall be as minimum of 2 Layer and as a minimum shall support IGMP Snooping Version 2 or later. It should have minimum two 1000 baseT copper ports and minimum two slots for 1000baseT fiber modules.
- ii. The IP network shall support multicasting between all ports and shall allow for Multicast streams to be routed between networks.
- iii. All the edge switches should be minimum Layer-2. All Layer-2 switches must finally be brought together using 1000baseT ports to central Layer-3 switch. Connection to the servers and clients must be 1000baseT from 10/100/1000baseT ports. Connection between Layer-2 and Layer-3 switch should use fiber backbone.
- iv. Uplink port should have sufficient speed to avoid network congestion, preferably network should not be loaded more than 70% at any stage.
- v. All these Edge switches should provide IEEE 802.3af compliant PoE on all the ports simultaneously.

CORE SWITCHES:

- i. All the Main and Redundant Core switches should be minimum Layer-3.

- ii. All these Edge switches should be connected to Core switches using Gigabit or 10G connectivity depending on the load on that part of network.
- iii. All the Core switches should support and be enabled with IGMP querier.

4. DIGITAL VIDEO MANAGEMENT SERVER SOFTWARE:

- The DVM Software shall be DVM application software.
- The DVM software shall consist of an MS-SQL 2008 or better based Main and Redundant Directory Database Server, Archive Server for audio and video, Failover recording, Redundant recording, Digital Virtual Matrix, Incident Reports, Alarm Management, Scheduled backup application, reporting tools and Watchdog modules. All the related software licenses should be the part of the offered system.
- The DVM should support any of the following Video Analytics Features on user defined cameras.
 - Trip wire detection
 - Illegal parking
 - Loitering detection
 - Stolen object detection
 - Object left / Removal detection
 - Crowd Detection
 - Directional Motion (Adaptive Motion),
 - Camera Sabotage
 - Object Counting
 - Vibration Removal
- The DVM Server shall maintain a catalogue of settings for all the client, servers, and IP cameras in the system
 - The DVM shall enable the client to dynamically create connections between any camera on the digital monitors (audio, video, serial ports and digital I/Os)
 - The DVM shall provide the client seamless operation of all cameras available in the system regardless of the actual connection to different archive servers.
- The DVM shall detect signal loss and have the capability to alert the systems administrator
 - The DVM Archive Server shall offer the capability to be install multiple servers software on multiple Computer Servers to enable distributed archiving architecture on the LAN or WAN.
- The DVM Archive Server, for video and audio, shall support and manage Camera connections from IP cameras each at 25FPS PAL at custom defined resolutions.

- The offered solution shall not load more than 100 cameras per server during normal functioning of the system to ensure designed server capacity can easily accommodate all the cameras recording at minimum resolution of 1280 x 720 @ 25FPS.
- **If the Bidder's solution needs additional servers to fulfil this requirement, then they shall quote for additional servers accordingly.**
- The DVM shall be able to set each camera frame rate, bit rate and resolution independently from other cameras in the system, and altering these settings shall not affect the recording and display settings of other cameras.
- The DVM shall utilize multicast network communication for video monitoring.
- The DVM shall offer privileged protected privacy masking feature on all the field cameras so as only the users with specific rights can unmask the picture during live or playback. It shall also support the password protection for such mask on exported videos.
- The DVM shall not allow to login in monitoring application on multiple clients using same login ID to avoid the misuse of the subsystem.
- The DVM shall have the capability to raise the alarm in case any of the video files are being deleted from video storage location.
- Offered cameras and software should be from the same make, or should be fully integrity tested and proven in the market place, considering the high level of complexities involved in IP system and future maintenance and upgrade issues.
- Unicast based equipment shall not be considered as an approved equal for alternate system.
- The DVM shall include a federated architecture, allowing clients on the host system with the right user rights to view video sources belonging to multiple independent video management systems simultaneously as if they were on the same system.
- The DVM shall contain recording servers used for recording video feeds and for communicating with cameras and other devices. The recording servers shall process the recordings and playback the video streams.
- The DVM shall contain a management server that shall be the central manager of the system and control recording servers, cameras, devices and users. The management server shall handle the initial client login, system configuration and logging.
- The DVM shall include an alarm management function that shall provide central overview, control and scalability in any number of federated video management system installations.
- It shall be possible to generate alarms based on internal system-related events, for example motion, or archiving problems or external integrated events, for example analytics events or third-party developed plug-in events.

- Generated alarm shall appear in an alarms list in the viewing client, and it shall be possible for operators to get an overview of, and to delegate and handle alarms from the alarm list.
- The management server shall allow access to a management client from where the administrator can configure and manage all servers, cameras and users.
- The system shall allow the management server and the event server to be installed on multiple servers within a cluster of servers ensuring that another server in the cluster automatically takes over in case the first server fails.
- The DVM shall support installation and the ability to run on virtualized Windows® servers.
- The DVM shall support high availability of recording servers. A failover option shall provide standby support for recording servers with automatic synchronization to ensure maximum uptime and minimum risk of lost data.
- The DVM shall support a versatile rule system including scheduled or event-driven actions with numerous options, including support for time profiles.
- The DVM software shall include multicast and multi-streaming support.
- The DVM shall include automatic camera discovery.
- The DVM shall support archiving for optimizing recorded data storage through data storage solutions that must combine performance and scalability with cost efficient long-term video storage.
- The video management system shall incorporate a fully integrated video-sharing functionality for distributed viewing of video from any camera in the system on any computer with the viewing client.
- The DVM shall incorporate intuitive map functions allowing for multi-layered map environment. The map functionality shall allow for the interactive control of the complete video management system, at-a-glance overview of system integrity, and seamless drag-and-drop integration with a video wall application option.
- The DVM shall support a video wall application, which shall be flexible and hardware independent to allow for seamless integration with the management client and viewing client.
- The DVM shall support 56-bit DEA encryption and 128-, 192- and 256-bit AES encryption of video for export purposes.
- The DVM shall support full two-way audio between clients and remote devices. Two-way audio integration shall support the following features and functions:
 1. Microphone inputs to clients shall transmit audio streams to speakers attached to remote IP devices.

2. Audio from remote IP devices equipped with microphones shall be transmitted to and recorded by the recording server. The audio shall be relayed to clients equipped with speakers.
 3. Operator audio to IP devices shall be recorded by the recording server.
- By default, each speaker and microphone shall be assigned to the same device that it is connected to. The speaker and microphone shall have the capability to be assigned to other devices as well.
 - The DVM software shall provide fast evidence export by exporting video in various formats, including video from multiple cameras in an encrypted native database format with an included standalone viewing client. It shall be possible to write a digital signature to the native database files containing recorded data. This shall allow the viewing client and the standalone viewing client to verify that the contents of imported and opened databases have not been tampered with and that no database files have been removed.
 - The DVM shall provide full awareness of the system through a system monitoring feature that shall monitor important system components such as recording servers, failover servers and hardware devices, and shall also include system logs and show user activity through comprehensive audit logs.
 - The DVM shall include support a transactional data application designed to integrate with Point of Sale (POS), or Automated Teller Machine (ATM) data and time-link video recordings with POS, or ATM transactions.
 - The DVM shall support a solution that makes it possible to integrate multiple third-party video content analysis applications seamlessly into viewing client environments.
 - The DVM shall include a Software Development Kit (SDK) that offers important capabilities for integrating the video management system with third party software and applications.
 - The DVM shall include a standalone viewing client application to be included with video exported from the viewing client application. The standalone viewing client application shall allow recipients of the video to browse and playback the exported video without installing separate software on their computers.
 - The DVM shall include support for Active Directory to allow users to be added to the system. Use of Active Directory requires that a server running Active Directory, acting as a domain controller is available on the network.
 - The DVM shall be designed to support each component on the same computer for efficiency in smaller systems, or each component on separate computers for large system deployments.

5. DETAILED SYSTEM SPECIFICATION

- All the vendors shall attach the point by point compliance for below specification in their technical bid.
 - **Offers without the compliance shall not be considered**
- The product described in this specification is (IP) based Digital Video Management (DVM) System.
- The proposed solution shall not require proprietary computer, server, and network or storage hardware.
- The proposed system shall be of a manufacturer with as minimum of five (5) years of experience and offerings in the IP network video software market, the letter stating the same should be submitted by the manufacturer. OEM for the offered cameras & software shall have a direct presence in India with sales and support facilities.
- The DVM database and video storage shall use SQL database for their operations.
- Considering this system is being deployed for Tier 3 Datacentre, offered DVM system shall compulsorily offer below resiliency and failover functionalities. System shall have the priority setting per camera basis with top 10% cameras nominated as “Most Critical”, another 10% as “Critical” and rest of the cameras as “Normal” cameras.
 - Failover Management shall be a basic feature of the DVM and should be included in offer. This functionality shall ensure the availability of past, present and future recording with near seamless continuity.
 - The system should be capable to switching between Main to Failover Server in case of a failure of any one of them; and from one recording server to the next recording server in case of failure of the former – in microseconds – to ensure near continuous surveillance capability.
 - Above failover mechanism shall be designed to achieve highest level of resiliency in the system with optimum system components.
- The DVM system shall be based on the latest in software programming technology Microsoft
 - .NET 3.5 frame work or better.
- The DVM approved IP cameras shall provide the ability to be powered by power over Ethernet (PoE) 802.3af option.
- If required, Outdoor PTZs shall be powered by redundant mode Solid State Power Supplies, which shall have inline filters and surge protection circuitry to enable safe operable power to the Cameras.
- The DVM should support any of the following Video Analytics Features on user defined cameras.

- Trip wire detection
- Illegal parking
- Loitering detection

- Stolen object detection
- Object left / Removal detection
- Crowd Detection
- Directional Motion (Adaptive Motion),
- Camera Sabotage
- Object Counting
- Vibration Removal

- The DVM video storage shall be capable of storing video for a period of 90 days available for on line access – The Bidder shall budget for unlimited storage capability in the Tender Bid. By Addition of Additional Storage Space, M/s AURIC should be able to expand the archival from 90 days to beyond, without any additional charges to be paid to the Bidder.
- The DVM Storage solution shall be as minimum set at RAID-5 configuration
 - Storage system shall be of RAID5 configured Direct Attached Storage (DAS) / Storage Area Network (SAN) Systems / Internal storage system.

- The DVM shall be based on high quality Dual / multiple H.264 stream IP cameras.
- Any other image based video compression JPEG, MJPEG, MPEG4, Wavelet, or shall not be considered as approved equal due to the high network bandwidth associated with these types of digital video compression.
- **Offered cameras and software should necessarily support ONVIF interface.**
- Each Camera shall provide dual video streaming technology providing independent settings per stream.
- The DVM shall have a capacity to switch and control all the current cameras. **DVM Software should be expandable to unlimited cameras in future, without any additional cost to M/s Netmagic**
- The system shall allow the recording, live monitoring, playback of archived video audio, and data simultaneously
- **The DVM shall provide file export tool for export the native video format with all video protections (e.g. watermark, encryption) and the ability to play this video on a standard computer.**

- The native file format video player shall show the status of the video authentication as available with the original file format.
- The IP Based DVM shall provide file export tool for export of single frames of video in J-PEG and BMP file formats and for export of motion video files in AVI file format for transport and playback on computers utilizing a Windows environment.
- The Client Reserves the right to, at a later date, depending on their sourcing economies, provide the required computers for the DVM client and servers, these computers shall be of the most current state of the art technology available at the time of installation and as minimum shall be better than the minimum requirements specified by DVM system manufacturer as well as tender specifications.

6. DVM Client MONITOR Application:

- The Client Monitor application shall allow for live monitoring of video and audio.
- The Monitor shall enable view of 1 to 32 video tiles simultaneously on a single SVGA (1024x768) monitor at up to 30fps per camera.
- The Monitor shall enable view of up to 32 video tiles simultaneously on a single monitor and shall provide the ability to connect up to Four (4) monitors to a single computer supporting multiple SVGA (1024x768) monitor outputs.
- The IP Based DVM Shall provide as minimum on each of the VGA monitors independently the following tile views:
 - Full screen, Quad, 3x3, 4x4, 5x5, 6x5, 1 + 9 (One large and 9 small view), 1+11 (One large and 11 small view), 1+12 (One large center tile and 12 small view), 1+15 (One large and 15 small view), And more.
- The DVM Monitor application shall allow operators to view an instant replay of any camera.
- The operator shall be able to define the amount of time he wishes to go back from a predefined list or through a custom setup period.
- The operator shall be able to control the playback with play, pause, forward, and speed buttons.
- The DVM Monitor application shall allow operators to add bookmarks to recorded clips of video or audio.
- The operator shall be able to choose and trigger an action from a list of available actions included but are not limited to:
 - View camera in a video tile
 - View camera on a Decoder (analog monitor)
 - View Map or procedure in a video tile

- Starting/stopping PTZ pattern
- Go to PTZ Preset
- Sending alert messages
- Send/receive messages through a serial data stream
- The DVM Monitor application shall be able to display all cameras attached to the system regardless of their physical location on the network.
- The DVM Monitor application shall be able to display all camera sequences created in the system.
- The DVM Monitor application shall allow for unlimited cameras sequences, which may be run independently of each other on either digital monitor tiles or analog CCTV monitors.

Technical Specifications for Security Systems

- The DVM Monitor application shall allow operators to control (Pause/Play, skip forwards, skip backwards) Camera Sequences, without affecting other operators' ability to view and control the same sequence.
- The DVM Monitor application shall display all cameras, sequences and analog monitors in a logical tree.
- The DVM Monitor application operator shall be able to drag and drop a camera from a tree of available cameras into any video tile or an analog monitor icon for live viewing.
- The DVM Monitor application shall support Graphical Site Representation (Maps) functionality, where digital maps are used to represent the physical location of cameras and other devices throughout facility.
- The DVM Maps shall have the ability to contain hyperlinks to create a hierarchy of interlinked maps.
- The DVM Maps shall be able to import maps from any graphical software supporting BMP, JPEG and/or GIF image formats.
- The DVM Monitor application operator shall be able to drag and drop a camera from a map into a video tile for live viewing.
- The operator shall be able to click on an icon in a map to initiate PTZ camera preset, run PTZ pattern, view camera in an analog monitor or send an I/O stream.
- The DVM Monitor application shall support the procedure functionality, where procedures can be triggered to appear during a certain event and can be used to provide detail written or verbal instructions to the operator as to the actions to be taken.
- The DVM Monitor application shall support digital zoom on a fixed camera's live and recorded video streams

- The DVM Monitor application shall support digital zoom on a PTZ camera's live and recorded video streams
- The DVM client shall provide the following video analytics alarm options:
 - Trigger alarms or events to draw the user attention
 - Provide a meaningful text description of the event.
 - Provide OSD graphics to depict the analytics event, including the participating objects, event location, motion directions and more.
 - Provide the above OSD graphics on live video, archived video and JPEG images
 - The Client Workstation shall have dual redundant 1 G (1000Mb) network interface and shall operate on 100/1000 Ethernet networked and shall be of the most current technology available by a major brand name manufacturer of computers and servers.

Technical Specifications for Security Systems

- The DVM Monitor application shall provide management and control over the system using a standard PC mouse, keyboard and CCTV Joystick controller. The vendors should provide joystick controller as an integrated part of each client workstation.
- The DVM client shall be able to use multiple CCTV keyboards to operate the entire set of cameras throughout the system, including cameras of various manufacturers' brands, including their PTZ functionalities (i.e.: one keyboard manufacturer controls other manufacturer's dome or vice-versa).
- The DVM client shall allow for a CCTV keyboard to be attachable directly to the PC running the DVM client application via its serial port.
- The DVM client CCTV Keyboard Interface shall provide full PTZ control.
- The operator shall be able to control pan-tilt-zoom, iris, focus, dome relays and dome patterns
- The DVM client software shall allow the operator to access the PTZ configuration menus with no need of additional hardware.
- This shall prioritize which operator has control over a camera vs. another operator trying to control the same camera at the same time.
- The DVM client CCTV Keyboard Interface shall provide full video matrix operations.

7. Integration Interface

- DVM should provide well defined SDK/API for integration development possibilities with third party ACS, FAS, BMS system.

- Development of integration module shall be in the scope of BMS system OEM, whereas DVM vendor should provide the requisite SDK/API for the same. Cost of the same should be included in the offer.

ACCESS CONTROL SYSTEM

GENERAL DESCRIPTION:

SUMMARY OF WORK

This document shall intended to specify the requirements for the provision of all equipment, materials, labor, documentation and services necessary to furnish and install a complete and operational Integrated Security Access Control and Alarm Monitoring System. The system shall consist of a fully automated and integrated Security System, including, but not limited to the following functions and capabilities:

- Automated Card Access Control at designated areas, doors, utility rooms, control rooms and Turnstiles.
- Direct Data Interface to an IP Video CCTV Subsystem to provide automatic camera call up and presets as well as scene display through the use of a graphical user interface and simple point and click action; as also for event storage with Picture clip for further analysis and reports.
- Configuration of the Access control system with Main and Parallel Redundant Servers, with the servers kept at the Security Room on the Ground Floor.

The system equipment and installation shall comply with all provisions and requirements of this specification as well as any and all applicable national, state and local codes and standards.

1. NETWORKED INTELLIGENT ACCESS CONTROLLERS

- The Bidder shall propose IP Enabled Access Controllers for the project. The Access controller shall be completely field upgradeable or by remote access on IP Network without changing the software or effecting any database information.
- The same shall be true for remote diagnostics purposes, wherein the service provider shall render services for monitoring / improvement / up gradation / trouble shooting.
- The Controller shall be Located mounted on the nearest column, in the False Ceiling void with an intent to reduce the cabling costs.
- The networked controller shall be capable of supporting cardholder databases of 250,000 cardholders (without database changeover) and 125,000 cardholders (with database changeover).
- The Intelligent Access Controller modules shall be support the monitoring and control of two (2) readers, with either or combination of various types of readers, keypads and Biometric Readers in any types and combinations.

- The Power Supply Module provided should be 230V AC / 24 VDC, complete with Battery Charger & Battery suitable for 30 minutes of operation in case of a power failure.
- Loss of Power from a Particular source should raise a pop-up alarm on the Access Control GUI.
- Each Networked Intelligent Controller shall utilize on-board self -diagnostic LEDs, and a connection diagram overlay for ease of installation and service.
- The controller shall also support technology feature which shall retain the last complete panel database as a default until the update has been confirmed, ensuring the integrity of the database in the field panel. The technology shall ensure corruptions due to hang-ups during downloads are accommodated and the field panel always has a complete and fully functional database.
- The networked controller / reader interface device shall be capable of supporting the following:
 - Two Wiegand interface readers with or without PIN keypads
 - Two Clock and Data readers
 - Two key pad readers.

2. Output Control Device

- The output control device shall connect to a networked controller via RS-485.
- The output control device shall support twelve (12) form C latching output circuits.
- The output control device shall support two (2) auxiliary input circuits, configurable for unsupervised or 2/4 state supervised monitoring.
- The output control device shall be capable of performing simple input / output linking locally on itself using aux inputs 1 & 2 and outputs 1 & 2 when offline.

3. Reader Interface Device

- The reader interface device shall perform all of the basic input / output and access control functions for two doors (or one door with entry and exit readers).
- The reader interface device shall connect to a networked controller via an RS-485 network, and shall have a rotary address switch (Range: 0 - 15).
- The reader interface device shall have the following IO connections:
 - Two (2) Readers, in one of the following configurations:
 - Two (2) Wiegand interface readers with or without PIN keypads
 - Two (2) Clock-and-Data readers
 - Two (2) Keypad readers
 - Two (2) Door Monitor switch/contact inputs

- Two (2) Request-to-Exit device inputs
- AC Fail (if provided by power supply) Monitor input
- Battery Fail (if provided by power supply) Monitor input
- Enclosure Tamper Monitor input
- The reader interface device shall have non-latching relay outputs for the following:
 - Two (2) door locking devices (configurable)
 - Two (2) auxiliary devices (door held/forced alarm, alarm shunt, communication failure, or general purpose)
- The reader interface device shall have local processing capabilities as follows:
 - Alarm Shunt and Strike relay timing and latching functions
 - Access control decisions based on facility code (degraded mode)
 - Simple input/output linking on the same V100
 - LED / Beeper control during Card + PIN and other transactions

4. Input Monitor Device

- The input monitor device shall connect to a networked controller via RS-485.
- The input monitor device shall support sixteen (16) input circuits, configurable for unsupervised or 2/4-state supervised monitoring.
- The input monitor device shall support two (2) auxiliary relay outputs.
- The input monitor device shall be capable of performing simple input / output linking locally on itself using inputs 1 & 2 and aux outputs 1 & 2 when offline.

5. DOOR CONTACT SWITCHES

- Recessed Mount (concealed) magnetic contact switches shall be provided to monitor the status of each card reader controller door and auxiliary door as noted on the contract drawings.
- Such Door contact Switches shall be either built in to the EM Lock (Feedback type EM Lock), or shall be individual equipment as per the directions of the Consultant / Client.
- Quantity and location of door contact switches shall be as specified in contract documents and drawings.

6. REQUEST-TO-EXIT DEVICES

- Request-to-exit devices shall be provided to allow a person to exit an access controlled door. These shall be SS Finish, and the contact capable of MTBF of 1million cycles.

- [Quantity and location of request-to-exit devices shall be as specified in contract documents and drawings.]

7. ELECTRIC LOCKING DEVICES

- Electronic locking devices shall be provided to lock (secure) and unlock (unsecure) each card reader controlled door and auxiliary door as note in the contract drawings.
- Electronic Locking Devices shall be capable of being activated from either the RRE or the Networked Intelligent Controller.
- The Electromagnetic Lock should have a holding force of 600 lbs with anodized aluminium housing and adjustable mounting bracket. Supply should be 12V or 24 V DC (selectable)
- Quantity and location of electric locking devices shall be as specified in contract documents and drawings.
- **ALL EM Locks shall be UL Listed.**

8. ACCESS CONTROL SOFTWARE

The system shall Support:

- Seamless active directory integration for single sign on, automatic import of employee. details and automatic deactivation of access rights on employee profile deactivation in active directory server.
- Adding and Managing users with standard and at least 10 custom fields.
- Adding employee photograph along with provision to add at least three more pictures corresponding to an employee such as scanned copies of national ID card, passport, police verification etc.
- Assigning access card to an employee using either of the following two options:
 - Add card as a **no-format card** by flashing the card on a reader
 - Add card as a **format card** by entering facility code and serial number
 - **Check** for the card facility code and the serial number by flashing the card on a reader
- Defining card start and expiry date.
- Activation/Deactivation of the card.
- Setting pass-back exemption.
- Setting extended access.
- Assigning upto 8 access groups allowing an employee to access various branch locations.
- Assigning access privileges to **employees in bulk.**
- Assigning current and **future shift** roster to an employee.
- Assigning shift roster to **employees in bulk.**

- Defining **custom employee groups**. The feature would facilitate the logical grouping of employees based on management structure, thus would empower the project coordinators, floor-managers or project managers to manage access & time attendance rules and view reports of a specific user-group.
- Defining **privilege level** of an employee, one or more than one of the following privileges can be assigned:
 - **Administrator All** (privilege to manage employees, Defining access groups, Defining shift rosters and report generation for the whole **company**)
 - **Administrator** (privilege to manage employees, Defining access groups, Defining shift rosters and report generation pertaining to a **specific branch**)
 - **Report Viewer** (privilege to generate organizational time attendance and access reports)
 - **Normal User** privilege
 - to generate personal time attendance reports
 - to put up on duty request
 - to request for a visitor
 - send messages to a specific web user
 - Privilege to enquire the presence and position of an employee
 - Privilege to approve on duty request
 - Privilege to approve visitor request
 - **Group User** (privilege to manage employee's access groups, shift rosters and report generation pertaining to a **specific group of employees**)
 - **Security Administrator** (Privilege to configure and monitor access control hardware)
 - **Security Viewer** (Privilege to monitor access control hardware and respond to real time system events)
 - None (No access to the system)
- Advanced search form to search users on fixed and mixed search criteria such as: name, department, title, access group, time attendance rule, card status etc.

BAGGAGE SCANNER

1. **SYSTEM DESCRIPTION** –The machine should be capable of scanning Laptop Bags, Tiffin carrier, tool kits, Visitor bags and very flat objects such as envelopes.
 - **Tunnel Dimensions** –Tunnel should be capable of scanning the baggage size of not less than 600 mm x 400 mm.
 - **Penetration** –The Penetration shall not be less than 39 mm steel plate (typical) & 37 mm steel plate (guaranteed)
 - **Sensitivity** –The machine should be able to display a single insulated copper wire of 38 Gauge Wire (Guaranteed) & 40 Gauge wire (Typical). The wire gauge measured in American Wire Gauge.
 - **Health & Safety** -Machine should be International standards including the U.S.F.D.A., Center for Devices and Radiation Health performance standards for cabinet X-Ray systems (Federal Standard 21-CFR 1020.40). Also permitted by the Federal Standard. Film safety guaranteed for high speed films up to ISO 1600.
 - **X-ray dose** –The radiation level should not exceed accepted health standard i.e., within 0.1 mR / hr at a distance of 5 cm from external housing.
 - **X-ray beam divergence** –The X-ray beam divergence should be such that the complete image of maximum size of bag is displayed without corner cuts.
 - **X-ray Inspection** –
 - Facility for variable contrast should be incorporated to allow enhancement of lighter and darken portion of the image. System should have facility of variable Gamma, organic & inorganic stripping, baggage counter.
 - **Lead impregnated safety screens** – Lead impregnated safety screens should be available at either ends of the tunnel.
 - **Color Imaging** – The system supplied shall be of 6 Colors & 1 Grayscale Color Image options.
 - **Conveyor Height** – The Conveyor height shall be in the range of 700-730 mm.
 - **Conveyor belt Speed** – Conveyor speed shall be atleast 0.23 m/s (45 ft/min) in forward direction.
 - **Input / output rollers system** – The input and output frame shall be provided with rollers of length in multiples of 500 mm on each side with barrier frame to prevent bags falling off.
 - **Conveyor Load** – 165 Kg distributed load (364 lbs)
 - **Operating Temperature & Humidity** – The operating temperature should be 0°C to 50 °C Humidity - Up to 95% non-condensing
 - **Power Requirements & Power Conditioning** –

Power Requirements shall be 220VAC: 183-253 VAC, 50 Hz. 10 Amp Max

- Power Conditioning -
- Suitable UPS for 15 minutes back up of reputed make should be provided
- Suitable voltage stabilizer with isolation transformer of reputed make should provide to the whole XBIS
- **Bi-directional Scanning** – Bi-directional scanning facility should be provided without holding any switch.
- **Certification** – The quoted system shall have the following approvals –
 - AERB
 - CE
 - CB
 - ISO 9001
 - 3rd Party Electrical Safety Certifications
- **Operational Safety** – Emergency stop switch at both the ends of tunnel should be provided
- **User Manual** – Two sets of operator manual should be provided with the system.
- **X-Ray Generator** - The X-Ray generator should be of the minimum rating as mentioned below –
 - Anode Voltage -160kV – operating at 140 kV.
 - The system should operate at a voltage lesser than the maximum or rated voltage to increase the life & output of the X-Ray Generator.
 - Tube Current – Shall not exceed 0.7mA
 - Cooling - Hermetically sealed oil bath
 - Beam Direction - Vertically upwards
 - Duty Cycle – 100%
- **Monitors / Display Units** – The system should be able to produce clear color & Monochrome images on a 17” LCD Monitor.
- **Keyboard Controls** – Image features should be keyboard controllable.
- **Zoom facility** – Zoom facility should be available to magnify the chosen area of an image up to x32 or more.
- **Contrast Sensitivity**– 24 Visible Levels & Approximately 4096 Grey levels should be stored.
- The Computer should from a standard manufacturer (Dell, HP, Compaq) with the minimum specifications as mentioned below –
 - Processor: Intel® Core i5, 3.1 GHz, 6MB cache
 - Memory: 2 GB RAM at 1333 MHz
 - Storage: 500 GB HDD

- Video Card: 1 GB Video Card, Dual Digital Display
- Platform: Windows® XP Pro
- Backup: Uninterrupted Power Supply
- (Computer Operation- 20 min)
- **Operating Software** – The system should work on one software only. The software shall be Windows based.
- **Keyboard Control** – i) All operating software features should be controlled from keyboard of machine only. ii) Keyboard function should be “user friendly”
- **Standard Features** – The standard features shall include the following –
 - Automated image archiving - up to 50,000 images.
 - User-friendly Image review - for up to last 100 images.
 - System Health, Advanced continuous diagnostics High penetration function.
 - Density alert Edge-enhancement imaging Baggage counter.
 - Color and black/white imaging Bi-directional conveyor movement Geometric image distortion correction. Horizontal and vertical imaging Image annotation.
 - Manual archiving of images in bitmap format Organic and inorganic image.
 - Clarify feature for improved resolution and penetration.
 - Print image function.
 - Programmable penetration and contrast levels Pseudocolor and reverse monochrome Real-time image manipulation.
 - High resolution 19 in. (48.26 cm) LCD Monitors User-defined access to image archive 2X to 32X User-selectable zoom Z-number measurement.
- **Physical Dimensions** – The Physical dimensions shall not exceed 1420 mm x 850 mm x 1260 mm
- **Continuous Diagnostic Software Feature** – The supplied system shall be equipped with Continuous Diagnostic software which will monitor all the critical components of the system like the Power Supplies, X-Ray Generator, Voltages, Current, Diodes, Tunnels, Temperature, etc and generate the log of errors files.

DOOR FRAME METAL DETECTOR**1. SPECIFICATIONS FOR DOOR FRAME METAL DETECTORS**

Door Frame Metal Detectors shall be provided at the Visitor / Employee Entrance, prior to the Reception Areas.

Bidder to meet the following Minimum Specifications for the Door Frame Metal Detector:

2. GENERAL

- This product shall be manufactured by a firm whose quality system is in compliance with The ISO 9001/2000 Quality system.
- Bidder is required to submit technical datasheets of all products and installation manuals of all Products, technical bids without these documents shall be considered incomplete and shall be rejected.

3. Technical details:

- **Principal of Operation:**
 - Microprocessor Based Operation, Digitally Controlled, voltage very low frequency.
- **Dimensions:**
 - Net Passage clearance is 0.76 m wide & 2.0 m high.
- **Frame:**
 - Rugged structure, not susceptible to false alarms due to mechanical Vibration. ABS Side panels should have ribbed design for additional support to structure and should be detachable for ease to install & transport.
- **Power :**
 - Operatable on both A/C main supply and battery supply
 - Operating voltage: Mains 230 V + 10% 50 Hz.
 - Battery operated from and provided with 12V SMF battery of suitable capacity to give 4 hours of operation.
 - AC connecting socket near the top of the side panel, for AC supply connection so that power frequency does not affect the detection capability of DFMD in long run.
- **Zones:**
 - Should have minimum 9 overlapping detector zones in DFMD.
- **Search Coil:**
 - Multi-loop search coils housed in two side panels only.
- **Control:**

- Control panel should be built inside the frame on the top with all the operating controls built in. It should have plug -in card system for easy maintenance
- **Control Unit Display Panel:**
 - The DFMD Panel should have digitally controlled membrane touch button pads for selection & programming of the system
- **LCD:**
 - Should have 4 lines Backlight LCD, which should display the security level settings, traffic, counters etc.
- **Metal Locator Display:**
 - There should be Alarm LED's on Control panel on a symbolic body showing the alarming zone. This would display whether the point of detection is in the right / left / centre of the body at the corresponding height level.
- **Metal Intensity Level Indicator:**
 - There should LED's on the display panel for graphical indication of the detection level of metal. The size of threat level shall be indicated by the colour of the LED's. More threat shall make the RED LED's glow. This display should operate only when the Infra Red beam is broken when a person passes through the detector.
- **Battery indicator:**
 - The control panel should also have battery indicator.
- **Traffic Light status indictor:**
 - An LED indicating Green / Red status of the traffic light should be installed on the:
 - Control unit display panel
 - Top and bottom of both side Panels on the exit side of the metal detector
 - Sensitivity level- should have atleast 8 security level and further provision for adjustments to a fine step.
 - While in operation the LCD should always display the IN and OUT counters separately, along with security level.
- **Detection**
 - Capable to detect all Metals, Zinc & Metal Alloys using single detection Program. Should be able to detect ferrous / non-ferrous metals at any location.
 - Shall be tested to IS: 14132: 1992
 - Shall have Continuous active detection capability, also quick reset capability after each detection.
 - Should allow minimum 30 people per minute to pass through MZDFMDU
 - Should have uniform sensitivity throughout the door frame.

- Should have Error Free reliable operation for various object speeds (slow walk speed)
- Should have Minimum Nine zones, all overlapping zones: Left Top, Center Top, Right Top, Left Middle, Center middle , Right middle, Left bottom, center bottom, right bottom.
- The unit should have Intelligent 5 digit traffic Counter display on LCD.
- The unit should show separately IN and OUT counter. The counters should have provision for selection of visible / invisible mode.
- **Sensitivity**
 - The unit shall provide for Individual zone sensitivity settings for all 9 overlapping zones.
 - The unit shall provide for Overall zone sensitivity adjustment.
 - The unit shall be capable of 20 different adjustable sensitivity levels.
 - The Magnetic field of the DFMD Equipment should be harmless to magnetic media, electronics device supported by Test certificate from NABL(India) or other accredited labs from the country of origin of equipment, wearers of heart pacemakers and pregnant women (by recognized medical institute).
 - Bidder should provide the certificate for the same along with bid.

BOOM BARRIER

- **GENERAL SPECIFICATIONS:**
- **Vehicle Barrier** shall mean an Electro-mechanical barrier system comprising of a Main Housing & a Boom Arm that serves as a blocking device.
 - The Main housing cabinet shall house the Motor, Controller, the electrical wiring etc., for the up and down movement of the blocking arm. The cabinet shall be IP44 rated and as an option if site conditions demand, be offered in 304 grade Stainless Steel.
- The **Barrier shall operate with a DC motor** & shall not adopt or involve a hydraulic device for the said operation. The Hydraulic device is not preferred in order to establish a trouble-free long life for the barrier as only a motor driven barrier is maintenance free not requiring oil replenishment, maintenance of oil seals etc.
- **The DC Motor** shall not be of more than **100 watts** for a barrier with 4 meter boom length & not more than **200 Watts** for a barrier with 6meter boom length so as to consume less power. The Drive shall have an ABS Electromagnetic Braking system so as to offer smooth lifting and lowering of the arm without any jerks during the operation or at the end position.
- **The Cabinet Housing:** Shall be fabricated from a 2mm thick sheet metal & powder coated in orange colour. The cabinet dimension shall be of a height of around 1000mm & a square or almost square dimension of around 300mm. The Barrier arm shall be at a height of around 900mm to the middle of the arm from the ground.
- **The Barrier Boom Arm:** known also as the blocking arm shall be an aluminium extrusion of dimension of approximately 90mm high, 30mm wide and of the desired length. The Boom arm shall be powder coated in white with red reflective tapes for easy, clear and good visibility at night against shining lights.
- **The Micro PC Programmable Logic Controller** shall offer Auto/Manual or Mixed function
 - Signal input for barrier open/closed position
 - Vehicle detection input while arm is closing
 - Automatic barrier closing can be set within 0-14 seconds interval & Compulsory barrier closing can be set within 15 seconds
 - Counter and memory function when barrier keeps opening and closing. The function allows barrier closed with automatic counting for safety reason.
 - Controller is able to monitor moves of machines and alert automatically in case of any unusual situation, such as collision.

- **Barrier Boom Swing-Away Function** As an option Boom with Swing Away Device may be requested. The Swing Away Flange shall be offered with Boom Release Switch that could in-turn trigger other devices to initiate appropriate action. This typically could be used to deploy Bollard or Road Blocker or even trigger a Video Camera or an annunciator when a vehicle hits the boom and dislodges the boom from its position. This way in all probability the boom may also not be damaged.
- **Barrier Opening & Closing Speed** for up to 3.5meter long arm shall be adjustable to 1.5, 2.5, 3.5 seconds with a single action stroke & that for a 6 Meter Boom Arm 4 Secs. The Barrier shall be capable of being operated manually in the event of power failure or any other abnormality. The Barrier arm shall be able to be folded in case of a basement installation or where there is a height restriction. The system shall offer the flexibility of 60°, 70°, 80° & 90° open. As a standard, 85° barrier arm open for folding arms may be offered.

BUILDING MANAGEMENT SYSTEM and SECURITY SERVICES REQUIREMENT

This details below explains briefly the Building Management, and Security Systems that are suggested for the project. Basic essential components of these systems are Design Parameters and Explanation on the areas of implementation of each system.

BUILDING MANAGEMENT SYSTEM

The BMS will perform the following general functions:

- Building Management & Control.
- Serve as operator Man – Machine interface.
- Managing and monitoring conditions (e.g. Temperature).
- Control monitoring.
- Notification of system faults and alarm controls.
- Data Collection & Historisation.
- Alarm Event & Management.
- Trending.
- Reports & MIS Generation.
- Maintenance & Complaint Management.
- Network Integration.

The BMS system consists mainly of the following components.

- a) Centralized control equipment in the main control room (BMS room) with graphic display for managing alarms, time programs and set values for technical systems and monitoring of individual air conditioning control.
- b) Substation and field controllers & sensors.

BMS facilitates the following utilities / areas:

- (i) ACMV - Chiller's sequential start-up, loading, unloading, sequential shutdown and monitoring of important parameters for Chiller, AHU, Fans and Pumps.
- (ii) FCUs – time scheduled start-up / shutdown and control of AHUs / FCUs to maintain comfort levels in the occupied areas at minimum energy levels. Control of chilled water supply through actuators.
- (iii) Supply / Exhaust fans of smoke free lobbies - control and status monitoring.
- (iv) Switchboards - monitoring of important parameters and status for HV and LV Main Switchgear.

- (v) Lighting Controls - control of common area lighting distribution boards.
- (vi) Elevators - Monitoring of important parameters and status.
- (vii) DG set- Monitoring of important parameter and status.
- (viii) Fire protection system.
- (ix) Monitoring of control panel, pumps and water tanks.
- (x) Domestic and potable water system - control of pumps and monitoring of tanks and pumps.
- (xi) The system shall comprise controllers located near the equipment they monitor / control. Signals from this equipment shall be connected to the controllers. The controllers shall be connected to each other over a bus and terminated at the Man Machine Interface (MMI). The MMI shall include PCs and printers and serves as the operator's interface to the system.
- (xii) Common BMS and FCC room for the whole campus with future expansion to be planned. The PC software shall feature a graphical user interface (GUI) for simplicity and ease of use. The software features shall include alarm presentation, report generation, trending of parameters, historical storage, maintenance schedule generation based on equipment run hours, programming of sequence schedules, implementation of duty cycling, etc.

PART - INTELLIGENT BUILDING MANAGEMENT SYSTEM

SCOPE OF WORK (SOW) FOR MASTER SYSTEMS INTEGRATOR (MSI) FOR THE INTEGRATED BUILDING MANAGEMENT SYSTEM

Document Structure

The document specifies IBMS requirements for the AURIC. Broadly information is presented in the following sections:

- Introduction
- The IBMS Software Platform
 - a. Energy Management Module
 - b. Alarm Management on E-Mail Module
- Direct Digital Controller
- Field Devices
- SERVER
- The IO Summary
- Third Party Integration Details
- List of Approved Makes

1. Introduction of IBMS System:

The Core Purpose is to Make a True **Intelligent Building Management System Framework** which can Integrate Seamlessly with IT Services, Building Services, Facility Services and further provide a Platform for Running User Customized Applications. (Please refer Block diagram below).

Core Objective of Implementation of Integrated / Intelligent Building Management System is to

1. Achieve Energy Savings
2. Operational Efficiency
3. Managing the Diversified Building Sub System via Web Interface.
4. Ensures Occupant Comfort
5. Ensure Code Compliances and Reduces Business Risk

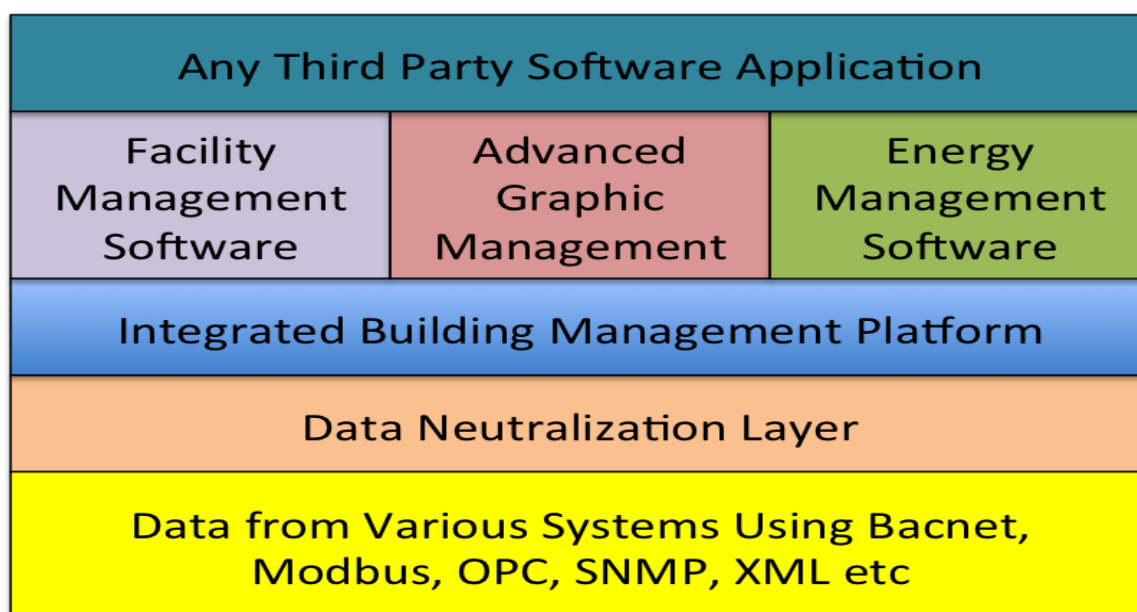
The Systems Requirements Document describes the **Integrated/Intelligent Building Management System (IBMS)** (systems & applications) requirements to be met in the proposals of the **Master System Integrator's (MSI)**, to secure under contract all materials, design, engineering, installation, supervision and training services for **AURIC**.

The IBMS Platform shall be designed to monitor / control / acquire and store data for following major sub-systems inside the Building but not limited to

1. HVAC System
2. Power Management System
3. Electrical System
4. Water Management System
5. Life Safety (FAS , PAS) and Security System
6. Elevators Monitoring System

For the above mentioned systems, the monitoring as well as control (wherever applicable) the scope shall be in line with the parameters mentioned in the Input / Output (IO) summary along with this Tender and as per the Operational Compliance elaborated later in this RFP

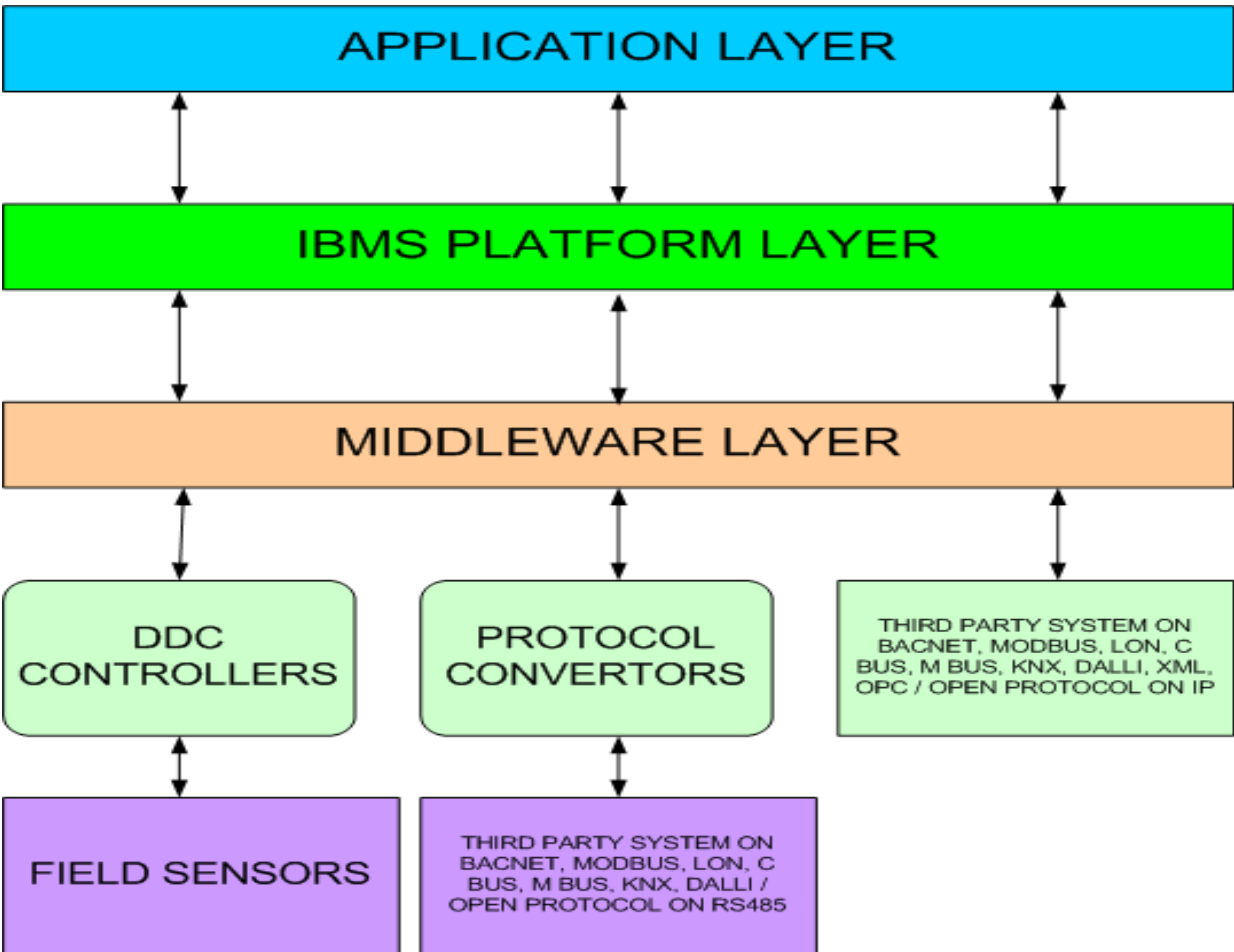
2. Block Diagram of IBMS Framework



3. Components of an Integrated Building Management System

The Core Components of an Integrated Building Management System can be classified as below:

1. The IBMS Software Platform
2. Direct Digital Controllers
3. Protocol Converters
4. Field Devices



4. The IBMS Software Platform

The IBMS has to be an Open Platform that is capable of Integrating with a host of Third Party Hardware using Industry Standard protocols like Bacnet, Modbus, OPC, Lonworks, SNMP, XML KNX , Dalli, SNMP,OBIX etc at the South End and further Integrate with Third Party Applications like Facility Management, Advance Graphics Management, Energy Management etc at the North End.

The Intent of Using a Platform is to ensure that the same remains 100% Agnostic to any Brand of Hardware and also is capable of Seamlessly Integrating with any type of Application Software.

5. Mandatory Functional Requirements of the IBMS Platform

No	Functional Requirement of the IBMS Platform	Compliance Yes / No / Remarks
1	The IBMS Platform must share an Openly Published API/SDK for Enabling Seamless Third Party Integration of Hardware & Software, with the Customer	
2	The IBMS Platform Must Publish all the IO Summary of Hardpoints and Soft Points on an Openly Discoverable Interface such as Bacnet IP Server/ OPC Server for Enabling 100% Seamless Two-Way Integration between Various Third Party Applications	
3	The IBMS Platform must Support Multiple Industry Standard Protocols Natively, without using Proprietary Converters. Minimum Support for Bacnet, Modbus, SNMP, Lonworks, OPC and XML must be available on the IBMS Platform without any additional cost.	
4	The IBMS Platform must support Graphic Display Capabilities which are advanced and based on HTML5 allowing 100% Customizable Charting and Visualization Functions.	
5	The IBMS Platform must have a Search Bar allowing Operators to Search for Information on Systems by just typing in the Data for Simple and Easy Navigation to the Point.	
6	The IBMS Platform must use an Automated Tagging Function to enable Grouping of Systems, Data and Points Effectively to further provide Actionable Intelligence using Analytics.	
7	The IBMS Platform must have an Automated Data Cleansing Capability to Archive Old and Unused Data effectively.	
8	The IBMS Platform must have Advanced Role Based Security Features with Integration to LDAP. All users action and security	

No	Functional Requirement of the IBMS Platform	Compliance Yes / No / Remarks
	related events are recorded in audit log for user traceability	
9	The IBMS Platform must be capable of Deploying Templates of Various Systems with Inbuilt Workflows to enable a Seamless Template based Device Integration capability.	
10	The IBMS Platform must be accessible on Mobile Devices using the Latest Screen Adaptive Technology without the need to Download any Applications.	
11	The IBMS Platform must use a Non Proprietary Interface for Configuring the Software. In the Event that there is a Use of any Proprietary Software / Dongle etc, the same must be handed over to the End Customer for Future Service Neutral Maintenance	
12	The IBMS Platform must Support SNMP Protocol	
13	The IBMS Platform must Support XML and OBIX Protocol	
14	The Quantity of License / tags will be as per the Detailed IO Summary + 10 % spare should be considered.	

6. Functional Features of the IBMS Platform

The IBMS Platform shall comprise of following modules as a minimum – specified and elaborated specified separately below

1. Rich Graphical User Management
2. Alarm Module for Alarm/ Event Logging and Alarm/Event Report Generation
3. Report Generator Module for Customized user defined BAS Reports
4. System Log Management
5. Reports
6. Data Storage
7. Utilities
8. Time Scheduling
9. Point History

10. Totalization
11. Demand Limiting
12. Scheduler Module
13. Logic generation and Control Modules
14. Diagnostics
15. Database management

The IBMS Platform Must have exhaustive and detailed scheduling functions inbuilt into the system.

The IBMS Platform Must have all Control Loop Objects like but not Limited to - PID Loops, Analogue IO, Binary IO, Comparison Objects, Mathematical Function Objects, Interlock Objects, Custom Programming Objects, Composite Object etc to enable a Free Programming Interface.

The IBMS Platform Must also Integrate with Third Party Advanced Graphic Engines using Open Interfaces.

The IBMS Platform Must be based on HTML5 only to display High Level of Graphical and reporting capabilities.

The IBMS Platform must include a freely configurable Data Trending functionality based on customer requirements including but not limited to single shot, roll-over, split, compare, benchmark etc.

The IBMS Platform must include exhaustive reporting and the flexibility of providing Custom Reports either by integrating to external applications or indigenously.

7. Graphical User Management

- The IBMS Platform Must have its own Inbuilt Graphics Management Engine
- The IBMS Platform Must also Integrate with Third Party Advanced Graphic Engines using Open Interfaces
- The IBMS Platform Must be based on HTML5 only
- The IBMS Platform Must have all the Functions to Import any type of Third Party Dashboarding and Charting Widgets into the HTML5 Interface
- The IBMS Platform Must be able to Provide User Configurable Screens with Role Based User Authentication
- The IBMS Platform Must be able to Provide a Search Engine for directly accessing Tagged or Untagged Data Points or Systems in the Facility
- The IBMS Platform Must be capable of Importing 3D Graphics using its Native HTML5 Programming Interface
- The IBMS Platform must provide a Drag & Drop Interface for Docking Important Information on the Screen as per User Requirements

8. Alarm Management & Handling

- Multiple priority levels of alarm shall be made available. Priority levels shall be deemed Critical Alarms and Non- critical (general) Alarms. Normally, critical alarms shall take precedence over non-critical alarms and high priority over low priority.
- Each analog point shall have the following limits defined; wherever required
 - High priority critical alarm limit
 - Low priority critical alarm warning limit
 - Low priority warning limit
 - Low general alarm limit
- When an analog point goes outside the low priority critical alarm limit or Low priority warning limit, a user defined warning message shall be directed to the appropriate alarm printers at the control station.
- The Warning limits shall be used to monitor controllability, not comfort conditions. The alarm limits shall be used to monitor comfort conditions. When a set point is changed the warning limits shall automatically change while the alarm limits shall not change. When an analog point goes outside any of the limits defined, a user defined alarm message for that level shall be directed to the appropriate alarm printer and to respective operator workstation. Alarm message shall require operator acknowledgement.
- When a digital point goes into alarm, a user defined alarm message shall be output to the appropriate alarm printer and to respective control station. Alarm messages shall require operator acknowledgement.
- When a point is overridden by operator command from an operator workstation or a local workstation, an alarm message shall be output to the appropriate alarm printer and to respective operator workstation. Alarm messages shall require operator acknowledgement.
- When a point returns to normal, the event shall be recorded in control stations as 'Return to Normal'.
- The Operator workstations shall be capable of displaying a list of all points in alarm for the building in a single summary. Systems which require the operator to make a separate summary for alarms shall not be acceptable.
- Annunciation: Alarms shall be annunciate at a terminal by an audible tone and icon. Critical alarms shall be defined by a different colour than non-critical alarms.
- Acknowledgement: It shall be necessary for all alarms to be acknowledged by an authorized operator. The facility shall exist for an additional message to be appended at the time of acknowledgement to provide further information as to any action taken.

- Acknowledgement of alarms shall be automatically printed and will indicate the time, date, and any message generated by the operator.
- Alarm silencing shall be by the authorized operators by pressing the silence key.
- Alarm Clear: When alarms are cleared, then a message shall be produced to indicate the description of the alarm point, its current state, and the time and date.
- Alarm Review: Points in alarm shall be displayed on the operator's panel using the alarm review function.

9. System Log Management

- It shall be possible to log the status or value of system points at regular intervals or on change of state and store this on hard-disk at any of the central station.
- It shall be possible to archive this information for future reference.
- In the case of timed interval logs, it shall be possible to specify a time interval (in minutes) and the points which are required to be logged.
- Storage of logged information shall be able to be carried out in any of three ways, single-shot, roll-over, or split. These are defined as follows
 - a) Single-shot: In this type of file, logging shall be carried out only during a predefined period for which the start and finish time and date shall be configurable.
 - b) Roll-over: This file shall be wrap-around where oldest data shall continuously be overwritten by new incoming data. It shall be possible to configure the number of records to be stored or the duration in hours, days or months before wrap around occurs.
 - c) Split: Data shall be continuously stored in a series of files automatically created. The change-over or creation of subsequent files shall be created by splits at user-defined boundaries. The boundaries shall be able to be defined by duration (hours, days, months) and by time and day of the first split.
- Logging files shall be terminal based, not system based, to provide true multi-terminal capability.
- Data produced by the logging facility must be able to be used by standard spreadsheet package for the analysis of information and the preparation of management report.
- In addition to the above, the data may be presented in a simplified customized package.

10. Reports

1. Standard reports shall be provided, which shall be operator selectable to appear on the operator station, any selected printer or both. A "terminate report" command shall be available to allow the

- operator to stop any report in the process of being printed. Standard pre-formatted reports to be provided shall include:
- i. Point summary reports may be requested at any penetration level. Point summary reports shall include the current value/status and condition, point descriptors and all relevant information. Point summary reports shall be selectable for all points.
 - ii. All reports shall be capable of being scheduled to run at a specific time and/or interval via an operator function supported by necessary data entry templates and interactive prompts.
2. As a minimum, the system shall provide the following summaries:
- i. Point summary
 - ii. Alarm summary
 - iii. Limits summary
 - iv. Lockout summary
 - v. Off-line summary
 - vi. Override summary
 - vii. Utility summary
 - viii. Point status (alarm, locked out, off-line, override)
 - ix. Point name
 - x. Point status/value (automatically updating)
3. The alarm summary shall list all points in alarm in the selected system. It shall be possible to print on a single summary, all points in alarm in the building. As a minimum, the alarm summary shall include:
- i. Point name
 - ii. Point status/value (when alarm occurred)
 - iii. Alarm message
 - iv. Date and time of alarm occurrence
 - v. The limits summary shall list all the alarm limits, and warning limits.
4. The lockout summary shall display points in the selected systems which have either reporting or triggering locked out.
5. The off-line summary shall display points in the selected systems which have lost communication with the system.
6. The override summary shall display points in the selected systems which have been overridden by operator command.

7. The utility profile shall display the total consumption, measured peak for the current period and the previous period.
8. Trend reports shall allow the operator to randomly select logical group of points to be recorded at selectable time intervals. It shall be possible to assign up to ten variables to each trend report. The format, headers, footers, and calculations shall be selectable by the operator. The trend report shall be stored to disk and shall be subsequently capable of being displayed, and/or printed by the operator.
7. Dynamic trends shall provide up to eight points and show real time activity of the associated points. This information shall be printed and/or displayed in numeric, bar chart, curve plot, pie chart, etc., as selected by the operator. Graphic plots shall allow a unique color for each point. Sample interval of points selected for dynamic trend shall be user selectable. 3-Dimensional dynamic trending must be provided in the system.
8. Alarm and run time reports shall be automatically issued to assigned printers immediately upon occurrence, and shall consist of the point with engineering unit, the time, and the date, and the alarm message.

11. Data Storage

1. History file capability shall be provided to allow automatic storage of certain records plus allow the operator to selectively direct critical real time system data and activity to a mass storage device for later recall and analysis.
2. All alarm and return to normal activity shall automatically be routed to history files. Alarms and return-to-normal shall include warning and alarm threshold violations with no-response, trouble, run time exceeded, demand alarms, and command failures. It shall be possible to request a report by specifying points of interest, the time window of interest, and the type of alarms of interest. Locking out or disabling of points shall also be historically stored and output in the all- type reports.
3. Operator shall be able to select, via the CRT terminal keyboard, those analog and digital inputs and outputs to be stored and the interval at which samples are taken.
4. It shall be possible to access software packages such as MS-Office / MS-Excel or similar, so that the operator may format display or printouts in the form of:
 5. Spread sheets.
 6. Bar charts.
 7. Curve plots.
8. History files shall be the source data for stored trend reports to be used for records and system analysis. Operator shall be able to select specific points to be trended, the time period of the trend,

the sample interval, and time at which the report is printed. Trend output format shall be as specified for trend logs (shaded, un-shaded etc).

12. Utilities

1. The Central Station personal computer (P.C.) shall be provided with the following menu selected graphic system utilities or desktop application packages.
2. The system provided must be capable of running standard software packages concurrently with the real time system. System should be capable of supporting third party software packages like spreadsheet, word processing etc.
3. The base system software shall include a “windowing” feature to allow the operator to monitor the real time system and use the third party software simultaneously.
4. All third party software packages identified shall have access to the system historical data base.

13. Time Scheduling

- There shall be real time clock facility to help in time scheduling. The scheduling feature shall not be dependent on a central database or an operator workstation.
- The following commands shall be able to be time scheduled to be issued at a later day and time from the operator workstation or portable workstation:
 - i. Start and stop a point
 - ii. Adjust analog value
 - iii. Change set point
- The following commands shall be able to be time scheduled to be issued at a later day and time from the operator workstation:
 - i. Change alarm limits or warning
 - ii. Lock/unlock point reporting or point control
 - iii. Demand limit target setting
 - iv. Load rolling target setting
 - v. Reset tracking period for energy statistics
 - vi. Trend point enable/ disable for a point
 - vii. Totalization enable/ disable for a point
 - viii. Reset totalization value
- The following summaries shall be able to time scheduled to be printed or stored in a disk file at a later day and time from the operator workstation:
 - I. Standard point summary

- II. Alarm summary
- III. Off-line summary
- IV. Override summary
- V. Disabled summary
- VI. Lockout summary
- VII. Utility summary
- VIII. Alarm limits summary

- Commands shall be able to be issued repeatedly on specified days of the week at specified times.
- A system wide calendar shall be set up to define each day as:
 - i. Regular day
 - ii. Special day
 - iii. Holiday
- The system wide calendar shall be stored in multiple locations so that the failure of any one device does not cause the system to fail.
- The calendar shall automatically accommodate the leap year and the turn of the century.
- The calendar shall allow the days to be scheduled one year in advance from the current system date.
- Separate schedules shall be stored for:
 - i. Regular days
 - ii. Special days
 - iii. Holidays

The system shall accept one-time schedules to accommodate overtime usage.

One-time schedules shall be automatically deleted from the system after execution.

The system shall allow one-time schedules to be programmed up to one year in advance.

After recovery from a power failure, the system shall determine any time scheduled commands which should have been issued during the period that the power was off. These commands shall automatically be issued.

14. Point History

1. For every analog point in the system, a 24 hour record of the value sampled on regular interval shall be maintained. The operator shall choose whether samples older than 24 hours shall be discarded or archived. The most recent 24 hours of analog point history shall be able to be displayed at the Control Station.

2. For every digital point in the system, a point history of the last 10 change of states shall be maintained. The operator shall choose whether point history previous to the last 10 change of states shall be discarded or archived.
3. The most recent 10 samples of digital point history shall be able to be displayed at the Control Station.
4. Point history samples with time/date shall also be taken under the following conditions:
 - i. Point in alarm/return to normal
 - ii. Point overridden/released by operator
 - iii. Point on-line/off-line
 - iv. Point reliable/unreliable
6. A report shall be available showing all points for which point history is being archived.
7. The system shall provide point history graphs for analog/digital points.

Point Trends
8. The trend feature shall be able to record any of the following parameters for any point :
 - i. Point value
 - ii. Point alarm status
 - iii. Controlling feature
 - iv. Operator override flag
 - v. On-line/Off-line flag
9. The operator shall be able to select points and define any interval on which samples may be taken.
10. For long term storage of samples, trend data shall automatically be updated.
11. A report shall be available listing all points being trended. The report shall display:
 - i. Trend status
 - ii. Point name
 - iii. Parameter being trended
 - iv. Display units
 - v. Sample interval
 - vi. Number of samples taken.
12. A trend for a point shall be able to be started either by operator command or according to a time scheduled command. A trend for a point will end as a result of an operator command, time scheduled command or when the required number of samples has been collected.
13. Trend samples shall be displayed in either tabular or graphical format. A minimum of eight trended points shall be able to be displayed concurrently on a graph or report.

14. The trend graph display shall automatically scale the value and time axis to display all samples. From the trend graph, the operator shall be able to select and read the instantaneous value of any previous sample.
15. The trend point graphing capability shall be a built-in feature of the system and shall not require operator set- up. Systems which require trend point data to be exported to third party software shall not be acceptable.

16. Totalization

- For every digital point, the system shall be able to calculate:
 - i. Cumulative on-time
 - ii. Cumulative off-time
- For every point, analog and digital, the system shall be able to calculate:
 - i. Cumulative time in alarm
 - ii. Cumulative time overridden by operator
 - iii. Cumulative time off-line
- Time totalization shall have a resolution of one minute or less. Time totalization shall be displayed in hours.

17. Demand Limiting

- 1 The system shall calculate the instantaneous demand based on the sliding average of the previous 30 minutes of the consumption.
2. The system shall calculate a predicted demand based on the sliding window average of the previous 20 minutes of consumption. The predicted demand shall be used for control calculations.
3. The operator shall be able to “lock” a load so that it is ineligible for shedding by demand, limiting or load rolling.
4. The operator shall be able to use the scheduling feature to program time/days for a load to be locked and unlocked.
5. The operator shall be able to use the scheduling feature to program time/days for target values for the demand limiting and load rolling features.
6. The demand limiting/ load rolling features shall allow a minimum of four priority groups to be defined. Within a priority group, a rotational shedding algorithm shall be used.
7. The operator shall be able to define a target reduction of electrical consumption and the load rolling feature shall turn off equipment to meet this target.

8. The operator shall be able to define a demand target that is not to be exceeded and the demand limiting feature shall analyze trends and electrical demand and turn off equipment when a demand peak is anticipated.
9. The demand limiting and load rolling features shall be fully integrated with all other features so that the following safety parameters are maintained:
 10. Minimum on time
 11. Minimum off time
 12. Maximum off time
 13. Maximum number of cycles per hour
14. At the end of the minimum off time, a comfort parameter, such as a temperature, shall be sampled. If the comfort parameter is in alarm, the point being controlled shall be turned on.
15. The following statistical data shall be maintained:
 16. Date / time of start of current period
 17. Total consumption for current and previous period
 18. Actual peak demand with time/ date for current and previous period.
 19. Instantaneous demand
 20. Interval demand
 21. Total shed loads
22. To provide the operator with an opportunity to manually shed loads that are not available to demand limiting or load rolling, the operator shall be notified when the demand limiting or load rolling run out of loads to shed.
23. To advise the operator when the performance is outside of expectations, the operator shall be notified when the demand peak target or load rolling target is exceeded.

18. **ENERGY MANAGEMENT MODULE**

The Enterprise Application for Energy Management & Energy Analytics:

The Energy Management System is intended to Offer the Customer a Holistic Use of their Energy Requirements and provide Transparency in the Following Areas of Operation –

- Energy Analytics and Measurement
- Energy Load Calculation
- Energy Budgeting
- Energy Predictive Analysis

The software should be Minimum Capable of Providing Aggregate Demand Summary - This report aggregates (totalizes) multiple points (meters) and shows the peak, minimum, average, and total

consumption as well as computes load factor. By reducing peak consumption and levelling the total load, volatility is reduced and energy customers can make significant improvements in their energy procurement.

1. Summary Ranking Reports - By selecting this report, the user can identify the 10 worst or 10 best sites in the database. Once the report type has been selected, parameters to define before the report can be generated will include the following:
 - a. Measurement unit – KW, therms, CCF gallons, PSI, etc. The database will search for all values matching the request.
 - b. Compare an entire facility or normalize by square foot
 - c. Time periods to compare
 - d. Highest values or lowest values – Will be able to view either the best or worst 10 points matching the defined parameters
 - e. Cost or consumption in future revisions
2. Spectrum Summary Report – A quick view of any point or aggregated point with color coding identifying the reasonableness of the data value. The chart can report on up to one year of data, with the ability to zoom to a higher definition. As data values approach and/or exceed historical ranges, the color on the graph will change to identify such. If all data values are within historical ranges, the user can move on to other functions. In the following screen shot, the Spectrum Summary Report is reporting on total electricity for an aggregated point, which consists of 6 schools. The reporting period is six weeks, with the blue identifying low loads overnight and on weekends. The fourth weekend in the report was a three day weekend which is identified by a larger blue gap. A user can also see rising consumption (red) as temperatures rise going into the summer season. When the user clicks on an area of the graph, the data value along with time stamp will appear. The colors and associated data value ranges are user definable. The following screen shot is an example of the Spectrum Summary Report.
3. Equipment Operation Reports - Users will have the ability to analyze digital points and identify run times. Comparisons between sites or points can be made and run times can be graphed. For example, comparing lighting or HVAC run hours in a group of stores or comparing HVAC run hours in June for Store 1 versus Store 2. Data will be displayed in time and percentage.
4. Relative Contribution Report – This pie chart report will give users the ability to identify how individual points contribute to a total from a point group. The user would select a group of points, calculate the aggregate consumption of the group, and report on the individual contribution of each. Data will be displayed both graphically in a pie chart as well as in tabular format. Users could identify that HVAC is 48% of the building load; lighting is 42%, or Building

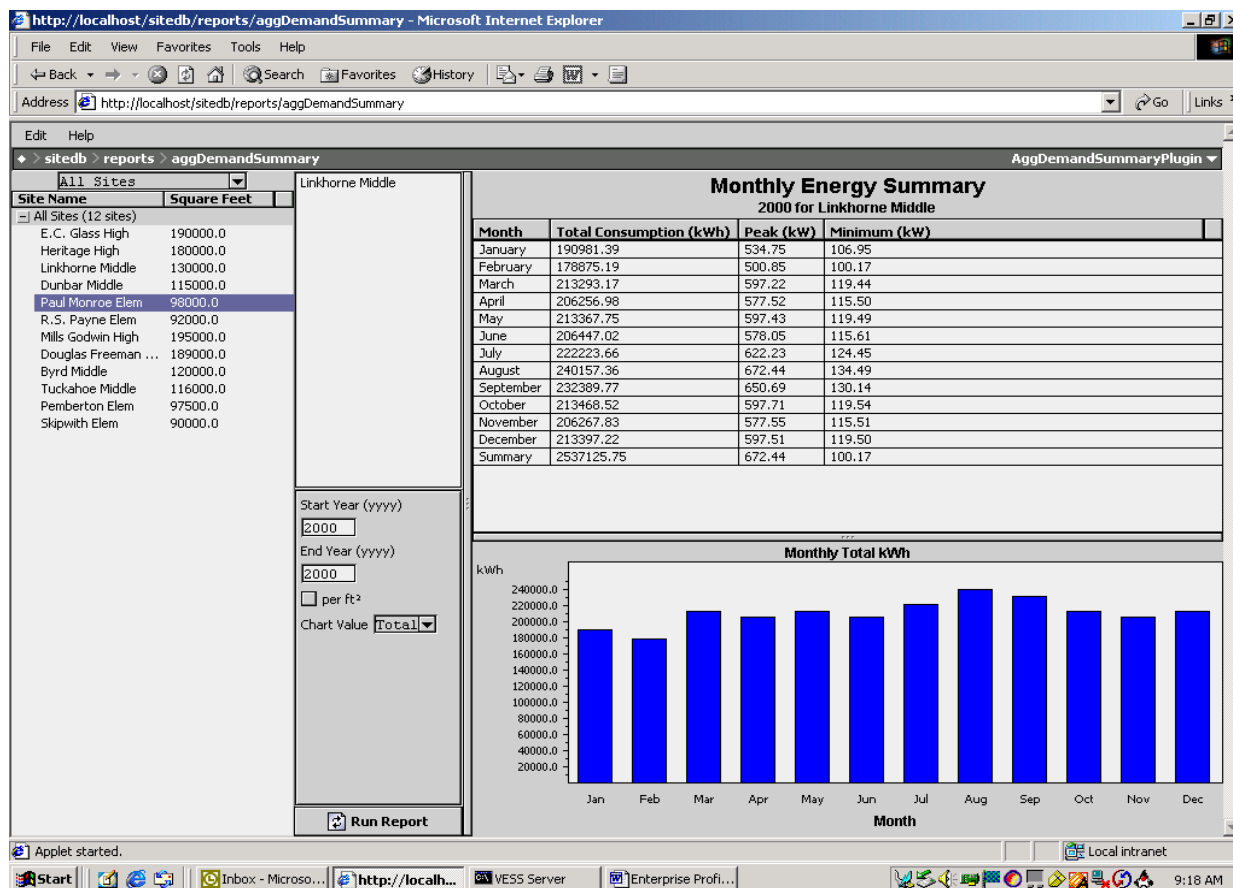
1 accounts for 14% of the total enterprise load and Building 2 contributes 19%. This report will allow users to identify inefficiencies and help perform budgeting.

5. Average Profile – The report will allow the user to average the load for a single load across time periods and give the average load, and/or aggregate multiple meters (loads) and view the average aggregated load. This report will be very beneficial when negotiating with energy service providers because it includes the load profile and consumption totals. With the ability to filter by time periods, measurement units, points or point groups, weekdays, and weekends, load profiles with associated data will allow the user to procure exactly the amount of energy required. This reduces risk for the energy provider and therefore reduces cost for the end-user.

The user will be able to manipulate between 1-minute intervals and hourly intervals. In addition, users will be able to choose between auto scale and manual scale. For example, if the minimum value is 100KW and the maximum is 500 kW, the user can have the chart automatically scale between those values or they can select any range to scale the 400kW range. When printing charts, this may be useful. This will be useful for sophisticated users who need a higher resolution of data. The following screen shot is an example of the Average Profile Report.

6. Point Trending – This report will allow the user to choose a single or multiple points and trend the values over a specified time period. Either analog or digital points can be trended and multiple variables can be selected to be report. For a visual representation of several point values, the user will view all points on the left Y-axis. If the user would like to perform a statistical analysis identifying correlation coefficient and standard deviation between variables, they will have the ability to select a single point for each Y-axis. If a point group has been created, it would be presented as a single point value. The same auto scale/manual scale feature discussed in Average Profile Report is available in Point Trending. The following screen shot is an example of the Point Trending Report.
7. Universal Comparison Report – This report will convert electricity, gas, and other fuels to KBtu, a common measurement unit. Once the consumption values are converted to a common unit, users will have the ability to compare efficiency or analyze the total energy breakdown for a site or group of facilities. Once this report is selected, the user will define parameters such as sites or points to compare, time period, type of graph, and percentage versus measurement unit. Gas, propane, oil, electricity and other fuels can be converted to KBtu.
8. Exception Report – This report will identify all data values for the specified period that does not fall in a user-defined range. Although the range will be user definable, the benchmark or baseline to be compared against will be historical data. Users can get to this report by selecting it among the library of nine report templates, or can automatically be taken here from the Average Profile

Report or Point Trending Report by clicking on an “Exception” button once a profile is being viewed.



19. Direct Digital Controllers

The Controller should have the ability to have true open source standards, using IP Based Ethernet connectivity. These include Modbus Server and Client at TCP and RS485 level, and also the BMS leading protocol BACnet, supporting both Client and Server at the TCP/IP and mstp levels.

Controller should have Framework, which is an open source development framework, should provide a complete software platform for developing, deploying, integrating, and managing pervasive device applications at the lowest level. The Framework distributes decision making control and manageability to any device and brings intelligence and connectivity to the network edge, and back.

1. Each DDC shall operate as a standalone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each DDC shall be a microprocessor-Based, **WEB BASED**, multi-tasking, real-time digital control processor. **EACH DDC CONTROLLER WILL BE MAX 30 POINT CONTROLLER.** DDC Shall be 100% open using Either Modbus, Bacnet or Lonworks Only as a Protocol.
2. Totalizer points would support Math resolution of 15 digits, or 999,999,999,999,999
3. On board RTC
4. Optimization for Heating and Cooling
5. The controllers shall consist of single 32 bit microprocessors IP for reliable throughput, based with EEPROM based operating system (O.S.). Multi microprocessor to meet 32 bit, such as 2 Nos. of 16 bit or 4 nos. of 8 bit, criteria **is not acceptable**. It should operate on should operate at 55 MHz and is supported with 2 MB of Flash memory and 8 MB of RAM.
6. Communication: **The controllers should have on board Ethernet Port. The Ethernet Protocol is the One to be Used in the AURIC Project well as the RS485 Protocol is kept as a Feature in case of emergency.** Supports Ethernet 10Base-T/ 100Base-T interface,
7. Device ID: Complementing existing standard protocols, the DDC shall be uniquely identifiable over the network. This facilitating online network device search and simplify reconfiguration
8. High Accuracy Analog Channels: shall be capable of 12-bits A/D converter and 12- bits D/A convertors
9. Shall be a standalone programmable device
10. Online Firmware Upgrade/Configuration: Shall support firmware upgrades either through RS485 or Ethernet connection.
11. The controller shall have a built-in High accuracy Real Time Clock lithium Battery Life Span: 5 years
12. Network Security: All configurations changes shall be protected via password setting, either through standard network protocol access or web browser
13. The DDC Controller shall be provided with LEDs for continuous status indication of power, communication bus, watches Dog, Networking OK, and self-diagnostics as a minimum.
14. All DDC controllers shall be DIN channel mountable and installed in suitable enclosures. The enclosures shall be provided with hinged doors with locking facility. Apart from the controllers, the enclosure shall house the terminal blocks, load relays and associated equipment. The internal wiring in the enclosure shall be factory wired. The packaging shall be such that complete installation of the field equipment and field wiring can be done prior to the installation of the electronics.
15. **Agency Listing: CE, UL 916, C-Tick**

16. Shall support the expansion from 24 to 96 or more IO points through expansion cards with following Input/output Configuration:

1. Universal Input:

Voltage: 0 - 10V (+/-0.005V), 0 - 5V (+/- 0.003V)

Current: 4 - 20mA (+/-0.01mA), 0 - 20mA (+/-0.01mA)

Resistance: 0 - 30K (+/-10 Ohm), 0 - 10K (+/-5 Ohm), 0 - 1.5K (+/-1 Ohm)

Thermistor: 10K, 10K Shunt, 1K Balco, 1K Platinum

2. Digital Input:

Type: Voltage Free

Limit: +5V at 500Ohm Resistance maximum

3. Digital Output:

Type: Relay Contacts, SPST NO, 48VA at 24VAC,

4. Transistor Output:

Type: Open Collector Output, Isolation 3.75KV- Max Rating: 1A, 60V

5. Analogue Output

12 bits resolution - Type: Current: 0 - 20mA, 4 - 20mA (up to 800 Ohm load), Voltage: 0 - 10V

20. Field Devices Specifications

Design Installation & Specifications

- Temperature sensor assemblies shall be readily accessible and adaptable to each type of application in such manner as to allow for quick, easy replacement and servicing without special tools or skills.
- Strap-on mountings shall not be permitted.
- Outdoor installations shall be; of weatherproof construction or in appropriate NEMA enclosures. These installations shall be protected from solar radiation and wind effects. Protective shield shall be stainless steel.
- Sensors shall be with enclosure where located in finished space.
- Sensors in ducts shall be mounted in locations to sense the correct temperature of the air only and shall not be located in dead air spaces or positions obstructed by ducts, equipment, and so forth. Locations where installed shall be within the vibration and velocity limit of the sensing element. Ducts shall be securely sealed where elements or connections penetrate ducts to avoid measuring false conditions.
- All sensors measuring temperatures in pipes larger than 2 inches in diameter or in pressure vessels shall be supplied with wells properly fabricated for the service. Wells shall be noncorrosive to

the medium being measured and shall have sufficient physical strength to withstand pressures and velocities to which they are subjected. Wells shall be installed in the piping at elbows where piping is smaller than the length of the well to effect proper flow across the entire area of the well.

- Thermowells

When thermowells are required, the sensor and well shall be supplied as a complete assembly including well head and greenfield fitting.

It shall be pressure rated and constructed in accordance with the system working pressure. Thermowells and sensors shall be mounted in a threadolet or 1/2" NPT saddle and allow easy access to the sensor for repair or replacement. Thermowells shall be constructed of the following materials:

- Chilled and Hot Water; brass.
- Steam; 316 stainless steel.
- Brine (salt solutions): marine grade stainless steel.

1. Temperature Sensors

Sensors and transmitters shall be UL / CE listed, provided, as outlined in the input/output summary and sequence of operations.

The temperature sensor shall be of the resistance type, and shall be either two-wire 100 ohm platinum RTD, or two-wire 1000 ohm platinum RTD.

The following point types (and the accuracy of each) are required, and their associated accuracy values include errors associated with the sensor, lead wire, and A to D conversion:

Point Type	Accuracy
Chilled Water	$\pm 0.2^{\circ}\text{C}.$
Room Temp	$\pm 0.2^{\circ}\text{C}.$
Duct Temperature	$\pm 0.2^{\circ}\text{C}.$
All Others	$\pm 0.2^{\circ}\text{C}.$

A. Duct Temperature Sensors:

Duct sensors shall be rigid or averaging as shown. For Rigid Sensors, length shall be 6". Averaging sensors shall be a minimum of 2m [6 feet] in length.

Ambient temperature rating of -30 to +80 deg. C, protection class IP65 and Pt 1000 sensing element with SS316 stem.

B. Immersion Temperature Sensors:

Immersion sensors shall be provided with a separable stainless steel well with ½” NPT (M) connection and length shall be 6”. Pressure rating of well is to be consistent with the system pressure in which it is to be installed.

Thermowell should be single piece Barstock Construction

Operating range shall be -20 to 80 deg C; pressure rating shall be min. PN 16, IP 65 protection, 1000 ohms platinum at 0 deg. C. Accuracy to $\pm 0.2^{\circ}\text{C}$ at 0°C , DIN Class A

C. Outside Air Temperature Sensors:

Outside Air sensors shall be rigid sensors with 2” length.

Ambient temperature rating of 80 deg. C, protection class IP66 and Pt 1000 sensing element.

D. Temperature Transmitters:

Transmitters shall be UL / CE listed, provided, as outlined in the input/output summary sequence of operations.

The temperature sensor shall be of the resistance type, and shall be two-wire 4 – 20mA and 0 – 10 V Jumper settable, range has to be programmable with MMI protocol.

The following point types (and the accuracy of each) are required, and their associated accuracy values include errors associated with the sensor, lead wire, and A to D conversion:

Point Type	Accuracy
Chilled Water	$\pm 0.1^{\circ}\text{C}$.
Room Temp	$\pm 0.1^{\circ}\text{C}$.
Duct Temperature	$\pm 0.1^{\circ}\text{C}$.
All Others	$\pm 0.1^{\circ}\text{C}$.

2. Humidity Sensors:

Duct and room sensors shall be UL / CE listed have a sensing range of 0% to 100% (at 25 Deg.C) with accuracy of $\pm 2\%$ R.H and ± 0.5 Deg.C. Humidity Sensor Element should be All-Polymer sensing element and NTC for Temperature. The RH sensors should incorporate the True RH technology. With fire retardant enclosure.

Duct sensors shall be provided with a protection cap with Stainless Steel sintered mesh. Duct probe material should be stainless steel.

Outdoor air humidity sensors shall have a sensing range of 0% to 100% R.H. It shall be suitable for ambient conditions of -40°C to 85°C with IP66 protection class.

Humidity sensor's drift shall not exceed 0.5% of full scale per year.

It should be programmable with MMI Protocol.

3. Pressure Sensors

A. Differential Pressure Transmitters for air:

1. Transmitter should be UL / CE listed and have a removable LCD display with multiple units. The response time, units and range should be site adjustable through DIP switch to counter adjust fluctuating readings.
2. Air pressure sensor shall have Silicone diaphragm construction. Sensing elements shall withstand continuous operating conditions of 1000 Pa and static pressure of 10000 Pa. Sensor shall be complete with 4-20 mA and output, with over voltage protection. The accuracy shall be $\pm 0.5\%$ or better. The total error band shall be $\pm 1\%$ or better.
3. Sensor shall be complete with 4-20 mA and 0 -10 V output simultaneously, with over voltage protection. Transmitter should be available with optional MODBUS output.
Sensor shall have linear output signal. Zero and span shall be field-adjustable with 5 Point onsite custom calibration.
4. Standard of acceptance: Omicron series M11 or approved equal.

B. Differential Pressure Switch for air:

1. Switch shall be UL / CE listed and have field adjustable set point with Snap action microswitch (SPDT) with silver / gold plated contacts.
2. Switch should be able to withstand static pressure of 15000 Pa and temperature of 85°C . The repeatability should be $\pm 2\%$ or better. Contact rating for the switch shall be 1A 250VAC.
3. The enclosure should have IP65 Protection with option of Direct and Panel Mounting.
4. Set of accessories should be given along with switch.

4. Chilled Water Flow Meters

1. Sensors shall be UL / CE listed. Flow meter shall be a single electro-magnetic type inline flow meter able to work in conductivities above 5 μ S.
 2. The wetted material shall be constructed of stainless steel with PTFE Lining and electrode material shall be Titanium with Die cast aluminium IP67 Enclosure and LCD Display. Display should indicate Instantaneous, Totalized flow and multiple units.
 3. Range shall be field settable.
 4. Flow meter accuracy shall not exceed $\pm 0.5\%$ with velocities from 3 to 30 fps.
- Provide output via 4 – 20mA Signal and MODBUS.

5. Carbon Dioxide Transmitters:

1. Sensors shall be UL / CE listed. Carbon Dioxide Transmitter should be wall mounted with 0 – 10000 PPM Range. The working range of the transmitter should be 2000 – 5000 – 10000 PPM jumper settable. .
2. Typical area coverage should be greater than 1000 m²
3. Warmup time should be less than 30 seconds
4. The internal NDIR CO₂ sensor should be replaceable.
5. The output should be field selectable between 4 – 20mA, 0 – 20 mA , 0 – 10 VDC , 2 – 10VDC, and MODBUS with Optional Removable LCD and LED light for power indication.
6. The accuracy for the transmitter should be $\pm 3\%$ of F.S with $\pm 1\%$ Drift / year.
7. The transmitter should be able to operate from -20°C to 80°C with fire retardant ABS enclosure.

6. Level Transmitters for water tanks:

1. Sensor shall be UL / CE listed and have linear output signal. The transmitter shall be submersible type.
2. Sensor sensing elements shall withstand continuous operating conditions plus or minus 50% greater than calibrated span without damage.
3. Sensor shall have SS316L diaphragm construction, proof pressure of 2 Bar and burst pressure of 20 Bar Minimum. Sensor shall be complete with 4-20 mA output, with over voltage protection. The accuracy shall be $\pm 0.25\%$ or better. The total error band shall be $\pm 0.5\%$ or better
4. The transmitter shall have IP68 protection with Corrosion resistant Cable. The cable should be vented type cable.

7. Level Switch:

1. Level Switches shall be UL / CE listed and have SPDT Contacts. The switch shall be Float operated, with top mounting.

2. Switch shall have SS316L wetted parts, proof pressure of 10 bar and burst pressure of 20 bar Minimum. The accuracy shall be $\pm 0.25\%$ or better. The total error band shall be $\pm 0.5\%$ or better
3. The switch shall have IP68 protection, with corrosion resistant cable. The current rating for the switch shall be 15A, 230VAC. Fire retardant ABS enclosure.

8. Water Hardness Analyser (In Future)

It shall suitable for monitoring of the quality of water (measure CaCO_3)

It shall have Alarms- Three relay outputs: limit values (LV1, LV2) and one fault alarm, Resistive load 4A

1. Housing Rating shall be IP65 rated.
2. Alarms- Three relay outputs: limit values (LV1, LV2) and one fault alarm, Resistive load 4A
3. Current output: 0 to 20mA or 4 to 20mA, Max. load 500Ω
4. Power Supply- Voltage: 115V, 230V or 24V AC $\pm 10\%$, 50/60 Hz
5. Power consumption: 30VA
6. Sample Pressure: 0.1 to 3 bar (1.5 to 45.5 psi)
7. Sample Temperature: 10 to 40°C (41 to 104°F) max.
8. Ambient Temperature: 10 to 45°C (41 to 124°F)
9. Ingress Protection: IP65

9. Level Transmitters for Diesel tanks:

1. Sensor shall be UL / CE listed and have linear output signal. The transmitter shall be Float operated.
2. Sensor sensing elements shall withstand continuous operating conditions plus or minus 50% greater than calibrated span without damage.
3. Sensor shall have SS316L wetted parts, proof pressure of 10 bar and burst pressure of 20 bar Minimum. Sensor shall be complete with 4-20 mA output, with over voltage protection. The accuracy shall be $\pm 0.25\%$ or better. The total error band shall be $\pm 0.5\%$ or better.
4. The resolution should be 5mm.
5. The transmitter shall have explosion proof enclosure IP67 protection with CCOE / Equivalent Government Approval.

Hardware Requirements:

1. IBMS Data Management Station: Client workstation with Intel i5 processor with minimum 320Gb HDD, 4 GB RAM, 19" TFT Monitor, DVD Writer, two serial (one for mouse and one for Serial data acquisition RS converter) and one parallel port (for Printer), multimedia speakers, infrared mouse;

2. 00 DPI colour Laser jet A4 printer for printing reports complete with communication cable, power cable, printer driver software etc.

Portable Operator Terminal (POT) / Operating Panel (OP)

POT shall be provided per each ONBOARD IP DDC for ONBOARD IP DDCs which are blind and without on-board HMI; for system supplied with ONBOARD IP DDCs having on-board HMI, a POT per single regulate Area shall be covered.

General Requirements.

The POT / DDU shall permit the project operating staff to:

Display point values

Display parameters

Change time schedule elements

List and acknowledge alarms

Monitor points in the system

Command points (manual overrides) of points

Override input points (put inputs in test)

Read and check LonWorks variables on the network

Password protected

POT / DDU shall be with the following components:

Liquid Crystal Display

Minimum 4x20 character

Pushbuttons for scrolling display and enter

Permanent mount or portable connection.

IO SUMMARY (Enclosed is the Excel Format)**THIRD PARTY INTEGRATION DETAILS (Please refer IO Summary Tab)**

LIST OF APPROVED MAKES - BMS SYSTEM

SR NO	Details of Materials / Equipment	Manufacturer's Name
1	Integrated Converged Technology/IBMS Platform	Tridium /Honeywell Trend, Siemens /JCI/ALC
2	GUI / Facility Dashboard	QA Graphics, Lucid Designs, Dg Logic
4	Energy Management Software	Siemens/ JCI/ Honeywell Certified
6	Protocol Integrator	Siemens/ JCI/ Honeywell/Field Server
7	IP Based DDC	Siemens/ JCI/ Honeywell / EASY IO
9	Workstation HW	HP/Dell/Lenovo
10	Printers	Samsung/HP
11	Cabling	Caliplast/ Technoflex/RR Kabel/ Polycab/ Supercab
12	Duct Mount Temp Sensor	Siemens/ JCI/ Honeywell/ Sontay / Dwyer/Omicron
13	Duct Mount RH Sensor	Siemens/ JCI/ Honeywell/ Sontay / Dwyer/Omicron
14	Immersion Temp Sensor	Siemens/ JCI/ Honeywell/ Sontay / Dwyer /Omicron
15	Duct Mount Pressure Sensor	Siemens/ JCI/ Honeywell/ Sontay / Dwyer/Omicron
16	Duct Mount Air Velocity Sensor	Siemens/ JCI/ Honeywell/ Sontay / Dwyer/Omicron
17	Air DP Sensor	Siemens/ JCI/ Honeywell/ Sontay / Dwyer /Omicron
18	Air DP Switch for Filter Status	Siemens/ JCI/ Honeywell/ Sontay / Dwyer/Omicron
19	Air DP Switch for Fan Status	Siemens/ JCI/ Honeywell/ Sontay / Dwyer/Omicron
20	Water DP Switch for Pump Status	Siemens/ JCI/ Honeywell/ Sontay / Dwyer/Omicron
21	Flow Meter	Kele/Omicron/Kamstrup

9.0 IGBC RATING SYSTEM

Following are the standards and codes are part of these specifications / guidelines:

Table 10

Codes / Specifications	Descriptions
IGBC 2011 for India	Core and Shell Projects (based on IGBC 2009).
ASHRAE 90.1.2007	Energy Standard for Buildings

11.1 SEWAGE TREATMENT PLANT

DESIGN BASIS FOR STP

Plant capacity

Package Sewage Treatment Plant (PSTP): - 105 KLD capacity [average flow].

A PSTP of 105 KLD capacity [average flow] is planned which will cater the sewage generated.

Characteristics of Raw Water

Understanding of the nature of physical, chemical and biological characteristics of sewage is essential in planning, design and operation of treatment and disposal facilities and in the engineering management of environmental quality. The influent characteristics expected for domestic sewage is given Table.

Table 13: Influent Characteristics (Reference CPHEEO Manual for Sewerage and sewage treatment system)

SI. No.	Parameter	Values
1	pH	6.5 - 8.5
2	BOD5 @ 20°C, mg/L	250 – 300
3	COD	400 – 500
4	To	300 - 400
5	Oil and grease, mg/L	10 - 20
6	Total kjeldahl Nitrogen (as N), mg/L	40 - 50
7	Total Phosphorus, mg/L	5 - 7
8	Faecal Coliforms MPN/100 ml	10^6 to 10^8

Characteristics of Treated Sewage

It is proposed that the sewage which is generated is to be treated to such standards that it can be used for gardening, toilet flushing and washing of internal roads & paved areas.

From the point of view of better environment, it is contemplated that the entire sewage will be treated to 5 mg/l (BOD and TSS) standards. The EPA standards for reuse of municipal sewage are given in **Table 14**.

Table 14: EPA Standard of Treated Sewage

Type of Reuse	All types of landscape irrigation, vehicle washing, toilet flushing, use in fire protection systems and commercial air conditioners and other uses with similar access or exposure to the water
Treatment	Secondary, Filtration, Disinfection
pH	6.5-8.5
BOD (mg/L)	: 5
Turbidity (NTU)	: 2
Faecal Coli/100mL	No detectable Faecal Coli
Residual Chlorine (mg/L)	1

- The reclaimed water should not contain measurable levels of viable pathogens.
- Reclaimed water should be clear and odourless.
- Higher chlorine residual and/ or a longer contact time may be necessary to assure that viruses and parasites are inactivated or destroyed.
- Chlorine residual of 0.3-0.5 mg/l or greater in the distribution system is recommended to reduce odours, slime, and bacterial re-growth.

Treated water from tertiary treatment of STP is proposed to be stored in a separate treated water tank near STP. This treated/ recycled water is proposed to be supplied for landscape & irrigation.

The reuse of the treated wastewater for the project area will be for gardening, toilet flushing, road washing, etc. Hence, expected standard will be as given in **Table 15**.

Table15: Treated Sewage Standards

Maximum limits / Type of Water usage	Unit	Minimum Values
Colour	-	Acceptable
BOD	mg/lit	< 5
COD	mg/lit	< 50
Residual Chlorine	mg/lit	<1

Maximum limits / Type of Water usage	Unit	Minimum Values
Faecal Coliform	mg/lit	No detectable Faecal Coli
Turbidity	NTU	<5*
pH		6.5-8.5
TSS	mg/lit	< 5

Residual chlorine for flushing water need not be >1 mg/l

* From Practical Consideration

12.0 SOLID WASTE MANAGEMENT SYSTEM

The following standards and codes and statutory requirements to be followed for design and implementation of the Solid Waste Management:

Table 16

Codes / Manuals	Description
CPHEEO	Manual on Municipal Solid Waste Management, Ministry of Urban Development, Government of India, 2000.
Guidelines by Supreme Court of India, 1999.	Solid waste management in class-I cities in India
[20/7/1998], S.O.630 (E), 1998.	Bio-medical waste (management and handling) rules
S.O. 2400(E), 1999.	Recycled plastic (manufacture and usage) rules
[25.9.2000], S.O. 908(E), 2000 and the amendment 2013	Municipal waste (Management and Handling Rules),
	Batteries (Management and handling) Rules, 2001.
1999, S. O.705 (E), 2003.	Amendment to the Recycled Plastic Manufacturing and Usage Rules,
[17.9.2003], S.O.1069 (E), 2003.	Bio-Medical Waste (Management and Handling) (Amendment) Rules,
	Hazardous waste management and handling rule, 1989.
S.O.2265 (E), 2008	Hazardous Wastes (Management, Handling and Trans boundary Movements) Rules,.
S.O. 2400(E), 2009.	Plastics (Manufacture, Usage and Waste Management) Rules, [17.09.2009],
	E waste (Management and handling) Rules, 2011.

Schedule E - Maintenance Requirements*(See Clause 2.1 and 14.2)***1.0 Maintenance Requirements**

- 1.1 The Contractor shall, at all times maintain the Project Components (AURIC Hall Building) in accordance with the provisions of this Agreement, Applicable Laws and Applicable Permits.
- 1.2 The Contractor shall repair or rectify any Defect or deficiency set forth in Paragraph 2 of this Schedule-E within the time limit specified therein and any failure in this behalf shall constitute non-fulfilment of the Maintenance obligations by the Contractor. Upon occurrence of any breach hereunder, the Employer shall be entitled to effect reduction in monthly lump sum payment as set forth in Clause 14.6 of this Agreement, without prejudice to the rights of the Employer under this Agreement, including termination thereof.
- 1.3 All materials and works for operations and maintenance of Potable water supply rising mains and distribution networks, Elevated Service Reservoirs (ESR), Recycled water supply rising mains and distribution networks including valves, flow meters etc. shall confirm to CPHEEO Manual on Operation and Maintenance of water supply systems, 2005, MoUD, GOI
- 1.4 Where the Standards and Specifications for any of the above work are not given, Good Industry Practice shall be adopted to the satisfaction of the Employer's Engineer.

2.0 Repair/Rectification of Defects and Deficiencies

The obligations of the Contractor in respect of Maintenance Requirements shall include repair and rectification of the Defects and deficiencies specified in Appendix E-I of this Schedule-E within the time limit set forth therein.

3.0 Other Defects and Deficiencies

In respect of any Defect or deficiency not specified in Appendix E-I of this Schedule- E, the Employer's Engineer may, in conformity with Good Industry Practice, specify the permissible limit of deviation or deterioration with reference to the Standards and Specifications, and any deviation or deterioration beyond the permissible limit shall be repaired or rectified by the Contractor within the time limit specified by the Employer's Engineer.

4.0 Extension of Time Limit

Notwithstanding anything to the contrary specified in this Schedule-E, if the nature and extent of any Defect or deficiency justifies more time for its repair or rectification than the time specified in Schedule M, the Contractor shall be entitled to additional time in conformity with Good Industry Practice. Such additional time shall be determined by the Employer's Engineer and conveyed to the Contractor and the Employer with reasons thereof.

5.0 Emergency Repairs/Restoration

Notwithstanding anything to the contrary contained in this Schedule-E, if any Defect, deficiency or deterioration in the Project Components (Administrative and Business Centre) poses a hazard to safety or risk of damage to property, the Contractor shall promptly take all reasonable measures for eliminating or minimizing such danger.

6.0 Daily Inspection by the Contractor

The Contractor shall, through its engineer, undertake a daily visual inspection of the Project Components (Administrative and Business Centre) and maintain a record thereof in a register to be kept in such form and manner as the Employer's Engineer may specify. Such record shall be kept in safe custody of the Contractor and shall be open to inspection by the Employer and the Employer's Engineer at any time during office hours.

7.0 Repairs On Account of Natural Calamities

All damages occurring to the Project Components (Administrative and Business Centre) on account of a Force Majeure Event or default or neglect of the Employer shall be undertaken by the Employer at its own cost. The Employer may instruct the Contractor to undertake the repairs at the rates agreed between the Parties.

Appendix E I – Repair / Rectification of Defects and Deficiencies
(Schedule-E)

The Contractor shall repair and rectify the Defects and deficiencies specified in this **Appendix E-I** of Schedule-E.

1.0 Architectural, Civil maintenance

- 1.1 Any break down of door / window / hatch accessories should be replaced / rectified within 24 hours.
- 1.2 Any breakage of flooring, false ceiling, peeling of paint should be rectified in 48 hours.
- 1.3 Any damage to External stone cladding, flooring, paving, hardscape, façade etc. shall be rectified within 48 hours.
- 1.4 Any crack / peeling of Plaster shall be repaired within 48 hrs
- 1.5 Any water leak in building shall be stopped with 2 hrs and suitable rectification process undertaken.

2.0 Electrical

- 2.1 Any Electrical equipment / Apparatus/ cables, etc. shall be restored within two hours in case of minor faults and within eight hours in case of major faults.
- 2.2 Faulty lighting fixtures should be rectified within six hours.
- 2.3 Essential spares to be available for immediate repairs.

3.0 HVAC, Fire Fighting and Plumbing

- 3.1 Chillers - Minor repair shall be rectified within 24 hrs. and major repair (compressor failure) shall be rectified within 5 days.
- 3.2 Pumps - Minor repair shall be rectified within 4 hrs. and major repair (motor/bearing failure) shall be rectified within 8 hours.
- 3.3 Cooling towers - Minor repair shall be rectified within 4 hrs. and major repair (motor/bearing failure) shall be rectified within 8 hours.
- 3.4 AHU - Minor repair shall be rectified within 4 hrs. and major repair (motor/bearing failure) shall be rectified within 8 hours.
- 3.5 DX units / VRV units - Minor repair shall be rectified within 4 hrs. and major repair (motor failure) shall be rectified within 24 hours.
- 3.6 Fans - Minor repair shall be rectified within 4 hrs. and major repair (motor/bearing failure) shall be rectified within 8 hours.

- 3.7 Piping/valve/ traps/ fittings / Taps leakages - Shall be rectified/replaced within 2 hrs.
- 3.8 Instruments like gauges/sensors - Shall be rectified / replaced within 2 hrs.
- 3.9 Any damage to sanitary ceramic fixtures or CP fittings shall be replaced or rectified within 24 hours.
- 3.10 Essential spares to be available for immediate repair.

4.0 Fire detection, alarm system, access control and surveillance

- 4.1 Any damage breakage of any apparatus, equipment, sensors and system in general should not remain nonfunctional for more than two hours.
- 4.2 Essential spares to be available for immediate repair.

6.0 Sewage Treatment Plant (Package STP)

- 6.1 Details for maintenance to be carried out
- 6.1 The plant should not remain nonfunctional for more than two hours in a month
- 6.2 Any leakage in pipelines shall be restored within 2 hrs.

7.0 Solid waste Management (SWM) – if applicable

- 7.1 The bins should not be allowed to overflow at any point of time and should be emptied irrespective of pre-determined frequency of lifting the bins.
- 7.2 OWC maintenance should be backed by proper plan so that the organic waste does not get accumulated for more than six hours

Schedule F - Applicable Permits

(See Clause 3.1.5(a))

1.1 Applicable Permits

The Contractor shall obtain, as required under the Applicable Laws, the following Applicable Permits:

- (a) Permission of the State Government for extraction of boulders from quarry;
- (b) Permission of Village Panchayat and Pollution Control Board for installation of crushers;
- (c) License for use of explosives;
- (d) Permission of the State Government for drawing water from river/reservoir;
- (e) License from inspector of factories or other competent Authority for setting up batching plant;
- (f) Clearance of Pollution Control Board for setting up batching plant;
- (g) Clearance of Village Panchayats and Pollution Control Board for setting up asphalt plant;
- (h) Permission of Village Panchayats and State Government for borrow earth; and
- (i) Any other permits, clearances or approvals required under Applicable Laws.
- (j) Any other permits, clearances or approvals required under Applicable Laws.

Applicable permits, as required, relating to environmental protection and conservation shall have been procured by the EMPLOYER in accordance with the provisions of this Agreement.

2.1 Architecture

- Commencement Certificate, Intermediate Certificates, Occupancy Certificate and Completion Certificate from local municipal body or designated authority for the buildings.
- Town Planning Department remarks for applicable norms / zones / uses.

3.1 Civil & Structures

- Forest department Clearance for clearing of site of trees and shrubs if required.
- Water Connection from Public Health Engineering Department (State).
- Provision and permit for connection to proposed municipal sewage collection system at directed location from local municipal body.
- Project Clearance from General Inspectorate for Emergency Situations.
- Project Clearance from the Solid Waste Management Authority.

4.1 Electrical

- Incoming Power Supply (Main and temporary): State electricity board or power supply authority.

- Substation & Elevators & Solar PV system: CEIG (chief electrical inspector to government) / local statutory authority / PWD
- License to Operate the Elevators from Ministry of Labour or relevant authority.

5.1 Fire Fighting

- Preliminary approval from Chief Fire Officer prior to construction and final approval on completion of project.

6.1 FDA Access Control & Security

- Fire Detection & Alarm System - Compliance with IS:2189:1988, BIS: 15908 standards and certification from the Regional Fire Officer / Chief Fire Officer.

7.1 Roads

- MIDC/PWD clearance for connecting to the any existing road.

8.1 STP

- State Pollution Control Board approval for STP.
- If any hazardous waste is generated from the facility like used DG oil, used batteries etc., the same should be handed over to only SPCB approved agencies for handling hazardous waste.

9.1 Solid Waste Management

- Permit from the Municipal Corporation for disposal of inert in the land fill site

Schedule G - Form of Bank Guarantee*(See Clause 7.1.1, 7.5.3 and 19.2)***Contents**

Annex-I – Performance Security.....	
Annex-II – Form for Guarantee for Withdrawal of Retention Money.....	
Annex-III – Form for Guarantee for Advance Payment.....	

Annex-I

(See Clause 7.1.1)

Performance Security

.....
 Employer.....

WHEREAS:

- (A) _____ [name and address of contractor] (“hereinafter called as Contractor”) and [name and address of the EMPLOYER], (**“the EMPLOYER”**) have entered into an agreement (the **“Agreement”**) for “Design , Construction and Maintenance of AURIC Hall Building for Phase-I in Shendra-Bidkin Industrial Area, Aurangabad, Maharashtra State on EPC Basis (Package – IV)” on Engineering, Procurement and Construction (“EPC”) basis, subject to and in accordance with the provisions of the Agreement.
- (B) The Agreement requires the Contractor to furnish a Performance Security for due and faithful performance of its obligations, under and in accordance with the Agreement, during the Construction Period and Defects Liability Period (as defined in the Agreement) in a sum of Rs. Crore (Rupees Crore) (the “Guarantee Amount”).
- (C) We, ...through our branch at (the “Bank”) have agreed to furnish this bank guarantee (hereinafter called the “Guarantee”) by way of Performance Security.

NOW, THEREFORE, the Bank hereby, unconditionally and irrevocably, guarantees and affirms as follows:

1. The Bank hereby unconditionally and irrevocably guarantees the due and faithful performance of the Contractor’s obligations during and under and in accordance with the Agreement, and agrees and undertakes to pay to the Employer, upon its mere first written demand, and without any demur, reservation, recourse, contest or protest, and without any reference to the Contractor, such sum or sums up to an aggregate sum of the guarantee amount as the EMPLOYER shall

claim, without the EMPLOYER being required to prove or to show grounds or reasons for its demand and/or for the sum specified therein.

A letter from the EMPLOYER, under the hand of an officer not below the rank of [.....of EMPLOYER], that the Contractor has committed default in the due and faithful performance of all or any of its obligations under and in accordance with the Agreement shall be conclusive, final and binding on the Bank. The Bank further agrees that the EMPLOYER shall be the sole judge as to whether the Contractor is in default in due and faithful performance of its obligations during and under the Agreement and its decision that the Contractor is in default shall be final, and binding on the Bank, notwithstanding any difference between the EMPLOYER and the Contractor, or any dispute between them pending before any court, tribunal, arbitrators or any other authority or body, or by the discharge of the Contractor for any reason whatsoever.

In order to give effect to this Guarantee, the EMPLOYER shall be entitled to act as if the Bank were the principal debtor and any change in the constitution of the Contractor and/or the Bank, whether by their absorption with any other body or corporation or otherwise, shall not in any way or manner affect the liability or obligation of the Bank under this Guarantee.

1. It shall not be necessary, and the Bank hereby waives any necessity, for the EMPLOYER to proceed against the Contractor before presenting to the Bank its demand under this Guarantee.
2. The EMPLOYER shall have the liberty, without affecting in any manner the liability of the Bank under this Guarantee, to vary at any time, the terms and conditions of the Agreement or to extend the time or period for the compliance with, fulfillment and/or performance of all or any of the obligations of the Contractor contained in the Agreement or to postpone for any time, and from time to time, any of the rights and powers exercisable by the EMPLOYER against the Contractor, and either to enforce or forbear from enforcing any of the terms and conditions contained in the Agreement and/or the securities available to the EMPLOYER, and the Bank shall not be released from its liability and obligation under these presents by any exercise by the EMPLOYER of the liberty with reference to the matters aforesaid or by reason of time being given to the Contractor or any other forbearance, indulgence, act or omission on the part of the EMPLOYER or of any other matter or thing whatsoever which under any law relating to sureties and guarantors would but for this provision have the effect of releasing the Bank from its liability and obligation under this Guarantee and the Bank hereby waives all of its rights under any such law.

3. This Guarantee is in addition to and not in substitution of any other guarantee or security now or which may hereafter be held by the EMPLOYER in respect of or relating to the Agreement or for the fulfillment, compliance and/or performance of all or any of the obligations of the Contractor under the Agreement.
4. Notwithstanding anything contained herein before, the liability of the Bank under this Guarantee is restricted to the Guarantee amount and this Guarantee will remain in force for the period specified in paragraph 8 below and unless a demand or claim in writing is made by the EMPLOYER on the Bank under this Guarantee all rights of the EMPLOYER under this Guarantee shall be forfeited and the Bank shall be relieved from its liabilities hereunder.
5. The Performance Security shall cease to be in force and effect 90 (ninety) days after the end of the Defects Liability Period as set forth in Clauses 7.1
6. The Bank undertakes not to revoke this Guarantee during its currency, except with the previous express consent of the EMPLOYER in writing, and declares and warrants that it has the power to issue this Guarantee and the undersigned has full powers to do so on behalf of the Bank.

Any notice by way of request, demand or otherwise hereunder may be sent by post addressed to the Bank at its above referred branch, which shall be deemed to have been duly authorized to receive such notice and to effect payment thereof forthwith, and if sent by post it shall be deemed to have been given at the time when it ought to have been delivered in due course of post and in proving such notice, when given by post, it shall be sufficient to prove that the envelope containing the notice was posted and a certificate signed by an officer of the EMPLOYER that the envelope was so posted shall be conclusive.

1. This Guarantee shall come into force with immediate effect and shall remain in force and effect for up to the end **** month in the year ***** or until it is released earlier by the EMPLOYER pursuant to the provisions of the Agreement.

Signed and sealed this day of 20..... at

SIGNED, SEALED AND DELIVERED

For and on behalf of the Bank

by: (Signature)

(Name)

(Designation) (Code

Number) (Address)

NOTES:

- (i) The bank guarantee should contain the name, designation and code number of the officer(s) signing the guarantee.
- (ii) The address, telephone number and other details of the head office of the Bank as well as of issuing branch should be mentioned on the covering letter of issuing branch.

Annex-II

(Schedule-G)

(See Clause 7.5.3)

Form for Guarantee for Withdrawal of Retention Money

.....

.....

.EMPLOYER,

Mumbai

WHEREAS:

[Name and address of contractor] (hereinafter called “the Contractor”) has executed an agreement (hereinafter called the “Agreement”) with the [name and address of the EMPLOYER], (hereinafter called “the EMPLOYER”) for the “Design , Construction and Maintenance of AURIC Hall Building for Phase-I in Shendra-Bidkin Industrial Area, Aurangabad, Maharashtra State on EPC Basis (Package - IV)” on Engineering, Procurement and Construction (the “EPC”) basis, subject to and in accordance with the provisions of the Agreement.

- a. in accordance with the Clause 7.5.3 of the Agreement, whenever the amount of the retention money (hereinafter called “Retention Money”) held by the EMPLOYER exceeds 1% (one per cent) of the Contract Price, the Contractor may, at its option, withdraw the Retention Money after furnishing to the EMPLOYER a bank guarantee for an amount equal to the proposed withdrawal.
- b. We, ...through our branch at (the “Bank”) have agreed to furnish this bank guarantee (hereinafter called the “Guarantee”) for the amount of Rs. (..... in words) (the “**Guarantee Amount**”).

NOW, THEREFORE, the Bank hereby, unconditionally and irrevocably, guarantees and affirms as follows:

1. The Bank hereby unconditionally and irrevocably undertakes to pay to the EMPLOYER, upon its mere first written demand, and without any demur, reservation, recourse, contest or protest,

and without any reference to the Contractor, such sum or sums up to an aggregate sum of the Guarantee Amount as the EMPLOYER shall claim, without the EMPLOYER being required to prove or to show grounds or reasons for its demand and/or for the sum specified therein.

- A letter from the EMPLOYER, under the hand of an officer not below the rank of [.....of EMPLOYER], that the Contractor has committed default in the due and faithful performance of all or any of its obligations under and in accordance with the Agreement shall be conclusive, final and binding on the Bank. The Bank further agrees that the EMPLOYER shall be the sole judge as to whether the Contractor is in default in due and faithful performance of its obligations during and under the Agreement and its decision that the Contractor is in default shall be final, and binding on the Bank, notwithstanding any difference between the EMPLOYER and the Contractor, or any dispute between them pending before any court, tribunal, arbitrators or any other authority or body, or by the discharge of the Contractor for any reason whatsoever.
1. In order to give effect to this Guarantee, the EMPLOYER shall be entitled to act as if the Bank were the principal debtor and any change in the constitution of the Contractor and/or the Bank, whether by their absorption with any other body or corporation or otherwise, shall not in any way or manner affect the liability or obligation of the Bank under this Guarantee.
 2. It shall not be necessary, and the Bank hereby waives any necessity, for the EMPLOYER to proceed against the Contractor before presenting to the Bank its demand under this Guarantee.
 3. The EMPLOYER shall have the liberty, without affecting in any manner the liability of the Bank under this Guarantee, to vary at any time, the terms and conditions of the Retention Money and any of the rights and powers exercisable by the EMPLOYER against the Contractor, and either to enforce or forbear from enforcing any of the terms and conditions contained in the Agreement and/or the securities available to the EMPLOYER, and the Bank shall not be released from its liability and obligation under these presents by any exercise by the EMPLOYER of the liberty with reference to the matters aforesaid or by reason of time being given to the Contractor or any other forbearance, indulgence, act or omission on the part of the EMPLOYER or of any other matter or thing whatsoever which under any law relating to sureties and guarantors would but for this provision have the effect of releasing the Bank from its liability and obligation under this Guarantee and the Bank hereby waives all of its rights under any such law.

4. This Guarantee is in addition to and not in substitution of any other guarantee or security now or which may hereafter be held by the EMPLOYER in respect of or relating to the Retention Money.
5. Notwithstanding anything contained hereinbefore, the liability of the Bank under this Guarantee is restricted to the Guarantee amount and this Guarantee will remain in force for the period specified in paragraph 8 below and unless a demand or claim in writing is made by the EMPLOYER on the Bank under this Guarantee all rights of the EMPLOYER under this Guarantee shall be forfeited and the Bank shall be relieved from its liabilities hereunder.
6. The guarantee shall cease to be in force and effect 90 (ninety) days after the end of then Defects Liability Period specified in Clauses 17.1 of the Agreement.
7. The Bank undertakes not to revoke this Guarantee during its currency, except with the previous express consent of the EMPLOYER in writing, and declares and warrants that it has the power to issue this Guarantee and the undersigned has full powers to do so on behalf of the Bank.

Any notice by way of request, demand or otherwise hereunder may be sent by post addressed to the Bank at its above referred branch, which shall be deemed to have been duly authorized to receive such notice and to effect payment thereof forthwith, and if sent by post it shall be deemed to have been given at the time when it ought to have been delivered in due course of post and in proving such notice, when given by post, it shall be sufficient to prove that the envelope containing the notice was posted and a certificate signed by an officer of the EMPLOYER that the envelope was so posted shall be conclusive.

1. This Guarantee shall come into force with immediate effect and shall remain in force and effect up to the end **** month in the year ***** or until it is released earlier by the EMPLOYER pursuant to the provisions of the Agreement.

Signed and sealed this day of 20..... at

SIGNED, SEALED AND DELIVERED

For and on behalf of the Bank by:

(Signature)

(Name) (Designation) (Code

Number) (Address) NOTES:

- (i) The bank guarantee should contain the name, designation and code number of the officer(s) signing the guarantee.
- (ii) The address, telephone number and other details of the head office of the Bank as well as of issuing branch should be mentioned on the covering letter of issuing branch.

Annex-III

(Schedule-G)

(See Clause 19.2)

Form for Guarantee for Advance Payment

.....,

..... EMPLOYER,

Mumbai

WHEREAS:

- i. [name and address of contractor] (hereinafter called “the Contractor”) has executed an agreement (hereinafter called the “Agreement”) with the [name and address of the EMPLOYER], (hereinafter called “the EMPLOYER”) for the “Design, Construction and Maintenance of AURIC Hall Building for Phase-I in Shendra-Bidkin Industrial Area, Aurangabad, Maharashtra State on EPC Basis (Package - IV)” on Engineering, Procurement and Construction (the “EPC”) basis, subject to and in accordance with the provisions of the Agreement.
- ii. in accordance with the Clause 19.2 of the Agreement the EMPLOYER shall make to the Contractor an interest bearing advance payment (hereinafter called “Advance Payment”) equal to 10% (ten per cent) of the contract price for mobilization expenses and acquisition of equipment; and that the Advance Payment shall be made in three installments subject to the Contractor furnishing an irrevocable and unconditional guarantee by a scheduled bank for an amount equal to the 110% amount of each installment to remain effective till the complete and full repayment of the installment of the Advance Payment as security for compliance with its obligations in accordance with the Agreement; and the amount of (first/second/third) installment of the Advance Payment is Rs. **** cr. (Rupees ***** crore) (the “Guarantee Amount”).
- iii. We, ...through our branch at (the “Bank”) have agreed to furnish this bank guarantee (hereinafter called the “Guarantee”) for the Guarantee Amount.

NOW, THEREFORE, the Bank hereby, unconditionally and irrevocably, guarantees and affirms as follows:

1. The Bank hereby unconditionally and irrevocably guarantees the due and faithful repayment on time of the aforesaid installment of the Advance Payment under and in accordance with the Agreement, and agrees and undertakes to pay to the EMPLOYER, upon its mere first written demand, and without any demur, reservation, recourse, contest or protest, and without any reference to the Contractor, such sum or sums up to an aggregate sum of the guarantee amount as the EMPLOYER shall claim, without the EMPLOYER being required to prove or to show grounds or reasons for its demand and/or for the sum specified therein.
2. A letter from the EMPLOYER, under the hand of an officer not below the rank of [.....of EMPLOYER], that the Contractor has committed default in the due and faithful performance of all or any of its obligations for the repayment of the installment of the Advance Payment under and in accordance with the Agreement shall be conclusive, final and binding on the Bank. The Bank further agrees that the EMPLOYER shall be the sole judge as to whether the Contractor is in default in due and faithful performance of its obligations during and under the Agreement and its decision that the Contractor is in default shall be final, and binding on the Bank, notwithstanding any difference between the EMPLOYER and the Contractor, or any dispute between them pending before any court, tribunal, arbitrators or any other authority or body, or by the discharge of the Contractor for any reason whatsoever.
3. In order to give effect to this Guarantee, the EMPLOYER shall be entitled to act as if the Bank were the principal debtor and any change in the constitution of the Contractor and/or the Bank, whether by their absorption with any other body or corporation or otherwise, shall not in any way or manner affect the liability or obligation of the Bank under this Guarantee.
4. It shall not be necessary, and the Bank hereby waives any necessity, for the EMPLOYER to proceed against the Contractor before presenting to the Bank its demand under this Guarantee.
5. The EMPLOYER shall have the liberty, without affecting in any manner the liability of the Bank under this Guarantee, to vary at any time, the terms and conditions of the Advance Payment or to extend the time or period of its repayment or to postpone for any time, and from time to time, any of the rights and powers exercisable by the EMPLOYER against the Contractor, and either to enforce or forbear from enforcing any of the terms and conditions contained in the Agreement and/or the securities available to the EMPLOYER, and the Bank shall not be released from its liability and obligation under these presents by any exercise by the EMPLOYER of the liberty with reference to the matters aforesaid or by reason of time being given to the Contractor or any other forbearance, indulgence, act or omission on the part of the EMPLOYER or of any other matter or thing whatsoever which under any law relating

to sureties and guarantors would but for this provision have the effect of releasing the Bank from its liability and obligation under this Guarantee and the Bank hereby waives all of its rights under any such law.

6. This Guarantee is in addition to and not in substitution of any other guarantee or security now or which may hereafter be held by the EMPLOYER in respect of or relating to the Advance Payment.
7. Notwithstanding anything contained hereinbefore, the liability of the Bank under this Guarantee is restricted to the Guarantee amount and this Guarantee will remain in force for the period specified in paragraph 8 below and unless a demand or claim in writing is made by the EMPLOYER on the Bank under this Guarantee all rights of the EMPLOYER under this Guarantee shall be forfeited and the Bank shall be relieved from its liabilities hereunder.
8. The guarantee shall cease to be in force and effect 90 (ninety) days after the end of the one year from the date of payment of the installment of the Advance Payment, as set forth in Clause 19.2 of the Agreement.
9. The Bank undertakes not to revoke this Guarantee during its currency, except with the previous express consent of the EMPLOYER in writing, and declares and warrants that it has the power to issue this Guarantee and the undersigned has full powers to do so on behalf of the Bank.
10. Any notice by way of request, demand or otherwise hereunder may be sent by post addressed to the Bank at its above referred branch, which shall be deemed to have been duly authorized to receive such notice and to effect payment thereof forthwith, and if sent by post it shall be deemed to have been given at the time when it ought to have been delivered in due course of post and in proving such notice, when given by post, it shall be sufficient to prove that the envelope containing the notice was posted and a certificate signed by an officer of the EMPLOYER that the envelope was so posted shall be conclusive.
11. This Guarantee shall come into force with immediate effect and shall remain in force and effect for up to the end **** month in the year ***** or until it is released earlier by the EMPLOYER pursuant to the provisions of the Agreement.

Signed and sealed this day of 20..... at

SIGNED, SEALED AND DELIVERED

For and on behalf of the Bank by:

(Signature)

(Name) (Designation) (Code

Number) (Address) NOTES:

- (i) The bank guarantee should contain the name, designation and code number of the officer(s) signing the guarantee.
- (ii) The address, telephone number and other details of the head office of the Bank as well as of issuing branch should be mentioned on the covering letter of issuing branch

Schedule H - Contract Price Weightages

(See Clause 19.3)

Schedule H shall be the detailed billing break up to be provided by the successful Bidder on award of job, prior to signing of the Contract, which shall form part of Contract and shall be the basis of payment milestones.

Schedule I - Drawings*(See Clause 10.2)***1.0 Drawings**

In compliance of the obligations set forth in Clause 10.2 of this Agreement, the Contractor shall furnish to the Employer's Engineer, free of cost, all Drawings listed in **Appendix I-I** of this Schedule-I.

2.0 Additional Drawings

If the Employer's Engineer determines that for discharging its duties and functions under this Agreement, it requires any drawings other than those listed in Appendix I- I, it may by notice require the Contractor to prepare and furnish such drawings forthwith. Upon receiving a requisition to this effect, the Contractor shall promptly prepare and furnish such drawings to the Employer's Engineer, as if such drawings formed part of Appendix I-I of this Schedule-I.

Appendix II – List of Drawings*(Schedule-I)*

List of drawings is given in table below;

List of drawings

S. No.	Description	
1	Site Layout	
	i	Plot Plan
	ii	Location Plan
	iii	Site Plan with Coordinates, Ground Floor details, Fire Engine Access Provision
	iv	Details for sync up with adjoining roads, infrastructure
2	BUILDINGS (SPV, BEC, UTILITY and SECURITY CABINS)	
	Architectural Drawings	
	i	Floor Plans
	ii	Roof Plans
	iii	Schedule of finishes
	iv	Door Window Schedule and Details
	v	Reflected Ceiling Plans
	vi	Elevations
	vii	Sections
	viii	Staircase details
	Description	
		Compound wall details
		Porch details
		Security gate details
		Atrium details
		Roof details
		Toilet details
		Fritted glass details
		Curtain wall details
		Screen details
		Furniture layouts
		Sanitary fixtures schedule

4	STRUCTURAL DRAWINGS

	i	Details of foundation level
	ii	Details at Footing tie level
	iii	Details at lower ground level
	iv	Details at plinth level
	v	Details at first floor level
	vii	Details at Second floor level
	ix	Details at Third floor level
	x	Details at Fourth floor level
	xi	Details at Fifth floor level
	xii	Details at Terrace floor level
	xiii	Staircase details
	xiv	Entrance Porch details
		Miscellaneous

6	HVAC Drawings	
	i	All buildings air distribution system layout - all floors
	ii	All buildings chilled water & equipment layout - all floors
	iii	Cooling Load calculations
	iv	P & ID for chilled water and condenser water system
	v	Chiller plant room layout
	vi	Utility building HVAC layout - all floors
	viii	Technical data sheets for all equipment / items
7	Electrical Drawings	
	i	Singe One Line Diagram (SLD)
	ii	All Buildings Electrical Room GA & Sectional Drawings
	iii	All Buildings Cable Carrier System Layout & Sectional Details for all Floor Plans
	iv	All Buildings Lighting & Small Power Layout for All Floor Plans
	v	All Buildings Earthing & Lighting Protection Layout
	vi	Overall Earthing and Lighting Layout
	vii	Solar PV System drawings
	viii	Electrical Equipment GA, Cable Tray Layouts
		DOCUMENTS:
	viii	Load List
	ix	Power and Control Cable schedule and interconnection schedule
	x	Design calculations of all system and equipment
	xi	Control scheme and data sheets
	xii	All Data-sheets with "By Bidder" details

8	Plumbing & Drainage Drawings	
	i	All buildings potable water, flush water, recycled water, drainage & rain water system network and layout - all floors
	ii	Pump room layout
	iii	Technical data sheets for all equipment / items
9	Fire Protection System	
	i	All buildings firefighting system including fire hose, fire extinguishers, sprinklers layout - all floors

	ii	Fire Pump room layout
	iii	P & ID for firefighting system layout
	iv	Hydraulic calculation for firefighting system - all floors
	v	Technical data sheets for all equipment / items
10	Fire Detection & Alarm & Access Control	
	i	All Buildings Detailed System Description with Block Diagram / Logical Flow Diagram (Hardware & software)
	ii	System Configuration / Design Diagrams (System Architecture Electrical Connectivity, Communication network)
	iii	Mapping of the device locations with the Floor Layouts (AutoCAD Drawings)
	iv	All buildings, fire Detection and Alarm Network and Layout

Schedule J - Project Completion Schedule*(See Clause 10.3.2)***1.0 Project Completion Schedule**

During Construction period, the Contractor shall comply with the requirements set forth in this Schedule-J for each of the Project Milestones and the **Scheduled Completion Date**. Within 15 (fifteen) days of the date of each Project Milestone, the Contractor shall notify the Employer of such compliance along with necessary particulars thereof.

2.0 Project Milestone-I

- 2.1 Project Milestone-I shall occur on the date falling on the 150 th (one hundred and fiftieth) day from the Appointed Date (the “**Project Milestone-I**”).
- 2.2 Prior to the occurrence of Project Milestone-I, the Contractor shall have commenced construction of the project components and submitted to the Employer duly and validly prepared Stage Payment Statements for an amount not less than 10% (ten per cent) of the Contract Price.

3.0 Project Milestone-II

- 3.1 Project Milestone-II shall occur on the date falling on the 300th (three hundredth) day from the Appointed Date (the “**Project Milestone-II**”).
- 3.2 Prior to the occurrence of Project Milestone-II, the Contractor shall have continued with construction of the project components (and submitted to the Employer duly and validly prepared Stage Payment Statements for an amount not less than 25% (Twenty-Five per cent) of the Contract Price.

4.0 Project Milestone-III

- 4.1 Project Milestone-III shall occur on the date falling on the 500th (Five hundredth) day from the Appointed Date (the “**Project Milestone-III**”).
- 4.2 Prior to the occurrence of Project Milestone-III, the Contractor shall have continued with construction of the project components and submitted to the Employer duly and validly prepared Stage Payment Statements for an amount not less than 50% (Fifty per cent) of the Contract Price.

5.0 Project Milestone-IV

- 5.1 Project Milestone-IV shall occur on the date falling on the 600th (Six Hundredth) day from the Appointed Date (the “**Project Milestone-IV**”).
- 5.2 Prior to the occurrence of Project Milestone-IV, the Contractor shall have continued with

construction of the project components and submitted to the Employer duly and validly prepared Stage Payment Statements for an amount not less than 80% (Eighty per cent) of the Contract Price.

6.0 Schedule Completion Date

6.1 The Scheduled Completion Date shall occur on the 730th (Seven Hundred and Thirtieth) day from the Appointed Date.

6.2 On or before the Scheduled Completion Date, the Contractor shall have completed construction in accordance with this Agreement.

7.0 Extension of time

7.1 Upon extension of any or all of the aforesaid Project Milestones or the Scheduled Completion Date, as the case may be, under and in accordance with the provisions of this Agreement, the Project Completion Schedule shall be deemed to have been amended accordingly.

Schedule K - Tests on Completion*(See Clause 12.1.2)***1.0 Schedule for Tests**

- 1.1 The Contractor shall, no later than 30 (thirty) days prior to the likely completion of construction, notify the Employer's Engineer and the Employer of its intent to subject the project components to Tests, and no later than 10 (ten) days prior to the actual date of Tests, furnish to the Employer's Engineer and the Employer detailed inventory and particulars of all works and equipment forming part of Works.
- 1.2 The Contractor shall notify the Employer's Engineer of its readiness to subject the project components to Tests at any time after 10 (ten) days from the date of such notice, and upon receipt of such notice, the Employer's Engineer shall, in consultation with the Contractor, determine the date and time for each Test and notify the same to the Employer who may designate its representative to witness the Tests. The Employer's Engineer shall thereupon conduct the Tests itself or cause any of the Tests to be conducted in accordance with Article 12 and this Schedule-K.

2.0 Tests

- 2.1 **Architectural & Interior Finishes:** Visual and physical check for all Architectural and Interior finishes, including but not limited to flooring, painting, glazing, GRC cladding, Murals, false ceiling, door hardware, cladding & dado, polishes, etc. Operations of doors, windows, louvers shall also be checked.
- 2.2 **Landscape / softscape works:** Visual and physical check for softscape works, plants & saplings, lawns, shrubs, irrigation system including sprinklers & drip irrigation, fountains, water circulation and filtration system, etc., including performance verification.
- 2.3 **Civil and Hardscape works:** Visual check of construction to determine that all civil, structural and hardscape works conform to the provisions of this Agreement. Physical test if required by the client.
- 2.4 **Entry Gates and Boom Barriers:** Visual and physical check for Boom Barriers, Automated Entry gate operations including performance verification for sensors, remote and manual controls, etc.
- 2.5 **Electrical:** Visual and physical and commissioning test for HT and LT panels, Dry type

transformers, UPS, DG set, DC System, bus ducts, rising mains, distribution boards, power & control cables, SCADA system, elevators, solar PV panels, lighting DB's, switches & sockets, safety features, luminaires / lighting fixtures, street lighting and pole, power supply, grounding, communication between luminaire to control panel and central control system, etc. including performance verification.

Tests And Inspection For HT VCB:

1. During fabrication, switchgear shall be subject to inspection by Owner/Consultant or by an agency authorized by the Owner. Manufacturer shall furnish all necessary information concerning the supply to inspectors.

The client/ Contractor has right to witness the test carried out on all the equipment.

2. Tests shall be carried out at the manufacturers' works under his care and expense.
3. All routine tests as specified by the applicable standard code shall be conducted. Type test certificates for the switchgear panel and CB from a recognized testing organization shall be furnished with the offer. If client / consultant wishes type test shall be carried out at laboratory in the suppliers region in clients / consultants presence. The supplier shall also submit a list of guaranteed technical particulars with the offer.
4. In addition specific tests shall be conducted to check mechanical and electrical operation and switchboard wiring to this specification and approved schematic drawings.
5. These tests shall be provisionally conducted at manufacturer's works by providing temporary connection to switchgear units in order to simulate the actual conditions.
6. Shop tests shall be witnessed by an inspector of Owner / Consultant or of an agency authorized by owner.

Acceptance tests shall be as follows:

- a) A general visual check. This shall cover measurement of overall dimensions, location, number and type of devices, terminal boxes, location and connection of terminals etc.
- b) Manual and electrical operation of CB/Relays shall be checked under the worst conditions of auxiliary supply voltage.
- c) Dry insulation test with power frequency voltage shall be conducted for the main and auxiliary circuits.
- d) Insulation resistance of the main and auxiliary circuits shall be checked.

- e) Operation check shall be carried out for every control function as per the approved schematic diagrams by manually stimulating the fault conditions and operation of control switches/relays etc.
- f) Preferably, relays shall be tested with secondary injection test equipment.

For equipment bought from other sub - suppliers certified test reports of tests carried out at the manufacturer's works shall be submitted. Normally, all routine tests as specified in the relevant standards shall be conducted by the sub - supplier at his works.

List of tests shall be as follows:

Routine tests: power frequency tests, manual operating mechanism tests, functional tests of L.V. auxiliaries and relays, making and breaking capacity for switches and breaker, short time withstand current tests, making and breaking capacities for earth switch.

Type tests: impulse dielectric tests, power frequency dielectric tests, temperature rise tests, mechanical operating tests, verification of degree of protection, verification of electromagnetic compatibility.

B) Tests and Inspection for Oil Type Transformer

1 TESTS

- A **Routine tests:** Routine test such as ratio test, open circuit test, short circuit test, no load test, induced high voltage test, insulation resistant test, measurement of winding resistance etc. shall be conducted as per IS: 2026. Including CT polarity test, earth continuity test, OLTC operation test, oil dielectric test.

Type tests: Type tests if required by client / consultant shall be carried out at certified laboratory of the supplier's area shall be carried out. If not required by client certificates for type test carried out for similar rating of transformer shall be submitted by the supplier. Type tests shall be carried out for temp. Rise, impulse voltage and short circuit analysis.

- B **Test certificates:** Five copies of the routine test and type test certificates shall be submitted for purchaser's record before dispatch of transformer, including test certificates of bought out items.

Inspection

- A. Inspection including witnessing routine tests will be carried out by purchaser or his authorized representative.
- B Vendor shall notify purchaser or his authorized representative in writing atleast fifteen days prior to vendor's scheduled inspection tests.

C) Test for LT Panels and ATS**1. CPRI Testing**

Switchboard configurations offered shall be subject to CPRI testing (Testing if required by the User). In case of no CPRI testing request by E/C, copies of the CPRI test certificates shall be submitted with the tender for the similar rated busbar panel.

2. Routine Test:

- a) Physical variation and dimensional check – To cross check dimensions with approved GA drawings.
- b) Verification of bill of material – Physically count all the components.
- c) Continuity test – shall be carried out for complete busbar system with continuity tester or actual charging.
- d) Functional check – Operation of all the switchgears and control logic to be checked after charging at works.
- e) HV test – 2500 V for 1 minute shall be applied and no tripping / Arching / Flashing shall occur.
- f) IR test – 1000 V shall be applied through meggar and the value shall be more than 30 M ohms.
- g) Polarity and Phase sequence test – Shall be checked for each feeder with phase sequence meter.

3. Type Test:

Type test certificates for all switchgears and panel of similar rated busbar shall be provided for

- a) Short circuit withstand test
- b) IP protection.
- c) All switchgears and other components.
- d) Temperature rise test

D) Tests and Inspection for Diesel Generator Set

- 1. The owner or his authorized representative may visit the works during manufacture of equipment to assess the progress of work as well as to ascertain that only quality raw materials are used for the same. He shall be given all assistance to carry out the inspection.

2. Detailed test procedure along with the facilities available at vendors works shall be furnished along with the bid. Owner's representative shall be given minimum four weeks advance notice for witnessing the final testing. Test certificates including test records and performances curves etc. shall be furnished by the vendor.
 3. Equipment shall be tested to conform to the appropriate standards and the following tests shall be conducted in the presence of purchaser's:
 4. Functional tests, continuity tests and high voltage test on control panel to establish the performance called for in the specification.
 5. Power frequency voltage test on switch gear and mechanical / electrical operational check.
 6. Routine tests for alternator as per IS: 4722.
 7. Over speed test (1.2 times the rated speed for 2 minutes)
 8. Transient response tests for sudden application and rejection of loads of 25%, 50%, 75% and 100% of rated capacity.
 9. Wave form test (type test results are acceptable)
 10. Phase sequence test.
 11. Vibration test
 12. Noise level test.
 13. Dimensional and alignment test.
 14. String test.
- 2.6 **HVAC:** Visual and physical and commissioning test for HVAC cooling system, dampers, VAV's, sensors, Ventilation system, drives, control gauges, instrumentations, flow meters, automation, vibration & acoustic insulation, etc including performance verification.

At an appropriate time in consultation with Client / Consultant / Project In Charge the contractor shall demonstrate performance (noise level, power consumption, actual capacity at design conditions etc.) at rated capacity over a period of 6 working days on continuous operating hours. If the tests specified above show that the performance of Air-conditioning & Ventilation system has failed to achieve all the guaranteed parameters or some of them, the contractor shall rectify the defects and carry out modifications if necessary to meet the guaranteed figures and the guarantee tests shall be repeated at no extra cost.

Routine and types tests for various items of equipment shall be performed at the contractor's work and the test certificates furnished. Functional test shall be conducted at site.

- 1.2 The performance test to determine whether OR not the full indent of the specification is met shall be conducted by the contractor. After notification to the Employer's that the installation has been completed and the plant has run continuously for a period of at least two weeks, the contractor shall conduct under the direction of the Consultant's and in the presence of Employer's representatives test, such test as specified to establish the capacity of various equipment supplied and installed by the contractor.
- 1.3 The contractor shall operate test and adjust the air conditioning system units, fans, motors, all air conditioning appliances including adjustment of regulators, dampers etc.
- 1.4 All test equipment, labour, operating personnel, oil and refrigerant required for this test shall be furnished by the contractor to enable the plant to be put in continuous running test for a period of 3 days after all other tests and adjustments have been made.

The contractor will be provided with electrical power water for testing by the client. The performance test shall be conducted during peak summer and peak monsoon.

2.0 PROCEDURE

2.1 Design Conditions:

The inside and outside conditions will be recorded for 48 hrs. (2 days) duration on hourly basis. The outside and inside Dry Bulb and Wet Bulb temperatures shall be recorded by the means of a sling psychrometer with mercury thermometers. The relative humidity shall be computed from the psychrometric chart. The inside Dry Bulb temp. and relative humidity shall fall within the specified limits.

2.2 CAPACITY OF THE PLANT:

The following aspects shall be checked before conducting the performance tests:

- 1) The outside conditions shall be as close to the design values as possible. The tests shall be arranged during the peak summer and monsoon.
- 2) The internal loads of various spaces shall be close to the design values as far as possible.
- 3) The plant shall be fully loaded and the temperatures stabilised
- 4) Hourly readings of water flow shall be recorded by a calibrated flow meter.

- 5) Hourly readings of pressure, temperature, electrical current, voltage and power factor shall be properly recorded

The capacity of the plant and various other equipment and accessories shall be ascertained as follows.

2.3 Cooling coil of AHUs and FCUs:

The flow of air over the cooling coil will be measured by recording the velocity of air across each filter placed before the cooling coil. The velocity shall be measured by means of end anemometer

Air quantity across the filters = velocity of air across the filters in FPM x net filter area (in sq. ft.).

The wet bulb temperature of air entering the coil and that leaving the coil shall be measured. The enthalpy of entering and leaving air shall be noted from the psychrometric chart, corresponding to the wet bulb temp. recorded

SAY,

he - Enthalpy of Entering Air in Btu /lb

H1 - Enthalpy of Leaving Air in Btu / lb.

Ve - Specific Volume of Entering Air (CFT. / lb. of air)

V1 - Specific volume of Leaving Air (CFT. / lb. of air)

Average specific volume = $(ve + v1) / 2 = v$ (CFT/ lb of air)

cap. Of cooling coil = $(CFM \times 60) / v \times (He - H1) / 1200$

$(CFM \times \{He - H1\} \times 4.5 / 12000)$

2.4 Chiller:

Factory testing of Capacity & Efficiency:

One Chiller shall be tested for performance at Manufacturer works at 100%, 75%, 50% & 25% at AHRI condition and at 100%, 75%, 50% and 25% at Design Conditions (at constant condenser entering temperature) for verification of IKW/TR & Capacity as per submission of AHRI selection data sheet. If the inspection is outside India, the contractor shall visit and witness the test and shall submit photographs/proof to ascertain his witnessing the testing. The Client / Consultant representative may also witness the test. The cost of their visit shall be borne by the Client. However, necessary coordination shall be arranged by the Contractor for their visit.

In case of failure of any equipment during testing, the Contractor shall be bound to arrange for subsequent inspections. All the expenses (including travel, boarding etc.) for such inspections shall be borne entirely by the Contractor.

The temperatures of inlet and outlet water, water flow and pressure drop shall be measured as suggested for the condenser.

The capacity of the plant in TR

$$= \frac{\text{water flow through chiller} \times \text{dT (F) in GPM}}{24}$$

24

Where dT = (Temperature of entering Water Minus Temperature of Leaving water)

2.5 Compressor:

The following readings shall be recorded:

I] Suction gas pressure

ii] Discharge gas pressure

iii] Suction gas temperature.

Iv] Discharge gas temperature.

V] Readings of Ammeter, voltmeter and power factor meter.

Same pressure gauge shall be used for different pressure measurements and the same thermometers shall be used for different temperature measurements. The capacity of the compressor shall be computed from the performance chart supplied by the manufacturer.

IKW / Ton of compressor-

$$= (\text{Power in put in KW}) / \text{Compressor Cap. in Tons.}$$

2.6 Air Balancing:

After the desired inside conditions are achieved, the quantity of air through every outlet shall be measured. Air quantity in CFM = Air velocity at the outlet in FPM x effective area of the outlet in Sq. Ft.

2.7 Fire Protection System: Visual and physical and commissioning test for complete firefighting system equipment's, internal & external hydrants, sprinklers, electric & diesel

engine pumps, portable fire extinguishers, etc., including performance verification.

3	Testing of The Hydrant System:
	All air shall be trapped from the pipeline through hydrants & air valves. Each section of the pipe shall be slowly filled with the water & allow to stand the water for few hours with the ends closed.
	Flushing of underground connections: Underground mains and lead-in connections to system risers shall be flushed before connections made to piping in order remove foreign materials which may have entered the underground during the course of installation. For hydrant system the flushing operation shall be continued until water is clear.
	Underground mains and lead-in connection shall be flushed at a flow rate of not less than 480 Ltrs. Per minute.
	Provision shall be made for the disposal of water issuing from test outlets to avoid property damage.
	Acceptance Test: At the time of taking over, the hydrant system shall fulfill the following acceptance tests:-
	Starting up of the pressure suction (Jockey Pump): The pressure switch shall be set at (-)0.5 kg/cm ² below Required Pressure at the lower limit and 0.0 kg/cm ² at the upper limit. The system drain shall be opened to cause a drop in the pressure. The Jockey Pump shall start as soon as the pressure gauge needle falls down by (-) 0.5kg/cm ² . The Jockey pump shall also stop automatically when the system has been pressurised again upto set pressure 0.0kg/cm ² .
	The main electrical pump shall be set to start by (-) 1.5 kg/cm ² drop in pressure. An external hydrant valve using a single length of hose and branch pipe shall be fully opened to cause a drop of pressure in the system. At first, the jockey pump shall start when the pressure drops by (-) 0.5 Kg/cm ² . Further, drop in the pressure by (-) 1.5 Kg/cm ² should be allowed to test automatic start-up of the electrical pump. The electrical pump shall continue to run atleast for 5 minutes and register rise in the pressure upto 0.0 Kg/cm ² the Jockey Pump shall be automatically stop at this. The electrical pump shall be stopped manually by pressuring the stop button.
	After having the system got fully charged at 0.0 kg/cm ² the external hydrant valve using hose and branch pipe at (ii) above shall be opened. When the pressure has dropped by (-) 1.5 Kg/cm ² , the electric main pump shall come into operation automatically. After the main pump has run for 5 minutes, the power supply in the pump house shall be switched off. The diesel pump shall automatically come into operation immediately.
	All these tests mentioned above shall be repeated after one hour interval. The result of all the tests shall be identical again. After the system has satisfactorily withstood the above tests, it can be taken over from the contractor.

Start-Up/System Testing:
It will be the responsibility of the Tendered to cause interim/stage inspection by the TAC/S.F.O during execution of the work as and when so called for by the Employer / Architect and shall carry out any rectification / modification as may be suggested by the Tariff Advisory Committee (TAC) / Chief Fire Officer (CFO).
Soon after the work is completed, the contractor shall inform the TAC/CFO in writing with a copy to the Architect / Employer for getting the complete system including all sub system and instrumentation, control etc. thoroughly inspected and tested for satisfactory performance. After satisfactory completion of tests of the systems by the TAC / CFO the contractor shall be required to submit in built drawings on tracing cloth to the Architect which have been so approved.
In addition to TAC, the contractor shall also be responsible for getting the system and equipment tested and approved by other Statutory Authorities like the Area Fire Officer or the State Fire Services as may be required.
Commissioning Of System:
Pressurised the fire hydrant system by running the main fire pump and after attaining the required pressure shut off the pump.
Open bye-pass valve and allow the pressure to drop in the system. Check that the jockey pump cuts-in and cuts-out at the pre-set pressure. If necessary adjust the pressure switch for the jockey pump. Close bye-pass valve.
Open bye-pass valve and allow the water to flow into the fire water tank in order to avoid wastage of water. The main fire pump should cut-in at the preset pressure and should not cut-out automatically on reaching the normal line pressure. The main fire pump should stop only by manual push button. However, the jockey pump should cut out as soon as the main pump starts.
Switch off the main fire pump and test check the diesel engine driven pump in the same manner as the electrically driven pump.
When the fire pumps have been checked for satisfactory working on automatic controls, open fire hydrant simultaneously and allow the hose pipe to discharge water into the fire tank to avoid wastage. The electrically driven pump should run continuously for eight hours so that its performance can be checked.
Diesel engine driven pump should also be checked in the same manner as given in para above by running for 8 hours.
Check each Hydrant valve, male and female couplings and branch pipes for compatibility with each other. Any fitting which is found to be incompatible and does not fit into the other properly, shall be replaced by the Contractor. Yard Hydrant valves shall be checked by opening

and closing under pressure.

- 3.0 **Plumbing & Drainage:** Visual and physical and commissioning test for Plumbing & drainage system including water pressure, faucets & valves, sanitary fittings, flush tanks, urinals, faucet & urinal sensors, leakages, etc. including performance verification.

Cleaning, Operation & Tests:
Plumbing equipment fixtures, piping etc. shall be free of stampings, makings (except those required by codes) iron cuttings & other foreign materials.
Hot, Cold & drinking water system shall be cleaned thoroughly filled & flushed with water.
The entire mechanical apparatus shall operate at full capacity without objectionable noise or vibrations.
Test all plumbing system in the presence of the site Engineer/Supervisor/Engineer-in-charge & ample advance notice to test dates. Provide all equipment materials & labour necessary for inspection & tests & repair all work, not passing the tests. After repairs are made, repeat tests until units system is found satisfactory, to the authorities. Carry out tests prior to concealing, insulating or back filling over any piping No exceptions will be made.
Test entire system of soil, waste & vent piping by water after the roughing in is completed & before the fixtures are set. After setting the fixtures, providing smoke test, after sealing all traps.
Water test: Test entire system or section of system by closing all opening in piping except the highest opening & filling system with water to the point of overflow. If the system is tested in sections, plug each opening except the highest opening of the section filled with water. Keep the water in system or in portion under test of or atleast 45minutes before inspection starts with test pressure/head lasting for two hours. The system must be tight at all joints.
Final Test: After fixture are set, test system with smoke as follows:-
Smoke Test : Fill traps with water, then introduce into system a pungent thick smoke produced by one or more smoke machines. Then smoke appears at stacks on the roof, plug stacks & allow pressure of 25mm water column to build up in system. Maintain pressure of 15 minutes before inspection starts. The system shall be tight at all joints.
Test all down spouts or rain headers & their branches within the building by water as described for the above soil, waste & vent system.
All water piping: Hydro-static test 150 PSI for a minimum of 2 hours without drop in pressure as required.

All tests on below grade lines shall be continued until backfilling on such lines is completed to disclose any damage caused by backfilling.

All system shall be tested in sections as required to expedite the work on other trades & meet construction schedules & final test on completion.

- 3.1 **FDA & Public Address:** Visual and physical test for Fire Alarm sensors / detectors, alarms / hooters, Public address system, BMS, etc., including performance verification.
- 3.2 **CCTV, Access Control & Surveillance:** Visual and physical test for Security systems including access control card readers and cards, CCTV cameras, monitors, recording and retrieval system, Visitor management system, operating software & hardware, etc., including performance verification.
- 3.3 **Road (Riding quality test):** Riding quality of each lane of the carriageway shall be checked with the help of a calibrated bump integrator and the maximum permissible roughness for purposes of this Test shall be 1800 (Eighteen Hundred) mm for each kilometer.
- 3.4 **Storm Water:** Visual and physical test for Rain water drainage system, storm water drains, manholes & manhole covers, rain water harvesting system, etc., including performance verification.
- 3.5 **STP:** Visual and physical test for Sewage treatment plant, untreated and treated wastewater quality & quantity for polluting parameters, electrical & mechanical equipment's etc., including performance verification. It should be run successfully for one complete cycle before handing over.
- 3.6 **Other tests:** The Employer's Engineer may require the Contractor to carry out or cause to be carried additional tests, in accordance with Good Industry Practice, for determining the compliance of the project components with Standards and Specifications.

3.0 Audits

- 3.1 **Environment Health and Safety Requirements:** The Employer's Engineer shall carry out a check to determine conformity of the project components with the environmental requirements set forth in Applicable Laws and Applicable Permits.
- 3.2 **Safety Audit:** The Employer's Engineer shall carry out, or cause to be carried out, a safety audit to determine conformity of the project components with the safety requirements and Good Industry Practice.

Schedule L - Provisional Certificate and Completion Certificate

(See Clause 12.2 and 12.4)

Contents

Provisional Certificate

Completion Certificate

Provisional Certificate*(See Clause 12.2)*

1. I, ... (Name of the EMPLOYER's Engineer), acting as EMPLOYER's Engineer, under and in accordance with the Agreement dated (the "**Agreement**"), for Design , Construction and Maintenance of AURIC Hall Building for Phase-I in Shendra-Bidkin industrial area, Aurangabad, Maharashtra state" through Engineering, Procurement & Construction (EPC) Basis Contract through..... (Name of Contractor), hereby certify that the Tests in accordance with Article 12 of the Agreement have been undertaken to determine compliance of the Project..... with the provisions of the Agreement.
2. Construction Works that are incomplete on account of Time Extension have been specified in the Punch List appended hereto, and the Contractor has agreed and accepted that it shall complete all such works in the time and manner set forth in the Agreement. In addition, certain minor works are incomplete and these are not likely to cause material inconvenience to the users of the Project or other their safety. The contractor has agreed and accepted that as a condition of this Provisional Certificate, it shall complete such minor works within 30 (thirty) days hereof. These minor works have also been specified in the aforesaid punch list.
3. In view of the foregoing, I am satisfied that that Project can be safely and reliably placed in service of the users thereof, and in terms of the Agreement, the Project is hereby provisionally declared fit for entry into operation on this the day of 20

ACCEPTED, SIGNED, SEALED
DELIVERED

SIGNED, SEALED AND DELIVERED AND

For and on behalf of

For and on behalf of

CONTRACTOR by

EMPLOYER's Engineer by:

(Signature)

(Signature)

Completion Certificate*(See Clause 12.4)*

1. I, ... (Name of the EMPLOYER's Engineer), acting as EMPLOYER's Engineer, under and in accordance with the Agreement dated (the "**Agreement**"), for Design , Construction and Maintenance of AURIC Hall Building for Phase-I in Shendra-Bidkin Industrial area, Aurangabad, Maharashtra state" through Engineering, Procurement & Construction (EPC) Basis through (Name of Contractor), hereby certify that the Tests in accordance with Article 12 of the Agreement have been successfully undertaken to determine compliance of the Project with the provisions of the Agreement, and I am satisfied that the Project can be safely and reliably placed in service of the Users thereof.
2. It is certified that, in terms of the aforesaid Agreement, all works forming part of Project Works have been completed, and the Project Works is hereby declared fit for entry into operation on this the day of 20

SIGNED, SEALED AND DELIVERED For and on behalf of

EMPLOYER's Engineer by:

(Signature)

Schedule M - Payment Reduction for Non-Compliance

(See Clauses 14.6., 15.2 and 19.7)

1.0 Payment reduction for non-compliance with the Maintenance Requirements

- 1.1 Monthly lump sum payments for maintenance shall be reduced in the case of non-compliance with the Maintenance Requirements set forth in Schedule-E.
- 1.2 Any deduction made on account of non-compliance with the maintenance Requirements shall not be paid even after compliance subsequently. The deduction shall continue to be made every month until compliance is done.
- 1.3 The Employer's Engineer shall calculate the amount of payment reduction on the basis of weightage in percentage assigned to non-conforming items as given in Paragraph 2.

2.0 Percentage reductions in lump sum payments

- 2.1 The following percentages shall govern the payment reduction:

Table 1: Percentage reductions for Architectural and Civil works

S. No.	Item/Defect/Deficiency	Percentage
1	(a) + (b) + (c) (of the applicable monthly maintenance amount)	20%
(a)	Openings and glazing works (door, window, hatches, skylight, glazing coloured and otherwise etc.)	3%
(i)	Breakage or damage of openable shutters their finishes and accessories like handles, door closers, locks, vinyl, floor springs etc.	2%
(ii)	Repairs of fixed glazing, polycarbonate skylight, louvers, sealants, etc.	1%
(b)	Flooring, false ceiling, painting	7%
(i)	Defect, breakage, chip off, loosening of flooring	3%
(ii)	Any breakage or damage of false ceiling and peeling or chip off of painting.	4%
(c)	External stone cladding, flooring, ramps, paving, hardscape, facade	10%
(i)	Damage to facade, external stone cladding and flooring	5%
(ii)	Any breakage, damage to hardscape, ramps, paving	5%

Table 2: Percentage reductions for Electrical works

Sr. No.	Item/Defect/Deficiency	Percentage
1	(a) + (b) (of the applicable monthly maintenance amount)	20%
(a)	Electrical Equipment like DG Sets, UPS, Apparatus, Cables	5%
(i)	Faulty, damaged or non-working equipment, apparatus or cable	5%
(b)	Fixtures	5%
(i)	Faulty, damaged or non-working fixtures	5%
(c)	Elevators	5%
(i)	Non-functioning of elevators or its accessories	5%
(d)	Street Lights	5%
(i)	Repair or replacement of fittings, accessories	5%

Table 3: Percentage reductions for HVAC and Firefighting, Plumbing and Drainage

Sr. No.	Item/Defect/Deficiency	Percentage
1	(a) + (b) (of the applicable monthly maintenance amount)	23%
(a)	High Side HVAC (Chillers, Pumps, Cooling towers, AHUs, DX units, VRF units, Fans)	7%
(i)	Failure of any of the above systems.	3%
(ii)	Leakages / breakages or damage of piping, traps, valves,	2%
(iii)	Non maintenance of design temperature	2%
(b)	Water Supply Network (Potable water, Recycled water)	4.5%
(i)	Rising and distribution network repairs,	2.5%
(ii)	Valve and flow meters repairs and calibrations, refilling of	2%
(c)	Sewage collection network	4.5%
(i)	De-silting, overflows in surrounding areas	2%
(ii)	Man holes damages.	2.5%
(d)	Low side HVAC, firefighting, plumbing and drainage	7%
(i)	Damage or leakage of Piping, traps, fittings, Gauges, sensors	2%
(ii)	Damage to Sprinklers, firefighting equipment's	2%
(iii)	Breakage or leakage of Sanitary Ceramic and CP fixtures	3%

Table 4: Percentage reductions for Fire Detection, Alarm system, Access Control, Surveillance

Sr. No.	Item/Defect/Deficiency	Percentage
1	(a) + (b) (of the applicable monthly maintenance amount)	7%
(a)	Apparatus, equipment, sensors, cameras	7%
(i)	Non-functioning of any of above	7%

Table 5: Percentage reductions for STP and SWM

Sr. No.	Item	Percentage
1	STP and SWM	5%
(i)	Not meeting the effluent parameters	2%
(ii)	Replacement of damaged bins	1%
(iii)	Default on bin lifting frequency	2%

2.2 The amount to be deducted from monthly lump-sum payment for non-compliance of particular item mentioned in Table-1 to 7 shall be calculated on a pro-rata basis for each of the above items as under:

$$R = P/100 * M * L1/L$$

Where

P= Percentage of particular item/non- compliance /Defect /deficiency for deduction. For example, in Architecture and Civil works, if a broken flooring/tile is not repaired/replaced within 48 hours, the percentage of non-compliance item P is 3%.

M = Monthly lump-sum payment for maintenance in accordance with the Contract Agreement.

A1= Non-complying area (sqm) of the particular Item.

A= Total area (sqm) of the particular Item.

R= Reduction (the amount to be deducted for noncompliance for a particular item /Defect /deficiency).

The total amount of reduction shall be arrived at by summation of reductions for such items/Defects/deficiency or noncompliance.

For any Defect in a part of 10 sqm, the non-conforming area shall be taken as minimum 10 sqm.

Schedule N - Selection of Employer's Engineer

(See Clause 18.1.1)

Contents

1 - Selection of EMPLOYER's Engineer

2 - Terms of Reference

3 - Appointment of Government entity as EMPLOYER's Engineer

Annex-I - Terms of Reference for Employer's Engineer

1.0 Selection of EMPLOYER's Engineer

- 1.1 The provisions of the Model Request for Proposal for Selection of Technical Consultants, issued by the Ministry of Finance in May 2009, or any substitute thereof shall apply for selection of an experienced firm to discharge the functions and duties of an EMPLOYER's Engineer.
- 1.2 In the event of termination of the Technical Consultants appointed in accordance with the provisions of Paragraph 1.1, the EMPLOYER shall appoint another firm of Technical Consultants forthwith and may engage a government-owned entity in accordance with the provisions of Paragraph 3 of this Schedule-N.

2. Terms of Reference

The Terms of Reference for the EMPLOYER's Engineer (the "TOR") shall substantially conform with Annex 1 to this Schedule N.

3. Appointment of Government entity as EMPLOYER's Engineer

Notwithstanding anything to the contrary contained in this Schedule, the EMPLOYER may in its discretion appoint a government-owned entity as the EMPLOYER's Engineer; provided that such entity shall be a body corporate having as one of its primary functions the provision of consulting, advisory and supervisory services for engineering projects; provided further that a government-owned entity which is owned or controlled by the EMPLOYER shall not be eligible for appointment as EMPLOYER's Engineer.

Annex – I*(Schedule - N)***Terms of Reference for Employer's Engineer****1.0 Scope**

- 1.1 These Terms of Reference (the “**TOR**”) for the EMPLOYER's Engineer are being specified pursuant to the EPC Agreement dated..... (the “**Agreement**”), which has been entered into between the Name of EMPLOYER (the “EMPLOYER”) and (the “**Contractor**”) for “Design, Construction and Maintenance of AURIC Hall Building for Phase-I in Shendra-Bidkin industrial area, Aurangabad, Maharashtra state on Engineering, Procurement & Construction (EPC)” Basis, and a copy of which is annexed hereto and marked as Annex-A to form part of this TOR.
- 1.2 The TOR shall apply to design, construction and maintenance of the Project Roads and Services

2.0 Definitions and interpretation

- 2.1 The words and expressions beginning with or in capital letters and not defined herein but defined in the Agreement shall have, unless repugnant to the context, the meaning respectively assigned to them in the Agreement.
- 2.2 References to Articles, Clauses and Schedules in this TOR shall, except where the context otherwise requires, be deemed to be references to the Articles, Clauses and Schedules of the Agreement, and references to Paragraphs shall be deemed to be references to Paragraphs of this TOR.
- 2.3 The rules of interpretation stated in Clauses 1.2, 1.3 and 1.4 of the Agreement shall apply, *mutatis mutandis*, to this TOR.

3.0 General

- 3.1 The EMPLOYER's Engineer shall discharge its duties in a fair, impartial and efficient manner, consistent with the highest standards of professional integrity and Good Industry Practice.
- 3.2 The EMPLOYER's Engineer shall perform the duties and exercise the authority in accordance with the provisions of this Agreement, but subject to obtaining prior written approval of the EMPLOYER/PMNC before determining:
- (a) any Time extension;

- (b) any additional cost to be paid by the EMPLOYER to the Contractor;
 - (c) the Termination Payment; or
 - (d) any other matter which is not specified in (a), (b) or (c) above and which creates an obligation or liability on either Party for a sum exceeding Rs.5,000,000 (Rs. fifty lakh).
- 3.3 The EMPLOYER's Engineer shall submit regular periodic reports, at least once every month, to the EMPLOYER/PMNC in respect of its duties and functions under this Agreement. Such reports shall be submitted by the EMPLOYER's Engineer within 10 (ten) days of the beginning of every month.
- 3.4 The EMPLOYER's Engineer shall inform the Contractor of any delegation of its duties and responsibilities to its suitably qualified and experienced personnel provided, however, that it shall not delegate the authority to refer any matter for the EMPLOYER's prior approval in accordance with the provisions of Clause 18.2.
- 3.5 The EMPLOYER's Engineer shall aid and advise the EMPLOYER on any proposal for Change of Scope under Article 13.
- 3.6 In the event of any disagreement between the Parties regarding the meaning, scope and nature of Good Industry Practice, as set forth in any provision of the Agreement, the EMPLOYER's Engineer shall specify such meaning, scope and nature by issuing a reasoned written statement relying on good industry practice and authentic literature.

4.0 Construction Period

- 4.1 During the Construction Period, the EMPLOYER's Engineer shall review the Reports, Designs and Drawings furnished by the Contractor along with supporting data, including the geo-technical and hydrological investigations, characteristics of materials from borrow areas and quarry sites, topographical surveys, and the recommendations of the Safety Consultant in accordance with the provisions of Clause 10.1.6. The EMPLOYER's Engineer shall complete such review and send its observations to the EMPLOYER/ PMNC and the Contractor within 15 (fifteen) days of receipt of such Reports, Designs and Drawings; provided, however that in case of a Structure, the aforesaid period of 15 (fifteen) days may be extended up to 30 (thirty) days. In particular, such comments shall specify the conformity or otherwise of such Drawings with the Scope of the Project and Specifications and Standards.
- 4.2 The EMPLOYER's Engineer shall review any revised Reports, Designs and Drawings sent to it by the Contractor and furnish its comments within 10 (ten) days of receiving such Reports, Designs and Drawings.
- 4.3 The EMPLOYER's Engineer shall review the (a) Quality Assurance Plan (b) Health, Safety and Environmental Management Plan submitted by the Contractor and shall convey its comments to

- the Contractor within a period of 21 (twenty-one) days stating the modifications, if any, required thereto. The Employer's Engineer shall ensure the Contractor's Project Management requirements, BIM and CAD requirements regularly on a monthly basis to the Employer/PMNC.
- 4.4 The EMPLOYER's Engineer shall complete the review of the methodology proposed to be adopted by the Contractor for executing the Works, and convey its comments to the Contractor within a period of 10 (ten) days from the date of receipt of the proposed methodology from the Contractor.
- 4.5 Deleted.
- 4.6 The EMPLOYER's Engineer shall review the monthly progress report furnished by the Contractor and send its comments thereon to the EMPLOYER/ PMNC and the Contractor within 7 (seven) days of receipt of such report.
- 4.7 The EMPLOYER's Engineer shall inspect the Construction Works and the Project Roads and shall submit a monthly Inspection Report bringing out the results of inspections and the remedial action taken by the Contractor in respect of Defects or deficiencies. In particular, the EMPLOYER's Engineer shall include in its Inspection Report, the compliance of the recommendations made by the Safety Consultant.
- 4.8 The EMPLOYER's Engineer shall conduct the pre-construction review of manufacturer's test reports and standard samples of manufactured Materials, and such other Materials as the EMPLOYER's Engineer may require.
- 4.9 For determining that the Works conform to Specifications and Standards, the EMPLOYER's Engineer shall require the Contractor to carry out, or cause to be carried out, tests at such time and frequency and in such manner as specified in the Agreement and in accordance with Good Industry Practice for quality assurance. For purposes of this Paragraph 4.9, the tests specified in the relevant Codes or any modification/substitution thereof and standards for shall be deemed to be tests conforming to Good Industry Practice for quality assurance.
- 4.10 The EMPLOYER's Engineer shall test check at least 20 (twenty) percent of the quantity or number of tests prescribed for each category or type of test for quality control by the Contractor.
- 4.11 The timing of tests referred to in Paragraph 4.9, and the criteria for acceptance/ rejection of their results shall be determined by the EMPLOYER's Engineer in accordance with the Quality Control Manuals and/or the relevant Codes and Standards. The tests shall be undertaken on a random sample basis and shall be in addition to, and independent of, the tests that may be carried out by the Contractor for its own quality assurance in accordance with Good Industry Practice.

- 4.12 In the event that results of any tests conducted under Clause 11.10 establish any Defects or deficiencies in the Works, the EMPLOYER's Engineer shall require the Contractor to carry out remedial measures.
- 4.13 The EMPLOYER's Engineer may instruct the Contractor to execute any work which is urgently required for the safety of the Project Works, whether because of an accident, unforeseeable event or otherwise; provided that in case of any work required on account of a Force Majeure Event, the provisions of Clause 21.6 shall apply.
- 4.14 In the event that the Contractor fails to achieve any of the Project Milestones, the EMPLOYER's Engineer shall undertake a review of the progress of construction and identify potential delays, if any. If the EMPLOYER's Engineer shall determine that completion of the Project Works is not feasible within the time specified in the Agreement, it shall require the Contractor to indicate within 15 (fifteen) days the steps proposed to be taken to expedite progress, and the period within which the Project Completion Date shall be achieved. Upon receipt of a report from the Contractor, the EMPLOYER's Engineer shall review the same and send its comments to the EMPLOYER/ PMNC and the Contractor forthwith.
- 4.15 The EMPLOYER's Engineer shall obtain from the Contractor two copies of all the Contractor's quality control records and documents before the Completion Certificate is issued pursuant to Clause 12.4.
- 4.16 EMPLOYER's Engineer may recommend to the EMPLOYER/ PMNC suspension of the whole or part of the Works if the work threatens the safety of the Users and pedestrians. After the Contractor has carried out remedial measure, the EMPLOYER's Engineer shall inspect such remedial measures forthwith and make a report to the EMPLOYER recommending whether or not the suspension hereunder may be revoked.
- 4.17 In the event that the Contractor carries out any remedial measures to secure the safety of suspended works and Users, and requires the EMPLOYER's Engineer to inspect such works, the EMPLOYER's Engineer shall inspect the suspended works within 3 (three) days of receiving such notice, and make a report to the EMPLOYER/ PMNC forthwith, recommending whether or not such suspension may be revoked by the EMPLOYER.
- 4.18 The EMPLOYER's Engineer shall carry out, or cause to be carried out, all the Tests specified in Schedule-K and issue a Completion Certificate or Provisional Certificate, as the case may be. For carrying out its functions under this Paragraph 4.18 and all matters incidental thereto, the EMPLOYER's Engineer shall act under and in accordance with the provisions of Article 12 and Schedule-K.

5.0 Maintenance Period

- 5.1 The EMPLOYER's Engineer shall aid and advise the Contractor in the preparation of its monthly Maintenance Programme and for this purpose carry out a joint monthly inspection with the Contractor.
- 5.2 The EMPLOYER's Engineer shall undertake regular inspections, at least once every month, to evaluate compliance with the Maintenance Requirements and submit a Maintenance Inspection Report to the EMPLOYER/ PMNC and the Contractor.
- 5.3 The EMPLOYER's Engineer shall specify the tests, if any, that the Contractor shall carry out, or cause to be carried out, for the purpose of determining that the Project Works is in conformity with the Maintenance Requirements. It shall monitor and review the results of such tests and the remedial measures, if any, taken by the Contractor in this behalf.
- 5.4 In respect of any defect or deficiency referred to in Paragraph 3 of Schedule-E, the EMPLOYER's Engineer shall, in conformity with Good Industry Practice, specify the permissible limit of deviation or deterioration with reference to the Specifications and Standards and shall also specify the time limit for repair or rectification of any deviation or deterioration beyond the permissible limit.
- 5.5 The EMPLOYER's Engineer shall examine the request of the Contractor for closure of any lane(s)/utilities lines of the Project Roads and/or Services for undertaking maintenance/repair thereof, and shall grant permission with such modifications, as it may deem necessary, within 5 (five) days of receiving a request from the Contractor. Upon expiry of the permitted period of closure, the EMPLOYER's Engineer shall monitor the reopening of such lane(s), and in case of delay, determine the Damages payable by the Contractor to the EMPLOYER under Clause 14.5.

6.0 Determination of costs and time

- 6.1 The EMPLOYER's Engineer shall determine the costs, and/or their reasonableness, that are required to be determined by it under the Agreement.
- 6.2 The EMPLOYER's Engineer shall determine the period of Time Extension that is required to be determined by it under the Agreement.
- 6.3 The EMPLOYER's Engineer shall consult each Party in every case of determination in accordance with the provisions of Clause 18.5.

7.0 Payments

- 7.1 The EMPLOYER's Engineer shall withhold payments for the affected works for which the Contractor fails to revise and resubmit the Drawings to the EMPLOYER's Engineer in accordance with the provisions of Clause 10.2.4 (d).
- 7.2 EMPLOYER's Engineer shall -

- (a) within 10 (ten) days of receipt of the Stage Payment Statement from the Contractor pursuant to Clause 19.4, determine the amount due to the Contractor and recommend the release of 90 (ninety) percent of the amount so determined as part payment, pending issue of the Interim Payment Certificate; and
 - (b) within 15 (fifteen) days of the receipt of the Stage Payment Statement referred to in Clause 19.4, deliver to the EMPLOYER/ PMNC and the Contractor an Interim Payment Certificate certifying the amount due and payable to the Contractor, after adjustments in accordance with the provisions of Clause 19.10.
- 7.3 The EMPLOYER's Engineer shall, within 15 (fifteen) days of receipt of the Monthly Maintenance Statement from the Contractor pursuant to Clause 19.6, verify the Contractor's monthly statement and certify the amount to be paid to the Contractor in accordance with the provisions of the Agreement.
- 7.4 The EMPLOYER's Engineer shall certify final payment within 30 (thirty) days of the receipt of the final payment statement of Maintenance in accordance with the provisions of Clause 19.16.

8.0 Other duties and functions

The EMPLOYER's Engineer shall perform all other duties and functions as specified in the Agreement.

9.0 Miscellaneous

- 9.1 A copy of all communications, comments, instructions, Drawings or Documents sent by the EMPLOYER's Engineer to the Contractor pursuant to this TOR, and a copy of all the test results with comments of the EMPLOYER's Engineer thereon, shall be furnished by the EMPLOYER's Engineer to the EMPLOYER/PMNC forthwith.
- 9.2 The EMPLOYER's Engineer shall retain at least one copy each of all Drawings and Documents received by it, including 'as-built' Drawings, and keep them in its safe custody.
- 9.3 Within 90 (ninety) days of the Project Completion Date, the EMPLOYER's Engineer shall obtain a complete set of as-built Drawings, in 2 (two) hard copies and in micro film form or in such other medium as may be acceptable to the EMPLOYER, reflecting the Project as actually designed, engineered and constructed, including an as-built survey illustrating the layout of the Project Works and setback lines, if any, of the buildings and structures forming part of Project Facilities; and shall hand them over to the EMPLOYER against receipt thereof.
- 9.4 The EMPLOYER's Engineer, if called upon by the EMPLOYER/PMNC or the Contractor or both, shall mediate and assist the Parties in arriving at an amicable settlement of any Dispute between the Parties.

-
- 9.5 The EMPLOYER's Engineer shall inform the EMPLOYER/PMNC and the Contractor of any event of Contractor's Default within one week of its occurrence.
- 9.6 The Employer's Engineer, if called upon by the Employer/ PMNC, shall attend the meetings on Project reviews, discussions to be held at Employer/ PMNC office with required reports and presentations.

Schedule O - Forms of Payment Statements*(See Clauses 19.4.1, 19.6.1, and 19.8.1)***Contents**

1 - Stage Payment Statement for Works.....	
2 - Monthly Maintenance Payment Statement.....	
3 - Contractor's claim for Damages.....	

1. Stage Payment Statement for Works

The Stage Payment Statement for Works shall state:

- (a) The estimated amount for the Works executed in accordance with Clause 19.3.1 subsequent to the last claim;
- (b) Amounts reflecting adjustments in price for the aforesaid claim;
- (c) The estimated amount of each Change of Scope Order executed subsequent to the last claim;
- (d) Amounts reflecting adjustment in price, if any, for (c) above in accordance with the provisions of Clause 13.2.3 (a);
- (e) Total of (a), (b), (c) and (d) above; (f) Deductions:
 - (i) Any amount to be deducted in accordance with the provisions of the Agreement except taxes;
 - (ii) Any amount towards deduction of taxes; and
- (iii) Total of (i) and (ii) above. (g) Net claim: (e) – (f) (iii);
- (h) The amounts received by the Contractor up to the last claim:
 - (i) For the Works executed (excluding Change of Scope orders);
 - (ii) For Change of Scope Orders, and
- (i) Any deductions
- (ii) Taxes deducted

2. Monthly Maintenance Payment Statement

The monthly Statement for Maintenance Payment shall state:

- (a) the monthly payment admissible in accordance with the provisions of the Agreement;
- (b) the deductions for maintenance work not done;
- (c) net payment for maintenance due, (a) minus (b);
- (d) amounts reflecting adjustments in price under Clause 19.12; and
- (e) amount towards deduction of taxes

3. Contractor's claim for Damages

Note: The Contractor shall submit its claims in a form acceptable to the EMPLOYER/ PMNC.

Schedule P - Insurance*(See Clause 20.1)***Contents**

1 - Insurance during Construction Period.....	
2 - Insurance for Contractor's Defects Liability.....	
3 - Insurance against injury to persons and damage to property.....	
4 - Insurance to be in joint names.....	

1. Insurance during Construction Period

- 1.1. The Contractor shall effect and maintain at its own cost, from the Appointed Date till the date of issue of the last Completion Certificate, the following insurances for any loss or damage occurring on account of Non Political Event of Force Majeure, malicious act, accidental damage, explosion, fire and terrorism:
- (a) insurance of Works, Plant and Materials and an additional sum of [15 (fifteen)] per cent of such replacement cost to cover any additional costs of and incidental to the rectification of loss or damage including professional fees and the cost of demolishing and removing any part of the Works and of removing debris of whatsoever nature; and
 - (b) Insurance for the Contractor's equipment and Documents brought onto the Site by the Contractor, for a sum sufficient to provide for their replacement at the Site.
- 1.2 The insurance under paragraph 1.1 (a) and (b) above shall cover the EMPLOYER and the Contractor against all loss or damage from whatsoever cause arising under paragraph 1.1 other than risks which are not insurable at commercial terms.

2. Insurance for Contractor's Defects Liability

The Contractor shall effect and maintain insurance cover for the works from the date of issue of the Completion Certificate until the end of the Defects Liability Period for any loss or damage for which the Contractor is liable and arises from a cause occurring prior to the issue of Completion Certificate. The Contractor shall also maintain other insurances for maximum sums as may be required under the Applicable Laws and in accordance with Good Industry Practice.

3. Insurance against injury to persons and damage to property

- 3.1 The Contractor shall insure against each Party's liability for any loss, damage, death or bodily injury which may occur to any physical property (except things insured under Paragraph 1 and 2 of this Schedule or to any person (except persons insured under Clause 20.9), which may arise out of the Contractor's performance of this agreement and occurring before the issue of the Performance Certificate. This insurance shall be for a limit per occurrence of not less than the amount stated below with no limit on the number of occurrences.
- The insurance cover shall be not less than: Rs. 20 Lakhs.
- 3.2 The insurance shall be extended to cover liability for all loss and damage to the EMPLOYER's property arising out of the Contractor's performance of this Agreement excluding:

- (a) the EMPLOYER's right to have the construction works executed on, over, under, in or through any land, and to occupy this land for the Works; and
- (b) Damage which is and unavoidable result of the Contractor's obligations to execute the Works.

4. Insurance to be in joint names

The insurance under paragraphs 1 to 3 above shall be in the joint names of the Contractor and the EMPLOYER.

Schedule Q - BIM and CAD Requirements*(See Clause 3.1.7 K)***Contents**

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1.1 OBJECTIVE

- The Employer mandates the use of advanced computer based dynamic 3D-model driven approach for the detailed planning, design, engineering, construction and operation of the DMIC nodes to allow simulation, visualization and engineering analysis of all transportation, utility, building, civil works and geospatial infrastructures.
- This includes an aggregate dynamic 3D Building Information Model (BIM) for the city infrastructure systems with 3D building models. 3D civil infrastructures, 3D models for rail, roads and underground and above ground utilities systems participating.
- 3D infrastructure modelling tools shall be used to develop and produce project models and simulations (e.g. in case of natural calamity etc.) as required for submittals.
- The 3D infrastructure Information Models are to be used throughout the design, construction and operational life-cycle of the asset, including but not limited to for system collision detections, materials quantification, construction sequencing and carbon impact analysis.
- 3D infrastructure models use shall be maximized for project reviews, decision support, design analysis, and quality assurance during all phases of this program.

2.1 GENERAL

2.2 Purpose

- 2.1.1. The purpose of the 3D Building Information Modelling (BIM) requirements describes the use of computer aided design (CAD), geographical information (GIS) and building information modelling (BIM) for the work under the Contract.
- 2.1.2. These requirements shall be used as a reference for the Design & Build Contractor to develop specific Work Package BIM Execution Plan (BEP) that shall detail the specific CAD/GIS/BIM software used within the Work Package to control the specific BIM and CAD process. The outputs from this process will be drawings and 3D models as PDF's that will be input to the Project Management Information System (PMIS) for distribution.
- 2.1.3. BEPs establish the methodology for managing the production, distribution and quality of the design information generated by CAD, GIS and BIM systems, using a disciplined process for collaboration and a specified file and model naming policy.

- BIM Project Execution Plan Overview Information: Document the reason for creating the Project Execution Plan.
- Project Information: The Plan should include critical project information such as project numbers, project location, project description, and critical schedule dates for future reference.
- Key Project Contacts: As part of the reference information, A BIM Plan should include contact information for key project personnel.
- Project Goals / BIM Objectives: This section should document the strategic value and specific uses for BIM on the project as defined by the project team in the initial step of the planning procedure.
- Organizational Roles and Staffing: One of the primary tasks is to define the coordinator(s) of the BIM planning and execution process throughout the various stages of the project. This is particularly important when identifying the organization(s) who will initiate the development of the BIM Plan, as well as the required staff to successfully implement the plan.
- BIM Process Design: This section should clearly illustrate the execution process through the use of process maps which are developed in the second step of the planning procedure.
- BIM Information Exchanges: The model elements and level of detail required to implement each BIM use should be clearly defined in the information exchanges requirements.
- BIM and Facility Data Requirements: The owner's requirements for BIM must be documented and understood.
- Collaboration Procedures: The team should develop their electronic and collaboration activity procedures. This includes the definition of model management procedures (e.g., file structures, and file permissions) as well as typical meeting schedules and agendas.
- Model Quality Control Procedures: A procedure for ensuring that the project participants meet the defined requirements should be developed and monitored throughout the project.
- Technology Infrastructure Needs: The hardware, software and network infrastructure required to execute the plan should be defined.
- Model Structure: The team should discuss and document items such as model structure, file naming structure, coordinate system, and modeling standards.
- Project Deliverables: The team should document deliverables required by the owner.
- Delivery Strategy / Contracts: This section should define the delivery strategy which will be used on the project.

2.3 Scope

- 2.3.1 This BIM requirement document outlines the roles and responsibilities that are necessary for a successful collaborative 3D Building Information Modelling (BIM) approach.
- 2.3.2 The Project Management Information System (PMIS) and Common Data Environment (CDE) will be mandated for the structure and the controlled sharing of the building information with known provenance and status in a multi-disciplinary environment.
- 2.3.3 Contractor's BEPs are required to control the production and coordination of the design information within each Works Package.

2.4 Standards and Specifications Reference for Design

In order to establish a consistent approach to collaboration, the Contractor shall refer with the Standards and Specifications for Drawing and Modelling as given below.

- 2.4.1 In order to establish a consistent approach to collaboration, the Contractor shall refer with the Standards and Specifications for Drawing and Modelling as given below.

Sr.	Description	Code/Document No.
1	BS 1192:2007 Collaborative production of architectural, engineering and construction information	BS 1192:2007
2	BS 7000-4:1996A Design Management System	BS 7000-4:1996A
3	PAS 1192-2:2013 Specification for information management for the capital/delivery phase of construction projects.	PAS 1192-2:2013
4	PAS 1192-3:2014 Specification for information management for the operational phase of assets using building information modelling	PAS 1192-3:2014
5	BS 1192-4:2014 Collaborative production of information	BS 1192-4:2014
6	PAS 1192-5: Specification for security-minded building information management, digital built environments and smart asset management	PAS 1192-5
7	Classification: Uniclass2 : classification system for structuring information	Uniclass2
8	CAD Symbols (Singapore Standard Code of Practice for Construction Computer Aided Design (CAD))	CP 83

2.5 BIM Uses

2.5.1 BIM uses that have been established as required thus far are:

BIM Uses	Description/Comments
Existing Conditions Modelling	This will require the gathering of existing conditions information from a range of sources, and validating the quality, accuracy and reliability of that information for use on the project. The physical extent of what is needed to be modelled is to be determined, based on location, physical/spatial/visual relationship and potential impact on the project. Areas or elements identified as posing risk to the project should be communicated clearly to inform future risk mitigation efforts. In the
Site Analysis	The site context should be understood thoroughly and acknowledged within the design, accounting for factors that may impact on siting/position of proposed construction works, such as interfaces with existing structure or services, vistas, nearby land use, hydraulic analysis, geotech and topographic conditions, site access/egress issues, traffic flows, other infrastructure and so on.
Design Authoring	A process in which software is used to develop a Building Information Model based on criteria important to the communication of the building's design. Two types of software applications are core to the BIM-based design process: design authoring tools and audit and analysis tools. Authoring tools are used to create models while audit and analysis tools draw from or enhance the richness of information in a model. Most audit and analysis tools can be used for Design Reviews and Engineering Analysis BIM Uses. Design authoring tools are required in the first instance, and employ a powerful database of properties, quantities, means
Design Visualization	The BIM can be used to generate rendered images, animated fly-throughs and read-only versions of the model as requested by the Client (with due notice) to support effective communication of the design intent of the building. This is critical for stakeholder engagement at a number of levels
Interference Detection	General coordination will take place during early design via visual inspection and design coordination workshops. In particular, coordination efforts will be applied to key pinch points, such as cores, risers, plenum spaces, and plant areas. Aggregation/intensity of interferences detected will further inform priority zones and element types. Late in the design process, and particularly for preconstruction planning (during early Construction stage), interference severity criteria will be defined and interference rules configured that will support element-level coordination. Good interference rule definitions will be key to avoiding 'false positives'
Design Review	A process in which stakeholders interrogate and interact with a 3D model to validate various design criteria. These may include evaluating the ability to meet the program, previewing spatial or visual relationships in a virtual environment, layout, sightlines, lighting, security, ergonomics, acoustics, textures and colours, etc. This BIM use can be achieved with the

Planning of Construction Scheduling and Sequencing	This focuses on planning or staging and sequencing of major works, predominantly for stakeholder communication and buy-in, in order demonstrate that the design is buildable. The contractor shall adhere to employers preferred systems on the construction methodology to be employed, and would be responsible for modelling and communicating this as part of their work. Typically this is something that engineers are able to provide (as part of validating design approach), though for actual
Record Modelling	This entails updating the project federated model to represent an as-built record of the as-constructed works. The basis for the model updates is currently sketches and other records provided by the contractor to the design team during construction. The precise level and method of field

2.6 Definitions

2.6.1 The following terms are specific to the BIM requirements:

- **3D Building Information Modelling and Management (BIM):** The managed approach to the collection and exploitation of information across the life cycle of a built environment asset. At its heart are computer generated 3D and 2D models containing all graphical and tabular information about the design, construction and operation of the asset.
- **BIM Execution Plan (BEP):** The BIM Execution Plan (BEP) is to be submitted to address the issues raised in the EIR and then with more detail post- contract award to explain the contractors methodology for delivering the project using BIM.
- **BS1192:** Collaborative production of architectural, engineering and construction information. Code of practice.
- **Project Management Information System (PMIS):** A Common data environment (CDE) — a single source of engineering information for the project. It is used to collect, manage and disseminate all relevant approved project documents.
- **ECM (Engineering Content Management):** Set of hardware/software and processes that control the engineering content of CAD models and drawings together with their versions within the constraints of the PMIS.
- **Geospatial System:** Name or description of the system of spatial referencing by coordinates used for geographical information.
- **COBIE:** Construction-Operations Building Information Exchange – a standard spreadsheet data format that controls the transition of as built data into operations and maintenance.
- **Uniclass:** Unified classifications for the construction industry.

- **Workspace:** A predefined folder structure containing configuration and content relevant to the specific application.
- **Master Document Index (MDI):** A list of agreed model file and drawing deliverables produced by the Contractor against agreed milestones.
- **2D/3D Model:** A design model with entities having two/three-dimensional properties which are coordinated to the agreed geospatial reference system.
- **Model composite:** A model file containing multiple references of 2D/3D models coordinated using a common geospatial reference system to form a complete model representation of the information.
- **Model extraction:** A 2D model file containing elements generated from an external 3D model, usually in the form of sections, elevations and plans. Can contain graphical or non-graphical content.
- **Model files (MD2/MD3):** Native CAD files that can be in the form of a 2D or 3D model.
- **Model rendition (MDR):** Output from a model file, model renditions provide static ‘snapshots’ in a form that enables the information to be viewed, printed and marked up.
- **Output file:** A generated rendition of graphical or non-graphical information (a plan, section, elevation, schedule, table or other view of a project).
- **Model view:** The view within CAD files which contains entities or reference files using real—world coordinates
- **Originator:** The author of models, drawing and documents.
- **Production drawing:** An immutable electronic plot (PDF) produced from a drawing definition, having received all necessary reviews prior to issue.
- **Zone:** A manageable spatial 2D or 3D subdivision of a model allowing more than one person to work on the model, floor plan or staircase etc. at a time. Each zone is a reference file and when all references are viewed in a ‘model composite’ the full model shall be represented.
- **Status:** Defines the ‘fitness’ of information in a model, drawing or document
- **WIP:** Work In Progress: each individual company or discipline’s own work. This is information that has not been issued or shared with other parties. Refer to BS1192.
- **Shared:** Information that has been reviewed and is available to other parties. Refer to BS1192.
- **Published:** Documents and other data outputted from Shared information. Typically this shall include contract drawings, reports and specifications but can also include information for data exchange between BIM software, such as LandXML, IFC files. Refer to BS1192.

- **Component:** An individual building element that can be reused. Examples include doors, stair cores, furniture or internal room layouts, facade panels, etc. Components are typically inserted and moved/rotated into the required position.
- **Assembly:** A composition or collection of components and/or modelled elements arranged to define part or all of a building model, structure or site. An Assembly typically contains information that can be referenced without repositioning.
- **Container:** An optional 'parent' repository which can be used to compile assemblies and components for specific purposes including export and publication. A Container can exist for each individual profession/discipline or for multiple disciplines, for buildings or for a complete project.
- **Layer/Level:** Attribute given to entities within CAD files that enables their visibility to be controlled. Further values may be assigned to the attribute to control whether it can be edited or deleted.
- **IFC:** Industry Foundation Class is a neutral and open specification file format. The data model facilitates interoperability between object based software platforms.
- **LandXML:** LandXML is a specialized XML data file format containing civil engineering and survey measurement data commonly used in the Land Development and Transportation Industries.

2.7 Responsibility

The Design and Build Contractor shall provide: A structured BIM approach to the production of all required design and as built data and information for these Works under the Contract, modelled on BS1192 Collaborative production of architectural, engineering and construction information; Code of practice;

- Evidence that an all discipline integration, coordination and resolution process has taken place in a collaborative 3D object orientated CDE, the outputs of which meet or better the Employer's Requirements;
- A uniform and interoperable software/hardware platform across the entire Work Package, in that any software used shall be consistent with the principles of the sharing of multi-disciplinary object data in a CDE; That data shall include geometry and object attributes; Compatibility between software and hardware platforms, including processes for any interfaces with other Work Packages, as to ensure seamless integration at all areas of overlap;
- An Engineering Content Management System (ECM) which shall be configured to the CDE workflows consistent with those set out in BS1192 and integrate with Employers PMIS

- Access to the (ECM) for the Engineer;
- Structured data sets:
 - Detailed Design Stage 1
 - Detailed Design Stage 2
 - As-Built Drawings
- The data sets shall include all plot composition files and associated references, all models and associated references, all associated object and attribute data in mandated format; All renditions of the above (PDFs) all as listed in the Master Document Index (MDI);
- A copy of the database from the ECM system and its files store;
- All data in a structured (Level/Layer/Filename) format should be consistent refer BIM Guideline.
- AEC Uniclass.
- All As-Built data in a structured (format) consistent with the Construction Operations Building Information Exchange (COBie) format;
- Suitability trained personnel with the appropriate capabilities to execute the specific roles and responsibilities as outlined this BIM requirements, CAD and GIS manuals contained herein;

2.7.1 The Engineers BIM Manager:

- Defines the Program BIM requirement;
- Ensures the BIM process serves the engineering and business requirement during the design and build phase of the works;
- Ensures that data schema declared for the program serves the engineering requirements of the design and build phase of the Works;
- Ensures industry best practice is utilized for the BIM implementation and to facilitate the transition of design and as built data into operational data and information for SIA.
- Ensures seamless integration with other adjoining/other relevant contract work packages.

2.7.2 The Contractors BIM Manager:

- Produces a general BIM implementation plan for their specific Works package, together with the Contractor's Design Coordination Manager, containing:
 - Statements on how the work packages shall be zoned, the level of BIM resolution required in what zones, the number of specific discipline models that will be included what level of detail each of these models shall achieve for each stage for the design and build workflow.

- Statements on the level of program integration and construction sequencing with the BIM model.
 - Statements on how the interface with other Works packages shall be achieved and managed.
- Ensures the Contractors BIM systems are providing the tools, process is centred on the delivery of structured, coordinated and accurate information.
- Ensure that all CAD, GIS, BIM data is compatible consistent and accurate and all BIM processes are compliant with BS 1192.
- Ensures the Contractors BIM processes serves the engineering and business requirement of managing multi-discipline collaborative workflows, CAD QA, Clash resolution, program linkage and construction sequencing.
- Coordinates the project needs for IT solutions.
- Coordinates the agreed project BEPs and updates to the BEPS.
- Ensures compliance with those standards and methods.
- Shall be responsible for resolution of all interdisciplinary/other contract work packages and interface resolution.
- Provides the focal point for all file and document management issues in the project
Ensures that all information is compliant with standards and that each model or file has been signed off 'fit for purpose'.

2.7.3 The Contractors Information Manager:

- Provides the focal point for all file and document management issues in the project.
- Ensures that all information is compliant with standards and that each model or file has been signed off 'fit for purpose'.

2.7.4 The Contractors Lead Designer:

- Manages the design, including information development and approvals.
- Confirms the design deliverables of the design team, establishes the zone strategy and ownership.
- Signs and approves the documentation for detail design coordination on and prior to passing to 'shared'. Ref BS 1192 workflow.

2.7.5 The Contractors CAD Manager:

- Ensure that all CAD models and drawings are delivered to the SIA use agreed IT solutions, and are according to the agreed project requirements.
- Ensure that all object attribute data is structured and is compliant with the project SMPs Ref BS1192. This role should be responsible to the Contractor's BIM Manager.
- Completion of a table of names assigned to the roles described above and submit it to the client as a reference document.
- Ensure that all drawing production shall be in line with CAD Guidelines given in Annexure – I of this Schedule Q.

2.8 The Engineering Content Management (ECM) System

- 2.8.1 The Contractor shall produce ECM system information sufficiently detailed to produce traditional drawings or documents as views of multi-authored data.
- 2.8.2 The Contractor shall develop and utilize a suitable ECM system that allows for a suitable permissions matrix, workflow, referencing, version control, process and information hierarchy that is consistent with the principles of the CDE for all models and drawings.
- 2.8.3 The Contractor shall provide access to the ECM system for the Engineer.

3.1 BIM Modelling

3.2 Model file production principles

- 3.2.1 All model files shall be created at 1:1 scale.
- 3.2.2 All design and construction information shall be modelled as a single discipline model and coordinated in 3D in the composite model, using object based software, allowing for 2D models to be extracted as required.
- 3.2.3 All single discipline models shall be shared throughout the CDE. Clash detection and resolution process shall be run in this composite area. All 3D model data together with all 2D drawing extractions shall be spatially coordinated with the Geospatial System.
- 3.2.4 Model file composition.
- 3.2.5 Model files shall be generated using seed files, as prescribed in the Contractor's Work Package BEP.
- 3.2.6 All graphical elements shall be placed in the model view.

3.2.7 Model files shall have a title box placed in the sheet view.

3.3 Coordinates

3.3.1 A common coordinate system for all BIM data and adopt it consistently for all Models. As a priority the Client requires that Global Coordinates WGS 84, 43N shall be used.

3.4 Data Segregation (Zoning)

3.4.1 Each structure/Utility/Infrastructure shall be created in one file.

3.4.2 The BIM software in use will have a major impact on how the model is to be broken down, but in all cases sub-division is required to maintain workable files using appropriate hardware.

3.5 Planning the Work & Data Segregation:

3.5.1 The supply chain shall agree, adopt and maintain a BIM Strategy focusing on the following project-specific processes as a minimum:

- Model Management
- Zones and Areas
- Naming Conventions
- Publishing processes

3.5.2 Site Information: Minimum site information will as a digital default shall include:

- Site Name
- Site Status
- Land Area (Ha)
- Site Grouping
- Address including Postcode
- GIA of proposed asset(s)
- Site Cross Reference

3.5.3 Floor Data: All floor layouts will include the following minimum digital data set as a default

- Site Code
- Block No
- Floor Level
- Floor Code
- Floor Description
- GIA (m2)
- GEA (m2)

3.5.4 Room Data: All rooms will include the following minimum digital data set as a default:

- Site Code
- Block No
- Floor Level
- Room Number
- Zone Name
- Room Description
- Room Area (m2)
- Space Utilisation
- Functional Suitability
- Quality Room Height (m)
- Volume

3.5.5 Asset data will be provided for the client CAFM and AMS Systems as attributes of objects in the model with the following criteria:

Attribute Field	Description
GUID	3D Model Generated Code.
Building Name/Description	
Asset Template Name	
Asset Template Code	
Local Name/Description	Enter with a relevant name for the asset as it could be identified on site (e.g. West AHU No1). This is the name defined in the design process.
Quantity	In the case of individual assets created this will be one.
	In the case of "grouped" assets it will be the count of the assets. e.g. Fire Extinguishers; Fire Hose Reels; Lighting; Emergency
	Lighting; FCUs; Eye Bolts. These are multi selected when defined in
Manufacturer	The manufacturers name.
Model	The model or reference of the asset.
Serial No.	The asset serial number, this typically is added to the model late in the procurement and installation process and lends itself to being carried out via export, data entry and re-import. Where not applicable state N/A.
Floor/Level	The Level of the building or building zone.
Position	Detailed description of location.
	operating instructions
	maintenance instructions

Non-graphical attributes in an agreed digital format for:	fault finding instructions
	commissioning instructions
	working life expectancy of the asset including cost, remaining life etc. on sub elements e.g. windows, doors, sanitary ware etc.
	commissioning dates and data
	health and safety file
	regular statutory tests
	Specification and cleaning regime – finishes and fittings, furniture and equipment.
	Building level life cycle information Warranty information on sub
	Schedule of information on maintainable assets (site, building, floor,
	Schedule of information on maintainable systems e.g. security, access
	Fuel supply and storage arrangements (site and building level)
	Power consumption information
	Maintenance information on restricted access features e.g. high ledges,

3.6 Model outputs

- 3.6.1 Within the CDE the central premise is that only approved data is shared. Each discipline WIP area can only reference data from the shared area. i.e. approved data. When this data comes together in the composite model it can be fully coordinated and composite renditions can be produced, for example in 3D pdf format.

3.7 Model Reviews

- 3.7.1 The Contractor shall ensure that the level of complexity and granularity for each discipline CAD model is appropriate for the stage of Works.
- 3.7.2 The Contractor shall ensure that all disciplines integrate and coordinate their outputs in terms of both spatial and functional provision. This shall be demonstrated through the extensive use of coordinated design review sessions which shall include for the coming together of all relevant discipline models into a common master model (model composite) where engineering assurance and coordination checks shall take place.

3.8 Level of detail/Model Progression for the BIM Models

Project Stage	Model Description/Details

Detail Design	A more detailed version of the generalised building component or system with accurate dimensions, shape, location, orientation and quantity. Non-geometric information may be attached to the model elements. The Model Element is graphically represented within the Model as a design-specified system, object or assembly and associated components having accurate quantity, size, shape, location and orientation. Interfaces with other building elements and systems have been identified and coordinated; approximate allowances for spacing and clearances required for all specified supports; actual access/code clearance requirements modelled.
Final Design	Parameters required for procurement, including specification, materials and performance criteria are attached to the Model Element. Model Elements are uniquely tagged.
Pre-construction	The Model Element is graphically represented within the Model as a design-specified system, object or assembly and associated components having accurate quantity, size, shape, location and orientation. Interfaces with other building elements and systems have been identified and coordinated; approximate allowances for spacing and clearances required for all specified supports; actual access/code clearance requirements modelled. Parameters required for procurement, including specification, materials and performance criteria are attached to the Model Element. Model Elements are uniquely tagged.
Construction	The Model Element is graphically represented within the Model as a specific system, object or assembly having accurate size, shape, location, quantity, and orientation suitable for construction, fabrication and installation. Required non-graphic detailing, fabrication, assembly, and installation information is attached to the Model Element.
As-Built	The Model Element is a field verified representation with actual installed and accurate size, shape, location, quantity, and orientation. Non-graphic information as installed and required for operation and maintenance is attached to the Model Elements.

3.9 Component Grade

- 3.9.1 In order to produce information to the required scale, as with 2D CAD files, additional detail shall be created in separate model files. Where a Component is being used for multiple instances of the same object, the component shall (at the Contractor's discretion) be

created in three ‘grades’: low, medium and high resolution. Modelling in this way allows easier component management and simple ‘swapping’ of the grades should additional, or less detail be required. It also ensures the most efficient use of PC processing power at any particular stage. The Contractors Work Package BIM strategy document shall address the naming conventions for components, component grades, types, parameters, materials, etc. and the quality assurance and filing of such elements. It shall give guidance on using downloaded content.

3.10 Existing Infrastructure data sets

3.10.1 Employer shall share available existing data sets and models for contractor as reference.

3.10.2 Contractor shall be liable for validating the models before utilizing/enhancing them further.

3.10.3 The existing infrastructure and systems shall be modelled in sufficient detail as to provide integration with the Works under the Contract.

3.10.4 Data sets with distinct owners, e.g. TP2E, TP2W, TP2E-Water etc. Shall be referenced into the model. The data contained within these models shall remain under the authority of the owner at all times.

Unresolved areas of non-coordination in structure/services/finishes/clashes shall be clearly highlighted on the drawings and the model at all times. Provenance of all referenced data sets shall be explicitly declared on all relevant models and subsequent drawings.

3.10.5 Any discrepancies with the data shall be reported back to the owner for their action.

3.11 4D & 5D

The contractor shall take full advantage of the 3D object attributes available in the BIM environment to prove cost, constructional logic, fabrication, and program as required by the employer.

3.12 Coordination and integration – drawing packages

3.12.1 Within the BIM environment each of the disciplines shall reference other models in a timely manner for coordination purposes. The head of each discipline group shall decide the extent and nature of supporting discipline data that shall be displayed in each of their own discipline drawing submissions. Clash detection software routines shall be run on the multi-discipline model and on combined master models and any clashes resolved. The reports of which will be submitted on request of the Engineer.

3.12.2 Specific drawing packages are required from each discipline. The drawings shall comprise of 2D extractions of the 3D design models from the CDE. These include, but not limited to the examples below.

a) Buildings

- Architectural
 - Structural
 - Mechanical
 - Electrical
 - Building Services
- b) Combined Services Drawings (CSDs) on Structural/Civil/Architectural backgrounds:
- c) CSDs covering the main installations including closed circuit television (CCTV), power, fire systems, ventilation, lighting, and public address (PA), communications and signage. These shall be submitted in logical readable packages.
- d) Plan and Profile drawing extractions of linear infrastructure
- e) General Arrangement Drawings
- f) For detail of Models & Drawing.- See Annexure - II

3.12.3 All CAD drawings shall be comprised of 2D models extracted from the 3D master model. Any subsequent design scheme changes that are required to be fully coordinated shall be modelled in 3D and the drawing extraction re-run to produce revised plots.

3.12.4 All plot composition files shall be checked as prescribed by the workflow setup in the CDE before submission to the Engineer.

3.13 Deliverables

3.13.1 The number and extent of the design & build submissions shall be detailed by the Contractor in the MDI, which shall form part of the Contractor's BEP.

3.13.2 All native design/analysis models shall be listed and submitted in MDI

3.13.3 All CAD drawings submission shall have the original plot composition files containing all extractions.

3.13.4 All CAD drawings submissions shall have a simplified standalone 2D vector plot composition file.

3.13.5 All CAD drawings submissions shall have a corresponding PDF.

3.13.6 All CAD drawings submission shall have their provenance shown on the plot, i.e. the references, extractions, model revision used to generate plot.

3.13.7 All database and file store data from the Contractor's ECM system.

3.13.8 BIM Deliverables:

- Site Model
- Massing Model

- Architectural Model
 - For regulatory submissions
 - For coordination and / or clash detection analysis
 - For visualization
 - For cost estimation
- Schedule (material, time etc.) and phasing program (in BIM or spreadsheet)
- Construction and fabrication models
- Shop drawings.
- As-built model (in native proprietary or open formats)
- Data for facility management
- Other additional value added BIM services

3.13.9 To support the development of a Project Information Model (PIM) and Asset Information Model (AIM) at handover the information exchange formats will include the following information from the same data set in a commonly accessible electronic formats:

- 2D portable format document drawings (.dwg and .pdf) cut from the native Model(s)
- The native Model(s)
- The model(s) in IFC format
- Programme files .mpp
- Text files (.doc and .pdf) for specification and all other tender docs

3.14 Master Document Index (drawing and model register)

3.14.1 The Contractor shall provide a MDI at the start of the Works that shall list all the ‘file identifiers’ for models and drawings that are needed, along with their delivery dates and intermediate milestones. The following document properties (metadata) shall be included:

- Company Code
- Project Code
- Design Stage
- Discipline Code
- Level
- Location
- Drawing Type
- Revision

3.14.2 All CAD models and drawings shall be compiled in a MDI (spreadsheet) by the Contractor prior to commencement of work. It shall list out all models and drawings to be submitted at

each of the design stages.

3.14.3 The CAD MDI shall be used as the basis of and be maintained by means of the drawing register.

3.14.4 The contractor shall follow the drawing and document numbering system as per the Document management system details that will be provided by Employer/ PMNC to them.

3.0 Recommended Software Requirement

Discipline	Function	Software	Version*	Operating System
Engineering Design Tools	3D BIM Modelling for Buildings	Autodesk Revit	Latest	Windows 7 (64 Bit Recommended)
		AECOSim Building Designer	Latest	
Engineering Design Review Tools	Project Review and coordination	Autodesk Navisworks Manage	Latest	
	4D Construction / 5D Schedule	Bentley Navigator	Latest	
	3D BIM and GIS integration/coordin	Autodesk Infraworks	Latest	
		Bentley MicroStation	Latest	
GIS -Asset Management	GIS	ESRI – ArcMap	Latest	
		AutoCad MAP	Latest	
Publishing	Publish read only single file containing graphical and non- graphical attribute	i-model Plug-in's For Revit For Adobe (Reader)	Latest	
Engineering Design Review Tools	3D/2D Models, Drawings and Maps	Adobe Acrobat Reader		
	Maps	ESRI ArcReader 10		
	3D/2D Models, Drawings	Autodesk DWG TrueView		
		Bentley View		
GIS -Asset Management	GIS	ESRI – ArcMap	Latest	
		AutoCad MAP	Latest	

*Products and product versions should be clearly stated in BEP and should be consistent across the project.

Annex – I
CAD Guideline
(Schedule - Q)

1 OVERVIEW

1.1 Purpose

Programme Manager for New Cities (CH2MHill) has initiated to manage a program that will assist in standardizing the use of CAD across all departments. The primary goal is to create an environment for seamless integration/collaboration between all disciplines & business lines of all consultants/contractors regarding the use of CAD for production of any drawing. The document will achieve this through setting out the Guideline for drawing data production. This will then enable drawing data to be incorporated into the Aurangabad Industrial Township limited (AITL) GIS.

1.2 Application

This CAD standard shall be applied to all disciplines in all offices and design houses working in this Project. The scope of this document is to provide guidelines and procedures for adopting AutoCAD layering standards in preparing design and as-built drawings for automated transference to DMICDC GIS. This Guideline will address the following:

- i. Layer assignments,
- ii. Standard symbols
- iii. Layers and layer names, iv. Attributes to each feature,
- v. Templates,
- vi. Colour usage associated with line widths for all Highways and Utility drawings.

The Guideline are to be applied for all drawings from Concept through to As Built handover stage.

1.3 Acronyms

First, a few useful acronyms:

- A-E – Architect-Engineer
- A/E/C – Architecture, Engineering, and Construction

- AIA – American Institute of Architects
- ANSI – American National Standards Institute
- ASTM – American Society for Testing and Materials
- BIM – Building Information Modeling
- CAD – Computer-Aided Design
- CSI – Construction Specifications Institute
- DoD – Department of Defense
- FM – Facility Management
- GIS – Geographic Information System
- IAI – International Alliance for Interoperability
- IFC – Industry Foundation Class
- ISO – International Organization for Standardization
- NCS – United States National CAD Standard
- NIBS – National Institute of Building Sciences
- SI – International System of Units (Le Système International d’Unités)
- UDS – Uniform Drawing System..

2. Filing and Storage of Drawings

2.1 Filing and Storage of Drawings

In order that the project information is readily accessible it is essential that all drawing data is filed and stored in a consistent and logical manner.

2.2 Electronic Copies

All electronic drawing and sketch files associated with a particular project shall be filed within the project folder.

2.3 Folder Structure

The standard folder structure for CAD data is as shown in Figure 1 below, it adopts the Code of Practice BS1192:2007 on Common Data Environment for collaborative working.

Figure 1:

2.4 Folder Name: Project Number and Title

This can be under the main office or discipline folder, or, if the number of files would render lists unwieldy, then further sub-folder are permissible. Folder names are not to include any symbols.

2.5 Sub Folder Name: CAD

Contains drawings and digital information organised as shown in Figure 1.

In a multi-disciplinary office the main sub-folders defined below may be sub-divided as necessary into the relevant disciplines:

2.5.1 Sub Folder Name: WIP (Work in Progress)

Contains the current working project drawings and sketches. This is where all files currently in the iterative process of design have not yet been approved to be shared.

This folder shall contain further sub-folders which can be amended to suit Project requirements.

2.5.2 Sub Folder Name: Shared

Contains verified, checked and approved CAD data for use by others for reference. This folder will hold the project specific drawings such as title frames, references, images, etc.

This folder shall contain further sub-folders which can be amended to suit Project requirements

2.5.3 Sub Folder Name: Published

Contains all final published sheet files, figures or sketches. This folder must contain the last issued Models/Xrefs. Data filed in this area shall never be deleted or overwritten, but will remain until archived.

2.5.4 Sub Folder Name: Archive

Contains all previous issues and superseded data. This folder is to allow retrieval of previously issued drawings at certain stages of design decisions. This folder will provide an audit trail of documentation and changes through the life of the project.

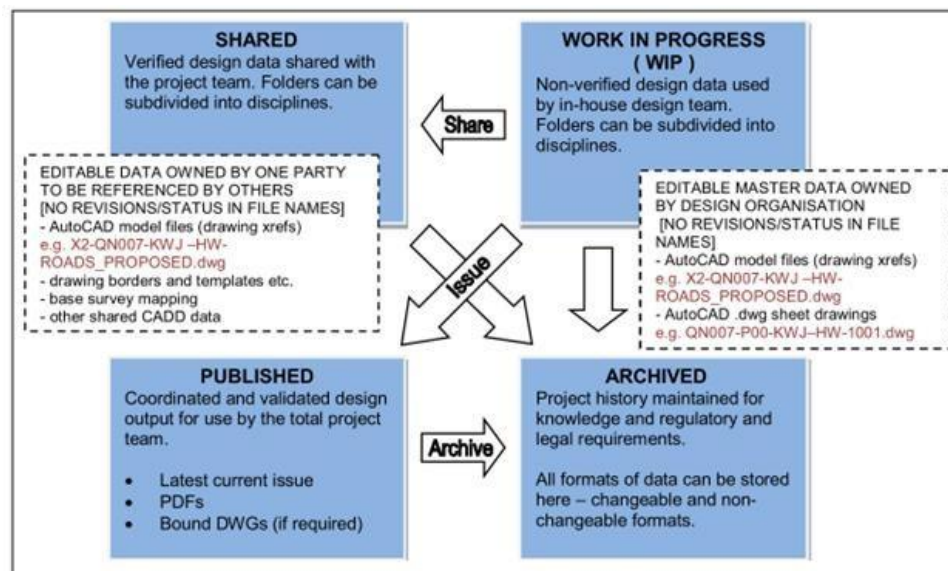
2.5.5 Sub Folder Name: Received

Contains read only copies of design data which have been received from Third Party sources or Stakeholders and will contain further sub-folders to identify the source and date of receipt.

The Received folder can be directly under the main project folder structure, under CAD or wherever the PMNC's find it suitable. The vital concern is that a folder must be dedicated for incoming issues, where a full archive of all received information is stored with an audit trail that is related to the sending company and the date received and the current copy is easily identifiable throughout the project.

2.6 Collaborative Working

Figure: 2 Application of code of practice BS 1192:2007 on Common Data Environment (CDE)



- i. Within WIP folder each discipline can create a folder structure to suit its needs.

- ii. Common resource files such as title sheets, mapping, surveys, imagery and other shared CAD data must be available to all disciplines in the Shared area.
- iii. Once data has been checked, verified and approved, it must be copied to the Shared area and other disciplines notified.
- iv. When models are revised or updated; other disciplines referencing the model will be affected, so effective communication between disciplines is essential.
- v. When data files have been authorised and verified for issue, it is copied to the Published area, to maintain a local copy within the design organization's server.
- vi. The previous version of the data in the Published area shall be moved to the Archive area as a historical record and to maintain an audit trail.

2.7 Hard Copies

The print containing the original stamped, checked and approved signatures becomes the hard-copy 'master plot' for the drawing. See Section 3.3.13.

2.7.1 Drawings

The Project Implementation Plan (PIP) will define the area where the hard-copies for projects are to be filed.

The electronic version of the master plot of the drawing shall be known as the 'reference master'. The reference master, if required, shall be utilised for the electronic issue of the file.

Superseded master plots shall be retained and endorsed "superseded".

2.7.2 Check Prints

All completed and signed check prints shall be filed within the drawing office by the drafting checker in an area in accordance with the Project Implementation Plan (PIP).

All check prints are to be retained at least for the term of the project unless otherwise agreed with the PMNC. No check prints are to be disposed of without the consent of the Project Manager.

3 DRAWING DEVELOPMENT

3.1 Drawing Numbering System

The drawing numbers are to be entered into the drawing register during creation of the drawings so as to eliminate duplicate drawing numbers being assigned. The drawing number shall be unique for each drawing and will normally be in the form:

Table 1

	Originator code	-	Project Name	-	Discipline / Drawing Type code	-	Document code	Drawing Number	-	Sheet No
Example	CH2MHILL	-	SBIA	-	BU	-	DWG	1001	-	001
See Reference	3.1.1		3.1.2		3.1.3		3.1.4	3.1.5		

Fields will be separated by a hyphen (-)

Example: **CH2MHILL-SBIA-AURIC Building-BU WG-1001-01**

3.1.1 Originator Code

A three letter code to identify who prepared the drawing. Refer to Appendix C.

3.1.2 Project Name

Refer to Appendix C

3.1.3 Drawing Type/ Discipline code

Two letter code to assist in identifying a discipline or type of drawing (i.e. HW for Highways, ST for Structures, SK for Sketch, etc.). Refer to Appendix C.

3.1.4 Document Code

Two letter code to assist in identifying type of document. Refer to Appendix C.

3.1.5 Drawing Number Code

TABLE-2

Note #3:

Working drawings shall not have the drawing status and revision in the file name.

Four digits' sequential number for a specific drawing type series. Refer to **Appendix C**. Subsequent issue of a drawing shall have the revision coding incremented by the next sequential number or letter.

Note #3: Working drawings shall not have the drawing status and revision in the file name.

3.2 Model File (Xref) Naming

Model Files shall be named in accordance with the convention described below

Table 3

	Model type Identifier	Originator code		Project Name	-	Discipline code	-	Short Description
Example	D2	CH2MHILL	-	SBIA	-	HW	-	Proposed _Centre_ line
See Reference	3.2.1	3.1.2		3.1.3		3.1.4		3.2.5

Example – CH2MHILL – **SBIA-ARUIC Building - Proposed_Centre_Line**

3.2.1 Model Identifier Code

This code identifies the model file if it is in 2D or 3D drawing as defined below:

Table 4

Description	Model Type Identifier
2D Model	D2
3D Model	D3

3.2.2 Originator Code

A three letter code to identify the PMNC who prepared the drawing. Refer to Appendix C.

3.2.3 Project Name

Refer to Appendix C

3.2.4 Drawing Type/ Discipline code

Two letter code to assist in identifying a discipline or type of drawing (i.e. HW for Highway, ST for Structures, SK for Sketch, etc.). Refer to Appendix C.

3.2.5 Short Description Field

A short description of the model/X ref file. An underscore is to be used in place of any spaces in the description field.

Working models shall not have the drawing status and revision in the file name.

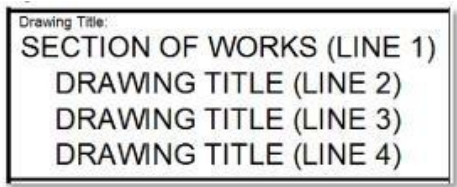
3.3 Drawing Title Blocks and Signatures

A standard drawing arrangement (drawing border and title block) shall be adopted for all drawings and shall be consistent across all drawings within the project. Title block entries shall be concise and informative to indicate fully the content of the drawing.

3.3.1 Drawing Title

- i) The top line shall identify the specific area or section within the contract, i.e. “HIGHWAYS”, or it may be left blank where no such area or section exists.
- ii) The second third and fourth lines shall identify the content or purpose of the drawing, i.e. “TRAFFIC SIGNS AND ROAD MARKINGS”
- iii) Where several drawings depict similar detail and no other qualifications are available for distinguishing between them, the distinction shall be made by labelling each drawing consecutively with sheet numbers, such as “SHEET 1 OF 10”, “SHEET 2 OF 10”, etc.

Figure 3



3.3.2 Drawing Status

The issue DRAWING STATUS box shown below (Figure 4) shall be completed to describe the current status of the drawing. Refer to Table 5 for the list of drawing status/stages:

Figure 4



Table 5

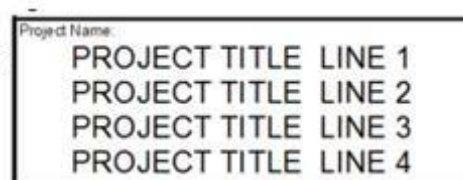
Drawing Status

Concept Design
Preliminary Design
Detailed Design
Tender
Contract
As Built

3.3.3 Project Name Field

For Project Name refer to Baseline Assessment Report on detailed list of projects.

Figure 5



3.3.4 Project Code Field

For PMNC-specific project codes refer to Baseline Assessment Report on detailed list of prioritized projects.

Figure 6



3.3.5 Drawing Creation Date Field

The drawing creation date shall be in the whole word format for **Month** and **Year** as highlighted below (Figure 7):

Figure 7

Drawn:	Checked:
Designed:	Approved:
Date:	Scale:
Drawing No:	REV:

3.3.6 Revision History Table

A concise description of each approved and issued revision shall be entered into the revision description column. The revision columns indicate the history and development of the drawing; therefore, the description shall be as informative as is practical.

Drawings that are issued under specific Submissions or Milestones sets shall have clear, consistent revision description that states the purpose of the submission. e.g. **ISSUED FOR APPROVAL**, etc.

Figure 8

		REISSUED FOR APPROVAL			
		ISSUED FOR APPROVAL			
Rev	Date	Revision Description	Drawn	Chkd	Appd.

The date shown in the revision history table shall be in the format DDMMYY as highlighted in Figure 9 below

Figure 9

	30SEP13				
	24SEP13				
Rev	Date	Revision Description	Drawn	Chkd	Appd.

The months shall be abbreviated as shown in table 6 below:

Table 6

Abbreviation	Month	Abbreviation	Month
JAN	January	JUL	July
FEB	February	AUG	August
MAR	March	SEP	September
APR	April	OCT	October
MAY	May	NOV	November
JUN	June	DEC	December

The date of completion of the revision and the initials of the person effecting the revision shall be stated.

The earliest revision descriptions shall be deleted when there is no space to include the current revision within the revision column.

3.3.7 Drawing Number Field

Drawing number field shall be completed as highlighted box below:

Figure 10

Drawn:	Checked:
Designed:	Approved:
Date:	SCALE (A1) : (A3) :
Originator Drawing No:	
Project Drawing No:	REV.

Refer to Section 3.1 for drawing numbering convention.

3.3.8 Revision Field Box

Revision field box shall be completed as highlighted below: Refer to 3.10.3

Figure 11

Drawn:	Checked:
Designed:	Approved:
Date:	SCALE (A1) : (A3) :
Originator Drawing No:	
Project Drawing No:	REV.

3.3.9 Name Fields

The 'Drawn', 'Designed', 'Checked' and 'Approved' field boxes on the title block, as highlighted below, shall include the first name initial and the full last name of the person who performed or is responsible for the major portion of the work.

Figure 12

Drawn:	Checked:
Designed:	Approved:
Date:	SCALE (A1) : (A3) :
Originator Drawing No:	
Project Drawing No:	REV.

3.3.10 Drawing Scale Field

For completing the drawing scale field box in the title frame, refer to Section 3.6. A scale bar for presenting the scale of the drawing should be used in the drawing layout.

Figure 13

Drawn:	Checked:
Designed:	Approved:
Date:	SCALE (A1) : (A3) :
Originator Drawing No:	
Project Drawing No:	REV.

3.3.11 Signatures

The revision history table shall contain the current issue revision number, date of issue, Drafter/Author, Checker, Approver signatures or initials and description of current revision.

Table 7

TITLE BLOCK	CAD	HARD COPY	PDF COPY
DRAWN BY	See 3.3.12	See 3.3.13	See 3.3.14
CHECKED BY	See 3.3.12	See 3.3.13	See 3.3.14
APPROVER BY	See 3.3.12	See 3.3.13	See 3.3.14

3.3.12 CAD Files

When issued, drawing files shall bear the typed CAD initials of the author, checker and approver on the revision history box.

Figure 14

Drawn: MOINUDDIN	Checked: SATYANARAYANA
Designed: RAVALI	Approved: Dr. SRAVAN
Date: DECEMBER 2014	SCALE (A1) : (A3) :
Originator Drawing No:	
Project Drawing No:	REV.

3.3.13 Hard Copy

The original hard copy set to be submitted to PMNC shall be signed by hand and stamped. This set will become the control set for reference. The drawing shall bear hand signature of the drawing **Approver** beside his/her name in the Approved field box on the title frame as shown in *Figure 15*. Each drawing shall be stamped with the issuing company's official stamp.

Figure 15: Signed hard copy by Approver

Drawn: MOINUDDIN	Checked: SATYANARAYANA
Designed: RAVALI	Approved: Dr. SRAVAN
Date: DECEMBER 2014	SCALE (A1) : (A3) :
Originator Drawing No:	
Project Drawing No:	REV.

Original hand-signed copy is required for all 'Final' drawings submitted for: Concept design, Preliminary design, Detailed design, Tender set, Contract set, GFC drawings (during construction) and As Built.

Subsequent hard copies of the submitted original do not have to be hand signed. Scanned copies of the hand signed drawing are permitted as long as the clarity of the drawing is not compromised. Alternatively, copies may be printed directly from CAD. It is acceptable for these not to contain a copy of the hand signature, but to bear typed initials instead.

3.3.14 PDF Copy

When Issued, PDF copy can be generated electronically from the cad file bearing the typed initials of the author, checker and approver.

3.4 Units

All general drawing work (e.g. Xrefs) are to be in model space and be produced in meters to three decimal places. Drawing borders to be in paper space and in millimeters.

e.g. **54.000**
78.720
0.325

sDimensions in meters and using whole numbers, can be expressed using the ‘m’ (meter) suffix as in the following

45.000m

The position of the decimal point shall be the same as a full stop and no space shall be left between the number and its units, to ensure clarity, as in the following example:

5.800m

All other non-linear measurements, e.g. areas and volumes, shall be followed by the unit symbol. The most common non-linear measurements are as follows

Square meter - m^2

Cubic meter - m^3

All detail drawing work (e.g. standard details) is to be in model space and be produced in millimeters in whole numbers (i.e. no decimal places).

e.g. **10000**

787

Dimensions in millimeters using whole numbers, can be expressed using the ‘mm’ (millimeter) suffix as in the following

250mm

Chainages shall be in meters and written as shown

0+100 (Chainages in whole numbers can be written without the decimal accuracy)

15+255.345

Chainages are plan measurements taken along a setting out line, and provide a horizontal distance not taking into account slope lengths.

3.5 Drawing Sizes

Drawing sizes shall conform to the International Standards Organisation (ISO). Sizes (in mm) are as follows: -

A0 – 1189 x 841

A1 – 841 x 594

A2 – 594 x 420

A3 – 420 x 297

A4 – 297 x 210

In general, all drawings shall be produced at the preferred A1 original size. The use of A0 size drawings shall be avoided wherever possible.

Each group or set of drawings shall use only one drawing size unless situations make this impractical.

3.6 Scales

Scales used on drawings shall be selected as indicated in the table below. Only standard metric scales shall be used. In all cases, the selected scale shall be large enough to permit easy and clear interpretation of the information depicted.

Specific scale requirements of particular drawings such as layouts will be as stated as per RFP.

Table 8

Permitted scales				
1:1	1:2		1:5	2:1
1:10	1:20	1:25	1:50	5:1
1:100	1:200	1:250	1:500	10:1
1:1000	1:2000	1:2500	1:5000	20:1
1:10,000	1:20,000	1:25,000	1:50,000	50:1

In exceptional cases where for functional reasons the recommended scale cannot be applied, intermediate scales may be chosen, provided that the required scale is of a whole number, such as 1:125, 1:150, etc.

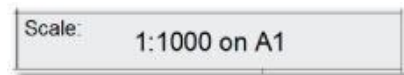
The following scale notes shall be considered:

- i. Number of scales on any one drawing shall be kept to a minimum.

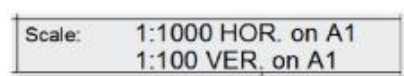
- ii. CAD entities shall be drawn at full scale (1 Drawing unit = 1 Measurement unit). Final plotted scale shall be established during composition of the drawing layout for plotting.
- iii. Originators using AutoCAD shall employ the PAPER SPACE/MODEL SPACE facility to establish drawing layout and scales. All drawing entities shall reside in MODEL SPACE with the exception of view ports, general notes, revision clouding and its labels, title block and border.
- iv. Where different scales exist, each scale shall be specified under the title of the area of the drawing to which it applies and noted in the Title Block field as shown below:

Figure 16

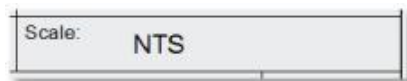
- v. Where a single scale is used on a drawing, it shall be specified within the title block only. (See the object area and shall be large enough to below). The scales selected shall depend on the object area and shall be large enough to permit easy and clear interpretation of information and ensure clarity of prints on the original as well as reduced copies i.e. A3 versions of A1 drawings.

Figure 17

- vi. Where different scales are used for horizontal and vertical dimensions, such as in profiles, each scale shall be clearly indicated on the drawing as shown below:

Figure 18

- vii. When the drawing is not drawn to any scale, 'NTS' (Not to Scale) shall be placed in the title block as shown below:

Figure 19

Scale bars shall be shown on all drawings containing plans.

3.7 Key Plan

Where layout plans are produced on a number of drawings to cover the extent or section of the project, a Key Plan shall be included on each sheet, clearly indicating the section of the works under consideration. A dedicated box in the title frame is provided for the Key Plan as shown below.

Figure 20

3.8 Drawing Notes

Notes are to be numbered and positioned appropriately and shall include the following notes:

- i. All Dimensions are in meters unless otherwise stated. (Only on drawings drawn in meters)
- ii. All levels are in meters (Only on drawings where this note is applicable)
- iii. All dimensions are in millimeters unless otherwise stated. (Only on drawings drawn in millimeters)

3.9 General Notes

Where notes are extensive and apply on several drawings, a General Notes

Drawing shall be provided which consolidates all notes. Deviation from these notes on a particular drawing may be permitted, provided this amendment is shown in the Notes section of the drawing.

Where a General Notes Drawing is used, the first note on each applicable drawing shall contain the following statement: -

“1. FOR GENERAL NOTES, REFER TO DRAWING NO. XXX”

3.10 Drawing Revision

3.10.1 Revision Clouds and Triangles

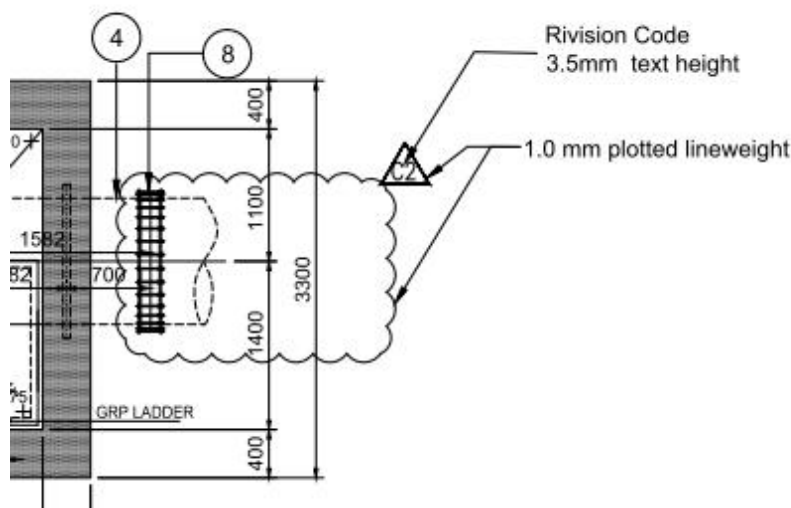
Each area where changes/revisions made since the last issue / submission shall be ringed with a cloud and marked with an equilateral triangle containing the current revision letter.

Revision clouds and its triangle label shall be placed on the paper space. Arc length of cloud shall be 15 as a general rule to maintain consistency.

Revision clouds shall be 1.0mm thick (gray or colour 252) and triangles shall be placed on layer REV.

Clouding and revision triangles denoting the previous revision shall be removed from the CAD file.

Figure 21



3.10.2 Revision Description

The date and description of the revision / issue shall be given in the revision history table on the title frame.

3.10.3 Drawing Revision Code

This code identifies the drawing revision and shall be as defined in Table 11 below. Subsequent issue of a drawing shall have the revision coding incremented by the next sequential number or letter.

Table 9

Revision / Issue Code
R01,R02,R03....etc.

Note:

As drawings move from one stage to another all historical revision history under that stage is to be removed from the revision history on the title block.

3.11 Drawing Register and Transmittal Record

The issue of drawings shall be recorded on the drawing register and a transmittal provided by drawing originators containing like information. The drawing register shall be a concise and continuous record of drawing revisions and issue history.

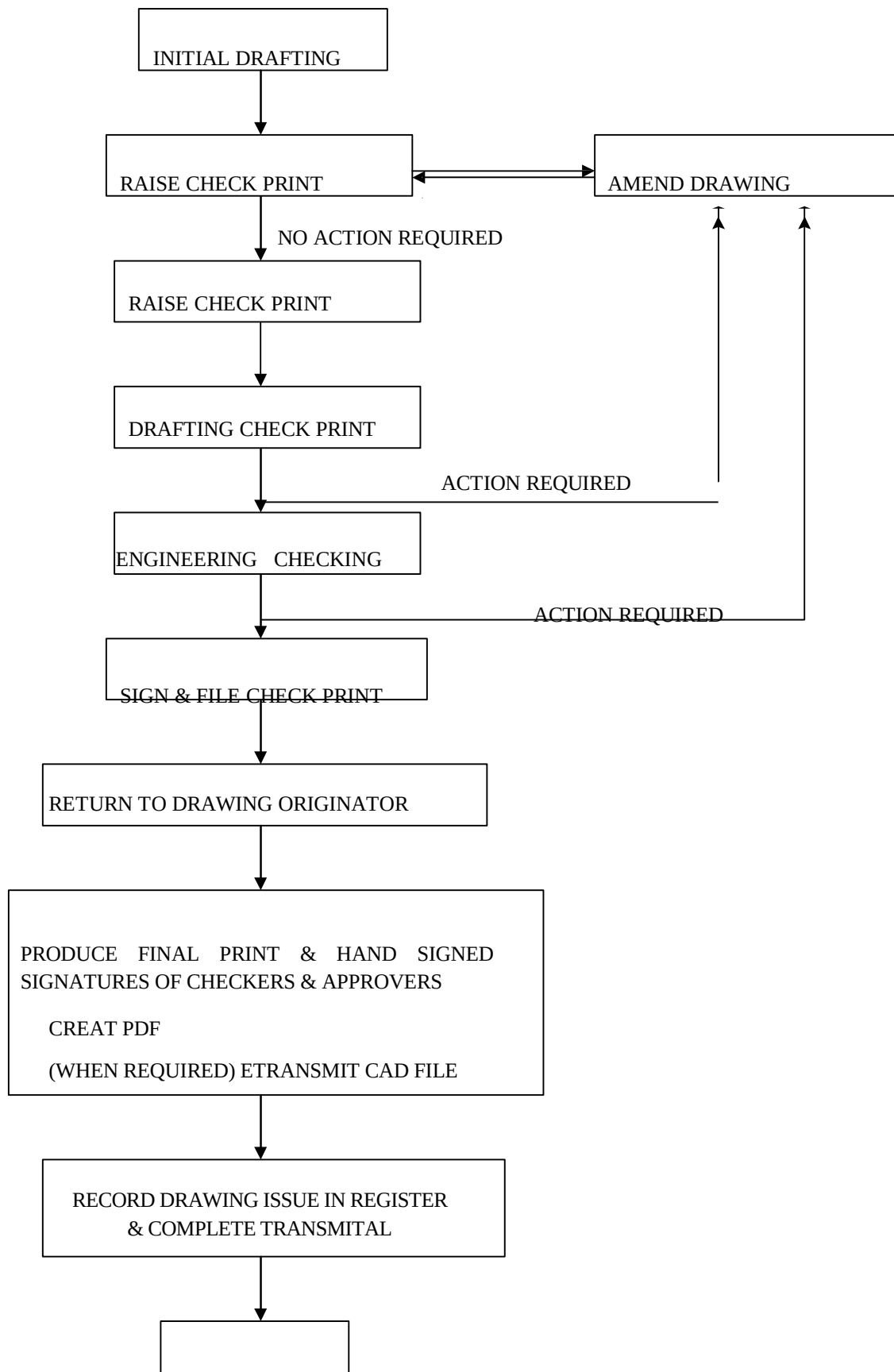
The current revision indicator shall be recorded for each issue.

3.12 Checking and Approval of Drawings

During drawing production a system of continuous checking shall be employed by the PMNC to confirm that all CAD information fully complies with the conditions set out in this document.

It is imperative that all drawings are subjected to a Quality Assurance and Quality Control (QA/QC) check and are duly signed and authorised prior to issue.

Any drawing leaving the drawing office shall have been properly checked for presentation, clarity, accuracy, technical correctness and compliance with the relevant CAD Standard. Refer to the flow chart overleaf in *Figure 22* for an overview of the checking procedure.

Figure 22: Flow diagram showing overview of CAD drawing checking procedure

3.12.1 Self Check

After preparation, the drawing shall be checked by the drawing originator and any required amendment to the drawing is to be carried out prior to handing over the check print for checking.

3.12.2 Drafting Check

Generally, the Drafting Check must precede the Engineering Check.

The Drafting Check will normally be carried out by a person designated by the CAD Office representative/Manager.

The Drafting Check shall verify adherence to the Project Brief in conjunction with any applicable supplied criteria. The checker shall also make an assessment with respect to presentation, standard of workmanship and adherence to the CAD Standard Manual.

The Drafting Check shall, where deemed necessary, include an electronic check of the CAD File to ensure compliance with applicable standards and/or client requirements.

The check print shall be clearly marked by the checker with any required modifications.

Upon completion of the Drafting Check the checker shall then sign, date and highlight the required action to be taken.

Any amendment to the drawing requirements may, if required, be carried out prior to the Engineering Check and a new print raised, duly stamped and signed.

3.12.3 Engineering Check

The Engineering check will normally be carried out by a competent and relevant experienced Senior Engineer within the PMNC's organization.

The Engineering check shall verify adherence to the design calculations, design standards and associated construction issues.

Upon completion of the Engineering Check, the checker shall then sign, date and highlight the required action to be taken.

3.12.4 Further drawing amendments

Upon completion of the Drafting Check and Engineering Check the completed check print shall be returned to the originator of the drawing for amendment of the drawing.

Where required, further check prints shall be raised and the checks repeated.

3.12.5 Approval

Upon completion of the checking process, a clean print of the drawing shall be submitted to the relevant checkers for signature and to the designated authority for approval. This then becomes the controlled drawing for reference. The checker's and approver's initials together with the relevant dates shall be entered in the appropriate areas of the CAD file.

4.1 Drawing set up

- i. All AutoCAD drawings should be produced & saved in AutoCAD version not lower than 2009.
- ii. Pre-defined project drawing templates will be used for setting the layers of identifiable drawings (e.g. drainage, roads).
- iii. Units in AutoCAD shall be set to meters for Infrastructure layouts and profiles and millimeters for detail drawings such as standard details.
- iv. The CAD files provided will be in the current version of AutoCAD file format used on the project.
- v. Fonts and line types are to be followed as provided in this manual.
- vi. Files shall be purged before issue only.
- vii. Drawing features/entities must be in model space. Title frames must be in paper space.
- viii. The colour and line type of each entity is drawn on BYLAYER.
- ix. All polygons shall be closed polylines.
- x. Do not place entities on layer 0. This layer is for the creation of blocks only.

4.2 Line Work

4.2.1 Line Types

The following guidelines shall apply to the use of line types:

- i. LINETYPE to be set BYLAYER. (Deviation: Standard AutoCAD Blocks)
- ii. All layers shall have their entities set to 'BYLAYER'
- iii. All colours of AutoCAD objects to be BYLAYER. (Deviation: Standard AutoCAD Blocks)

- iv. The plotted appearance of line types shall be consistent across all drawings.
- v. Modification of AutoCAD default source file is not permitted.
- vi. Lines on a drawing that cannot be represented by those in the default AutoCAD source file may be loaded from the approved Custom line types provided.

4.2.2 Line Weights

Table 10

Colour No.	Display Screen Color	Plotted Line Weight	Plotted Colour	
			SBIA_COL_ A1.CTB	SBIA_BW _A1.CTB
1	RED	0.18	BLACK	BLACK
2	Yellow	0.25	BLACK	BLACK
3	Green	0.35	BLACK	BLACK
4	Cyan	0.50	BLACK	BLACK
5	Blue	0.70	BLACK	BLACK
6	Magenta	0.35	BLACK	BLACK
7	White	0.25	BLACK	BLACK
8	Dark Grey	0.20	Object Colour	BLACK
9	Light Grey	0.15	Object Colour	BLACK
10	Object Colour	0.6	Object Colour	BLACK
11-79 & 81-249	Object Colour	0.35	Object Colour	BLACK
80	Object Colour	0.6	Object Colour	BLACK
250-255 (Greys)	Object Colour	0.15	Object Colour	Object Colour

4.3 Text

4.3.1 General

- i. The AutoCAD Styles shall have a default height setting = 0.
- ii. Sloping, italic, and elaborate fonts are not permitted.
- iii. The objective shall be to make all lettering highly legible so that information can be communicated with the minimal possibility of error in reading. Lettering sizes shall be chosen such that it shall remain legible when drawings are reduced to A3 size.
- iv. Lettering shall be consistent, both in size and placement. Lettering sizes for specific applications, such as notes or titles, shall not vary within the same drawing.
- v. Lettering shall be uniform, clear, sharp and distinct. The mixing of lettering styles, sloping, italic, and elaborate fonts shall not be permitted.
- vi. All text shall be regularly spaced, upright and uppercase and not be underlined.
Deviation: Titles under plans, details etc. are to be underlined.

- vii. All text shall be left justified. Deviation: Titles shall be centre justified and underlined.
- viii. Specific notations shall be carefully placed so they relate to the portion of the drawing or detail to which they apply.
- ix. The placing of notes through drawing lines is to be avoided.
- x. Leader arrows relating to specific text or annotation shall be placed in model space with the detail it is referencing on the same layer as the text to which it relates.

4.3.2 Fonts

Permitted text fonts are as shown below:

Table 11

AutoCAD Style Name	AutoCAD Font File	CAD Usage
ISOCAP	ISOCAP.SHX	Technical/Engineering drawings
ARIAL	ARIAL.TTF	Presentation Drawings

4.3.3 Text Assignments

The table below indicates approved texts with their appropriate colour/application assignments:

Table 12

Plotted Text Height (mm)	Width Factor	Plotted Line weight	Usage
1.8	1	0.18	General text, Dimensions, Notes – used on A3 & A4 only where drawing is not plotted at a reduced scale.
2.5	1	0.25	General text annotations, Dimensions, Notes Special Notes
3.5	1	0.35	For more prominent notes or labels requiring special emphasis.
5.0	1	0.5	Normal Titles, Drawing Numbers, Section titles.
7.0	1	0.7	Major Titles

- The preferred text height for general text and notes is 2.5mm.
- ii. The text height adopted for a project shall be consistent across all drawings unless situations make this impractical.

4.4 Dimensioning

Automated dimensioning commands within CAD software programs shall be used for creation and editing of dimensions, as shown in table 16 below.

The editing of dimension values via basic text editing commands is not permitted. Dimensions shall be associative and placed on their own unique layer.

Table 13

Dimension Text	Extension Line Offset	Extension Line Extension	Stack Offset	Arrow Size	Centre Mark
2.5mm	Dimexo = 2	Dimexe = 2	Dimdli = 6.25	Dimasz = 2.5	Dimcen = 1

4.5 Standard Symbols and Blocks

In order to promote consistency, standard symbols shall be utilized. All blocks are to be inserted into the drawing on its appropriate drawing layer. Where a symbol required is not available from the blocks provided with this manual, symbols compliant to International standards shall be used. These new blocks shall be submitted to PMNC to update the list of standard symbols library for the programme.

All symbols shall be consistent within a drawing or set of drawings.

All blocks that need to be created as new blocks shall have all their elements saved on layer 0.

All symbols used within a drawing must be defined using a legend.

4.6 Hatching

Wherever possible, all hatching created shall be associative and placed on its own unique layer. Exploding of hatches must be avoided.

4.7 Colours

In AutoCAD, entity colour shall be assigned “By Layer”. Deviation can be on standard blocks, i.e. are Road signs blocks where specific standard colours are assigned for each.

4.8 Layering

CAD Layering shall be in accordance with PMNC AutoCAD Layering Standards as included in Appendix A of this document.

Additional layers may be required and the naming of such layers must be in the same format in accordance with PMNC AutoCAD Layering Standards as shown in Section

4.8.1 Layer Name Layout

Where new layers are to be created the AutoCAD layer naming convention is as follows:

1 2 3
RD_EX_CNRL

Where:

1 = Department Designator
2 = Status / Section Designator
3 = Feature / Entity Designator

Department Designator (Field 1)

This code identifies the PMNC Department (i.e. B = Building Affairs, D = Drainage Affairs and RD = Roads Affairs.)

Status / Section Designator (Field 2)

This code identifies the main classification of the type of element within a discipline. For example ‘EX_SEW’ describes as existing sewer.

Feature / Entity Designator (Field 3)

This code further identifies the entity description feature name. For example ‘ABD’ describes as the abandoned sewerage network.

4.8.2 List of PMNC Standard Layers

See Appendix A.

4.9 Models/Reference Files (Drefs)

- i. Where CAD data is to be shared between drawings the use of reference files is to be adopted.

- ii. All reference files are to be inserted in model space with the UCS set to 'world'. All files are to be inserted at 0,0,0.
- iii. Unused reference files shall be detached upon completion of drawings.
- iv. The number of reference files on a project shall be kept to a minimum.
- v. The preferred method of attaching Drefs shall be Overlay option.
- vi. Reference files shall be inserted on unique layer that does not conflict with the general content of the drawing. (i.e. layer Z_DREF in AutoCAD).
- vii. Reference files shall be "CLIPPED" within the Active drawing sheet file to ensure that only the design data relevant to the drawing is displayed.
- viii. Reference files issued externally or shared between departments shall indicate revised areas with a revision cloud and triangle. A revision history shall be maintained within the reference file. In AutoCAD, the revision history log shall be placed in paper space, see Figure 29 below.
- ix. For Model File Naming refer to Section 3.2

4.10 Plotting

The following standard colour source files shall be used:

Table 14

Colour	Black and White
Aarvee-SBIA--COL_A1.CTB	Aarvee-SBIA-BW_A1.CTB

This standard colour source file shall be flexible and can be adjusted to suit user's need during plotting. When drawing files are required, CTB file used for the plotting of the drawing must also be submitted.

4.10.1 Date and File location update

These are field entities contained within the drawing border and are used to print the date and time of print, file location, file name, etc.

Figure 23

CAD REF: Z:\PROJECT\AITL\SIA\DRF\AARVEE-SIA-A1-TITLE-DEC 2014.dwg Last saved: 15 Dec 2014 11:45 AM

4.11 Data Submission Standards

All drawing files must conform to the AutoCAD layering standards set forth in this document.

4.11.1 Submission

Refer to Programme Management Information System (PMIS) and Document Management procedures on submission of drawing.

4.11.2 File Format

Digital submittals shall be in PDF format & CAD format. DWG files must be in ZIP format when submitted in soft copy in CD. Also refer to Document Management Procedures for submission of document.

Appendix A – AUTOCAD LAYERS DEFINITIONS

A.1 General Layers

CORE LAYERS NON DISCIPLINE				
Layer Name	Screen Colour	Line type	Plotted Line weight	Description
Z_18TEXT	red	Continuous	0.18	TEXT AT RESPECTIVE HEIGHT
Z_25TEXT	white	Continuous	0.25	TEXT AT RESPECTIVE HEIGHT
Z_35TEXT	green	Continuous	0.35	TEXT AT RESPECTIVE HEIGHT
Z_50TEXT	cyan	Continuous	0.50	TEXT AT RESPECTIVE HEIGHT
Z_70TEXT	blue	Continuous	0.70	TEXT AT RESPECTIVE HEIGHT
Z_DIMS	red	Continuous	0.18	ALL DIMENSIONS
Z_DWG_GRID	251	Continuous	0.15	DESIGN ROAD FEATURE : GRID
Z_DWG_SHT	white	Continuous	0.25	DRAWING SHEET & TITLE BLOCK
Z_NORTH	green	Continuous	0.35	NORTH POINT
Z_REV	yellow	Continuous	0.25	REVISION CLOUD SAND TRIANGLE
Z_SECMK	green	Continuous	0.35	SECTION AND DETAIL MARKS
Z_XREF	white	Continuous	0.25	EXTERNAL REFERENCE (XREF)

GIS LAYERS				
Layer Name	Screen Colour	Line type	Plotted Line weight	Description
GIS_ACQ_BDRY	20	ACAD_ISO13W100	0.25	LAND AQUISITION BOUNDARY
GIS_CADASTRAL	red	Continuous	0.18	CADASTRAL PLOT

GIS LAYERS				
Layer Name	Screen Colour	Line type	Plotted Line weight	Description
GIS_CNTRS	9	Continuous	0.15	CONTOURS
GIS_CNTRS_TEXT	red	Continuous	0.18	CONTOURS TEXT
GIS_CSTL	90	Continuous	0.35	COASTLINE
GIS_FLOWLINE	8	Continuous	0.20	FLOWLINES
GIS_PPLN	252	Continuous	0.15	POLICY PLAN
GIS_RD01	121	Continuous	0.35	MAJOR ROAD
GIS_RD02	151	Continuous	0.35	MINOR ROAD
GIS_RD03	181	Continuous	0.35	STREETS
GIS_ROW_BDRY	170	PHANTOM2	0.35	PROPOSED RIGHT OF WAY BOUNDARY
GIS_ZONE	13	Continuous	0.35	ZONE

A.2 Drainage layers

A.2.1 Surface Ground Water

PROPOSED SURFACE GROUND WATER (SGW)				
Layer Name	Screen Colour	Line type	Plotted Line weight	Description
D_PR_SGW	80	SGW_PR	0.6	PROPOSED SURFACE GROUND WATER LINES
D_PR_SGW_ATT	white	Continuous	0.25	PROPOSED SGW ATTRIBUTES (ID, Diameter, Length, Material etc.)

PROPOSED SURFACE GROUND WATER (SGW)				
Layer Name	Screen Colour	Line type	Plotted Line weight	Description
D_PR_SGW_DCH	90	Continuous	0.35	PROPOSED SGW DISCHARGE CHAMBER
D_PR_SGW_DT	yellow	Continuous	0.25	PROPOSED SGW DRAIN TRENCH
D_PR_SGW_FCH	90	Continuous	0.35	PROPOSED SGW FLUSHING CHAMBER
D_PR_SGW_FLOW	white	Continuous	0.25	PROPOSED SGW FLOW ARROW
D_PR_SGW_FMC	90	Continuous	0.35	PROPOSED SGW FLOWMETER CHAMBER
D_PR_SGW_GC	90	Continuous	0.35	PROPOSED SGW GULLY CONNECTION
D_PR_SGW_GL	90	Continuous	0.35	PROPOSED SGW GULLY
D_PR_SGW_ICH	90	Continuous	0.35	PROPOSED SGW INSPECTION CHAMBER
D_PR_SGW_ITCH	90	Continuous	0.35	PROPOSED SGW INTAKE CHAMBER
D_PR_SGW_MH	90	Continuous	0.35	PROPOSED SGW MANHOLE
D_PR_SGW_MH_ATT	white	Continuous	0.25	PROPOSED SGW MANHOLE ATTRIBUTES (ID, Depth, Cov. Lvl, Inv. Lvl, etc)
D_PR_SGW_OFCH	90	Continuous	0.35	PROPOSED SGW OUTFALL CHAMBER
D_PR_SGW_PS	90	Continuous	0.35	PROPOSED SGW PUMP STATION
D_PR_SGW_RM	90	RM_PR	0.35	PROPOSED SGW RISING MAIN
D_PR_SGW_VALV	90	Continuous	0.35	PROPOSED SGW VALVE
D_PR_SGW_VC	90	Continuous	0.35	PROPOSED SGW VALVE CHAMBER
D_PR_SGW_WCH	90	Continuous	0.35	PROPOSED SGW WASHOUT CHAMBER

EXISTING SURFACE GROUND WATER (SGW)				
Layer Name	Screen Colour	Line type	Plotted Line weight	Description
D_EX_SGW	96	SGW_EX	0.35	EXISTING SURFACE GROUND WATER LINES
D_EX_SGW_ATT	white	Continuous	0.25	EXISTING SGW ATTRIBUTES (ID, Diameter, Length, Material etc)
D_EX_SGW_DCH	96	Continuous	0.35	EXISTING SGW DISCHARGE CHAMBER
D_EX_SGW_DT	yellow	Continuous	0.25	EXISTING SGW DRAIN TRENCH
D_EX_SGW_FCH	96	Continuous	0.35	EXISTING SGW FLUSHING CHAMBER
D_EX_SGW_FLOW	white	Continuous	0.25	PROPOSED SGW FLOW ARROW
D_EX_SGW_FMC	96	Continuous	0.35	EXISTING SGW FLOWMETER CHAMBER
D_EX_SGW_GC	96	HIDDEN2	0.35	EXISTING SGW GULLY CONNECTION
D_EX_SGW_GL	96	Continuous	0.35	EXISTING SGW GULLY
D_EX_SGW_ICH	96	Continuous	0.35	EXISTING SGW INSPECTION CHAMBER
D_EX_SGW_ITCH	96	Continuous	0.35	EXISTING SGW INTAKE CHAMBER
D_EX_SGW_MH	96	Continuous	0.35	EXISTING SGW MANHOLE
D_EX_SGW_MH_ATT	96	Continuous	0.35	EXISTING SGW MANHOLE ATTRIBUTES (ID, Depth, Cov. Lvl, Inv. Lvl, etc)
D_EX_SGW_OFCH	96	DASHED2	0.25	EXISTING SGW OUTFALL CHAMBER
D_EX_SGW_PS	96	Continuous	0.35	EXISTING SGW PUMP STATION
D_EX_SGW_RM	96	RM_EX	0.35	EXISTING SGW RISING MAIN
D_EX_SGW_VALV	96	Continuous	0.35	EXISTING SGW VALVE

EXISTING SURFACE GROUND WATER (SGW)				
Layer Name	Screen Colour	Line type	Plotted Line weight	Description
D_EX_SGW_VC	96	Continuous	0.25	EXISTING SGW VALVE CHAMBER
D_EX_SGW_WCH	96	Continuous	0.25	EXISTING SGW WASHOUT CHAMBER

A.2.2 Domestic Sewage Water

PROPOSED DOMESTIC SEWAGE LINE				
Layer Name	Screen Colour	Line type	Plotted Line weight	Description
SEW_DE_PSWR	242	SEW_PR	0.35	DESIGN SEWER FEATURE: PROPOSED SEWER LINES
SEW_DE_MH	242	Continuous	0.25	DESIGN SEWER FEATURE: MANHOLE
SEW_DE_SWPS	242	Continuous	0.25	DESIGN SEWER FEATURE: SEWAGE PUMPING STATION
SEW_DE_VSHFT	242	Continuous	0.25	DESIGN SEWER FEATURE: VENT SHAFT
SEW_DE_SCONN	242	Continuous	0.25	DESIGN SEWER FEATURE: SEWER CONNECTION
SEW_DE_MHFC	242	Continuous	0.25	DESIGN SEWER FEATURE: MANHOLE FRAME & COVER
SEW_DE_STP	242	Continuous	0.25	DESIGN SEWER FEATURE: SEWAGE TREATMENT PLANT
SEW_DE_PM	242	Continuous	0.25	DESIGN SEWER FEATURE: SEWAGE PUMPING MAIN

A.2.4 Potable Water

PROPOSED POTABLE WATER LINE				
Layer Name	Screen Colour	Line type	Plotted Line weight	Description
PW_DE_PWTM	Blue	Continuous	0.35	DESIGN POTABLE WATER FEATURE: POTABLE WATER TRANSMISSION MAIN
PW_DE_PWDIST	Blue	Continuous	0.25	DESIGN POTABLE WATER FEATURE: POTABLE WATER DISTRIBUTION
PW_DE_PWPS	Blue	Continuous	0.25	DESIGN POTABLE WATER FEATURE: POTABLE WATER PUMPING STATION
PW_DE_VCH	Blue	Continuous	0.25	DESIGN POTABLE WATER FEATURE: VALVE CHAMBER
PW_DE_FH	Blue	Continuous	0.25	DESIGN POTABLE WATER FEATURE: FIRE HYDRANT
PW_DE_POTRES	Blue	Continuous	0.25	DESIGN POTABLE WATER FEATURE: POTABLE WATER RESERVOIR
PW_DE_PWM	Blue	Continuous	0.25	DESIGN POTABLE WATER FEATURE: POTABLE WATER METER
PW_DE_PWFIT	Blue	Continuous	0.25	DESIGN POTABLE WATER FEATURE:

A.2.5 Recycled Water

PROPOSED RECYCLED WATER				
Layer Name	Screen Colour	Line type	Plotted Line weight	Description
RW_DE_RWPM	Green	Continuous	0.35	DESIGN RECYCLED WATER FEATURE: RECYCLED WATER PUMPING MAIN
RW_DE_RWDIST	Green	Continuous	0.025	DESIGN RECYCLED WATER FEATURE: RECYCLED WATER DISTRIBUTION

RW_DE_RWPS	Green	Continuous	0.025	DESIGN RECYCLED WATER FEATURE: RECYCLED WATER PUMPING STATION
RW_DE_RWRES	Green	Continuous	0.025	DESIGN RECYCLED WATER FEATURE: RECYCLED WATER RESERVOIR
RW_DE_RWVCH	Green	Continuous	0.025	DESIGN RECYCLED WATER FEATURE: RECYCLED WATER VALVE CHAMBER
RW_DE_RWFIT	Green	Continuous	0.025	DESIGN RECYCLED WATER FEATURE: RECYCLED WATER

A.3 ROAD LAYERS

A.3.1 Road Design Layers

PROPOSED ROAD				
Layer Name	Screen Colour	Line type	Plotted Line weight	Description
RD_DE_AFNCE	22	FENCELINE1	0.35	DESIGN ROAD FEATURE: ANIMAL FENCE
RD_DE_BICYL	green	Continuous	0.35	BICYCLE LANE

PROPOSED ROAD				
Layer Name	Screen Colour	Line type	Plotted Line weight	Description
RD_DE_BRDG	yellow	Continuous	0.25	DESIGN ROAD FEATURE: BRIDGE FLYOVER
RD_DE_CHNL	red	HIDDEN2	0.18	DESIGN ROAD FEATURE: CHANNEL
RD_DE_CILND	green	Continuous	0.35	DESIGN ROAD FEATURE: CENTRAL/ROUNDAABOUT ISLAND
RD_DE_CLMN	red	Continuous	0.18	DESIGN ROAD FEATURE: COLUMN

RD_DE_CLVT	white	Continuous	0.25	DESIGN ROAD FEATURE : CULVERT
RD_DE_CNRL	red	CENTER2	0.18	DESIGN ROAD FEATURE: CENTERLINE
RD_DE_CSLPE	magenta	Continuous	0.35	DESIGN ROAD FEATURE: CONCRETE SLOPE PROTECTION
RD_DE_ECWAY	cyan	Continuous	0.5	DESIGN ROAD FEATURE: EDGE OF CARRIAGEWAY
RD_DE_FNCE	green	FENCELINE2	0.35	DESIGN ROAD FEATURE: FENCE
RD_DE_FTPH	11	Continuous	0.35	DESIGN ROAD FEATURE: FOOTPATH
RD_DE_GRAIL	white	Continuous	0.25	DESIGN ROAD FEATURE: GUARD RAIL
RD_DE_ILND	green	HIDDEN2	0.35	DESIGN ROAD FEATURE: ISLAND
RD_DE_JILND	green	Continuous	0.35	DESIGN ROAD FEATURE: JUNCTION ISLAND
RD_DE_KBDD	green	HIDDEN2	0.35	DESIGN ROAD FEATURE : DROPPED KERB
RD_DE_KBED	white	Continuous	0.25	DESIGN ROAD FEATURE: EDGE KERB
RD_DE_KBFL	yellow	DASHED2	0.25	DESIGN ROAD FEATURE: FLUSH KERB
RD_DE_KBRD	cyan	Continuous	0.5	DESIGN ROAD FEATURE: RAISED KERB

PROPOSED ROAD				
Layer Name	Screen Colour	Line type	Plotted Line weight	Description
RD_DE_LOW	blue	DASHDOT2	0.7	LIMIT OF WORKS
RD_DE_EMBK	yellow	Continuous	0.25	DESIGN ROAD FEATURE: EMBANKMENT
RD_DE_MEDIAN	green	Continuous	0.35	DESIGN ROAD FEATURE: MEDIAN

RD_DE_OTHR	red	Continuous	0.18	DESIGN ROAD DATA : OTHER
RD_DE_PBAY	green	Continuous	0.35	DESIGN ROAD FEATURE: PARKING BAY
RD_DE_PDCR	8	Continuous	0.2	DESIGN ROAD FEATURE: PEDESTRIAN
RD_DE_PRAMP	green	Continuous	0.35	DESIGN ROAD FEATURE: PEDESTRIAN
RD_DE_PRKG	white	Continuous	0.25	DESIGN ROAD FEATURE: PARKING
RD_DE_PTS	yellow	Continuous	0.25	DESIGN ROAD DATA : IPS, CURVE POINTS
RD_DE_PVMT	8	Continuous	0.2	DESIGN ROAD FEATURE: PAVEMENT
RD_DE_RAILWAY	white	TRACKS	0.25	DESIGN ROAD FEATURE: RAILWAY
RD_DE_RAMP	yellow	Continuous	0.25	DESIGN ROAD FEATURE: RAMP
RD_DE_RLVL	white	Continuous	0.25	DESIGN ROAD FEATURE: ROAD LEVEL
RD_DE_RNDA	white	Continuous	0.25	DESIGN ROAD FEATURE: ROUND ABOUT
RD_DE_RSTL	white	Continuous	0.25	DESIGN ROAD FEATURE: ROAD SPEED
RD_DE_SHLDR	green	Continuous	0.35	DESIGN ROAD FEATURE: SHOULDER
RD_DE_SPTR	20	Continuous	0.35	DESIGN ROAD FEATURE: ROAD SEPARATOR

PROPOSED ROAD				
Layer Name	Screen Colour	Line type	Plotted Line weight	Description
RD_DE_UPSS	yellow	Continuous	0.25	DESIGN ROAD FEATURE: UNDERPASS TUNNEL

RD_DE_URAREA	40	DASHED2	0.35	DESIGN ROAD FEATURE: UTILITY RESERVE AREA
RD_DE_VBAR	magenta	Continuous	0.35	DESIGN ROAD FEATURE: VEHICLE BARRIER
RD_DE_VERGE	yellow	Continuous	0.25	DESIGN ROAD FEATURE: VERGE

EXISTING ROAD				
Layer Name	Screen Colour	Line type	Plotted Line weight	Description
RD_EX_AFNCE	22	FENCELINE1	0.35	EXISTING ROAD FEATURE: ANIMAL FENCE
RD_EX_BICYL	green	Continuous	0.35	BICYCLE LANE
RD_EX_BRDG	yellow	Continuous	0.25	EXISTING ROAD FEATURE: BRIDGE FLYOVER
RD_EX_CHNL	red	HIDDEN2	0.18	EXISTING ROAD FEATURE: CHANNEL
RD_EX_CILND	green	Continuous	0.35	EXISTING ROAD FEATURE: CENTRAL/ROUNDAABOUT ISLAND
RD_EX_CLMN	red	Continuous	0.18	EXISTING ROAD FEATURE: COLUMN
RD_EX_CLVT	white	Continuous	0.25	EXISTING ROAD FEATURE : CULVERT
RD_EX_CNRL	red	CENTER2	0.18	EXISTING ROAD FEATURE: CENTERLINE

EXISTING ROAD				
Layer Name	Screen Colour	Line type	Plotted Line weight	Description
RD_EX_CSLPE	magenta	Continuous	0.35	EXISTING ROAD FEATURE: CONCRETE SLOPE PROTECTION
RD_EX_ECWAY	cyan	Continuous	0.5	EXISTING ROAD FEATURE: EDGE OF CARRIAGEWAY
RD_EX_FNCE	green	FENCELINE2	0.35	EXISTING ROAD FEATURE: FENCE
RD_EX_FTPH	11	Continuous	0.35	EXISTING ROAD FEATURE: FOOTPATH
RD_EX_GRAIL	white	Continuous	0.25	EXISTING ROAD FEATURE: GUARD RAIL
RD_EX_ILND	green	HIDDEN2	0.35	EXISTING ROAD FEATURE: ISLAND
RD_EX_JILND	green	Continuous	0.35	EXISTING ROAD FEATURE: JUNCTION ISLAND
RD_EX_KBDD	green	HIDDEN2	0.35	EXISTING ROAD FEATURE : DROPPED KERB
RD_EX_KBED	white	Continuous	0.25	EXISTING ROAD FEATURE: EDGE KERB
RD_EX_KBFL	yellow	DASHED2	0.25	EXISTING ROAD FEATURE: FLUSH KERB
RD_EX_KBRD	cyan	Continuous	0.5	EXISTING ROAD FEATURE: RAISED KERB
RD_EX_LOW	blue	DASHDOT2	0.7	LIMIT OF WORKS
RD_EX_EMBK	yellow	Continuous	0.25	EXISTING ROAD FEATURE: EMBANKMENT
RD_EX_MEDIAN	green	Continuous	0.35	EXISTING ROAD FEATURE: MEDIAN
RD_EX_OTHR	red	Continuous	0.18	EXISTING ROAD DATA : OTHER INFORMATION
RD_EX_PBAY	green	Continuous	0.35	EXISTING ROAD FEATURE: PARKING BAY

RD_EX_PDCR	8	Continuous	0.2	EXISTING ROAD FEATURE: PEDESTRIAN CROSSING

EXISTING ROAD				
Layer Name	Screen Colour	Line type	Plotted Line weight	Description
RD_EX_PRAMP	green	Continuous	0.35	EXISTING ROAD FEATURE: PEDESTRIAN RAMP
RD_EX_PRKG	white	Continuous	0.25	EXISTING ROAD FEATURE: PARKING
RD_EX_PTS	yellow	Continuous	0.25	EXISTING ROAD DATA : IPS, CURVE POINTS ETC
RD_EX_PVMT	8	Continuous	0.2	EXISTING ROAD FEATURE: PAVEMENT (BITUMINOUS, CONCRETE ETC.)
RD_EX_RAILWAY	white	TRACKS	0.25	EXISTING ROAD FEATURE: RAILWAY
RD_EX_RAMP	yellow	Continuous	0.25	EXISTING ROAD FEATURE: RAMP
RD_EX_RLVL	white	Continuous	0.25	EXISTING ROAD FEATURE: ROAD LEVEL
RD_EX_RNDA	white	Continuous	0.25	EXISTING ROAD FEATURE: ROUND ABOUT
RD_EX_RSTL	white	Continuous	0.25	EXISTING ROAD FEATURE: ROAD SPEED TABLE
RD_EX_SHLDR	green	Continuous	0.35	EXISTING ROAD FEATURE: SHOULDER
RD_EX_SPTR	20	Continuous	0.35	EXISTING ROAD FEATURE: ROAD SEPARATOR
RD_EX_UPSS	yellow	Continuous	0.25	EXISTING ROAD FEATURE: UNDERPASS TUNNEL

RD_EX_URAREA	40	DASHED2	0.35	EXISTING ROAD FEATURE: UTILITY RESERVE AREA
RD_EX_VBAR	magenta	Continuous	0.35	EXISTING ROAD FEATURE: VEHICLE BARRIER
RD_EX_VERGE	yellow	Continuous	0.25	EXISTING ROAD FEATURE: VERGE

A.3.3 Street Lighting Layers

STREET LIGHTING - PROPOSED				
Layer Name	Screen Colour	Line type	Plotted Line weight	Description
RD_DE_ST_CBLE	cyan	Continuous	0.5	STREET LIGHTING CABLE

STREET LIGHTING - PROPOSED				
Layer Name	Screen Colour	Line type	Plotted Line weight	Description
RD_DE_ST_DUCT	20	Continuous	0.35	STREET LIGHTING DUCT
RD_DE_ST_FDPL	magenta	Continuous	0.35	STREET LIGHTING FEEDER PILLAR
RD_DE_ST_POLE	yellow	Continuous	0.25	STREET LIGHTING POLE
RD_DE_ST_SUBSTN	cyan	Continuous	0.5	STREET LIGHTING SUBSTATION
RD_DE_ST_TEXT	white	Continuous	0.25	STREET LIGHTING ANNOTATION/TEXT

STREET LIGHTING - EXISTING				
Layer Name	Screen Colour	Line type	Plotted Line weight	Description

RD_EX_ST_CBLE	cyan	DASHED2	0.5	STREET LIGHTING CABLE
RD_EX_ST_DUCT	20	HIDDEN2	0.35	STREET LIGHTING DUCT
RD_EX_ST_FDPL	magenta	Continuous	0.35	STREET LIGHTING FEEDER PILLAR
RD_EX_ST_POLE	8	Continuous	0.25	STREET LIGHTING POLE
RD_EX_ST_SUBSTN	cyan	Continuous	0.5	STREET LIGHTING SUBSTATION
RD_EX_ST_TEXT	white	Continuous	0.25	STREET LIGHTING ANNOTATION/TEXT

A.3.4 Road Furniture Layers

ROAD FURNITURE LAYERS				
Layer Name	Screen Colour	Line type	Plotted Line weight	Description
RD_F_BNCH	yellow	Continuous	0.25	ROAD/STREET FURNITURE: BENCH/SEAT
RD_F_LGHT	white	Continuous	0.25	ROAD/STREET FURNITURE: LIGHTING
RD_F_OTHR	white	Continuous	0.25	ROAD/STREET FURNITURE: OTHERS
RD_F_POLE	yellow	Continuous	0.25	ROAD/STREET FURNITURE: POLE
RD_F_TEXT	white	Continuous	0.25	ROAD/STREET FURNITURE: ANNOTATION/TEXT

A.3.5 Roads – Common Layers

(ROADS) - COMMON LAYERS				
Layer Name	Screen Colour	Line type	Plotted Line weight	Description
RD_C_25DASH	white	DASHED2	0.25	HIDDEN DETAILS
RD_C_25HID	white	HIDDEN2	0.25	HIDDEN DETAILS
RD_C_50OUT	cyan	Continuous	0.5	ALL CONCRETE OUTLINES IN SECTION
RD_C_50REBARS	cyan	Continuous	0.5	REINFORCEMENTDETAILS
RD_C_CHAIN_TEXT	white	Continuous	0.25	CHAINAGE TEXT
RD_C_CHAIN_TICK	yellow	Continuous	0.25	CHAINAGE TICK MARK
RD_C_CONT_MAJR	8	Continuous	0.2	MAJOR CONTOUR

(ROADS) - COMMON LAYERS				
Layer Name	Screen Colour	Line type	Plotted Line weight	Description
RD_C_CONT_MINR	9	Continuous	0.15	MINOR CONTOUR
RD_C_COORD_GRID	252	Continuous	0.15	COORDINATE GRID
RD_C_CTRLINE	red	CENTER2	0.18	CENTRE LINE
RD_C_HATCH	red	Continuous	0.18	HATCH
RD_C_MATCH_LINE	blue	PHANTOM	0.7	SHEET CONTINUATION MATCH LINE
RD_C_PROF	cyan	DASHED2	0.5	PROFILES
RD_C_PROF-LINE	green	Continuous	0.35	PROFILE LINES
RD_C_PROF_GRID_MAJ R	8	Continuous	0.2	PROFILE GRIDLINE @ MAJOR STATIONS
RD_C_PROF_GRID_MIN OR	9	Continuous	0.15	PROFILE GRIDLINE @ MINOR STATIONS
RD_C_SPT_HGT	yellow	Continuous	0.25	SURVEY ROAD FEATURE : SPOT HEIGHT MARKER && TEXT
RD_C_SPT_NUM	yellow	Continuous	0.25	SURVEY ROAD FEATURE : SURVEY POINT NUMBER
RD_C_TABLE	white	Continuous	0.25	TABLES
RD_C_TEXT	white	Continuous	0.25	COMMON TEXT

A.3.6 Structures – Common Layers

STRUCTURES				
Layer Name	Screen Colour	Line type	Plotted Line weight	Description
BR_ABT	RED	Continuous	0.3	ABUTMENT
BR_BEARING	GREEN	Continuous	0.25	BEARING
BR_BH	11	Continuous	0.10	HATCH
BR_BR	160	Continuous	0.6	BOUNDARY
BR_CB	9	Continuous	0.25	CRASH BARRIER
BR_CEN	WHITE	Center	0.18	CENTER LINE
BR_DIM	MAGENTA	Continuous	0.18	DIMENSION
BR_DS	200	Continuous	0.18	DRAINAGE SPOUT
BR_GEN	YELLOW	Continuous	0.30	STRUCTURE
BR_HIDDEN	8	HIDDEN	0.15	DOTTED / HIDDEN LINES
BR_MAIN	RED	Continuous	0.35	HEADING TEXT
BR_MARK	CYAN	Continuous	0.15	HAUNCH LINES
BR_PIER	RED	Continuous	0.25	PIER
BR_REINF	BLUE	Continuous	0.35	REINFORCEMENT
BR_TEXT	GREEN	Continuous	0.3	TEXT IN NOTES & DIMENSIONS
BR_TITLE	WHITE	Continuous	0.35	TITLE BLOCK

A.4 UTILITIES LAYERS**A.4.1 Electricity**

(ELECTRICITY)				
Layer Name	Screen Colour	Line type	Plotted Line weight	Description
SVE_11KV	240	ACAD_ISO04W 100	0.35	SERVICES FIXTURES (ELECTRICITY) : 11KV
SVE_132K	240	ACAD_ISO04W 100	0.35	SERVICES FIXTURES (ELECTRICITY) : 132KV
SVE_66KV	240	ACAD_ISO04W 100	0.35	SERVICES FIXTURES (ELECTRICITY) : 66KV
SVE_ABDL	13	Continuous	0.35	SERVICES FIXTURES (ELECTRICITY) : ABANDONED
SVE_DUCT	10	Continuous	0.35	SERVICES FIXTURES (ELECTRICITY) : ELECTRICITY
SVE_ERTH_PIT	8	Continuous	0.2	SERVICES FIXTURES (ELECTRICITY) : EARTH PIT
SVE_FT_TEE	30	Continuous	0.35	SERVICES FIXTURES (ELECTRICITY) : ELECTRICAL
SVE_LOWV	220	Continuous	0.35	SERVICES FIXTURES (ELECTRICITY) : LOW VOLTAGE
SVE_MEDV	150	Continuous	0.35	SERVICES FIXTURES (ELECTRICITY) : MEDIUM
SVE_MHLL	white	Continuous	0.25	SERVICES FIXTURES (ELECTRICITY) : UTILITY/MANHOLE
SVE_MNHL	white	Continuous	0.25	SERVICES FIXTURES (ELECTRICITY) : MANHOLE
SVE_MRKR	white	Continuous	0.25	SERVICES FIXTURES (ELECTRICITY) : MARKER

ELECTRICITY				
Layer Name	Screen Colour	Line type	Plotted Line weight	Description
SVE_OHLL	white	Continuous	0.25	SERVICES FIXTURES (ELECTRICITY) : OVERHEAD LINE
SVE_OTHR	white	Continuous	0.25	SERVICES FIXTURES (ELECTRICITY) : OTHER
SVE_POLE	white	Continuous	0.25	SERVICES FIXTURES (ELECTRICITY) : POST/POLE
SVE_PYLN	white	Continuous	0.25	SERVICES FIXTURES (ELECTRICITY) : PYLON
SVE_SBOX	white	Continuous	0.25	SERVICES FIXTURES (ELECTRICITY) : SERVICE BOX
SVE_SJNT	green	Continuous	0.35	SERVICES FIXTURES (ELECTRICITY) : ELECTRICAL STRAIGHT JOINT
SVE_SSTL	yellow	Continuous	0.25	SERVICES FIXTURES (ELECTRICITY) : SUBSTATION
SVE_TEXT	white	Continuous	0.25	SERVICES FIXTURES (ELECTRICITY): ANNOTATION / TEXT
SVE_TRANSF	cyan	Continuous	0.5	SERVICES FIXTURES (ELECTRICITY) : TRANSFORMER
SVE_UGLL	white	Continuous	0.25	SERVICES FIXTURES (ELECTRICITY) : UNDERGROUND LINE

A.4.2 Water

WATER				
Layer Name	Screen Colour	Line type	Plotted Line weight	Description
SVW_ABDL	13	Continuous	0.35	SERVICES FIXTURES (WATER) : ABANDONED
SVW_BNDL	130	Continuous	0.35	SERVICES FIXTURES (WATER) : BUND
SVW_CLR_PT	200	Continuous	0.35	SERVICES FIXTURES (WATER) : CHLORINATION
SVW_CPRT	200	Continuous	0.35	SERVICES FIXTURES (WATER) : CASING
SVW_DRKL	130	Continuous	0.35	SERVICES FIXTURES (WATER) : DRINKING

WATER				
Layer Name	Screen Colour	Line type	Plotted Line weight	Description
				AREA
SVW_DUCT	30	Continuous	0.35	SERVICES FIXTURES (WATER) : DUCT
SVW_FT_ADPTR	150	Continuous	0.35	SERVICES FIXTURES (WATER) : FITTING ADAPTER
SVW_FT_BEND	150	Continuous	0.35	SERVICES FIXTURES (WATER) : FITTING BEND
SVW_FT_ENDCAP	150	Continuous	0.35	SERVICES FIXTURES (WATER) : FITTING ENDCAP

SVW_FT_RDCR	150	Continuous	0.35	SERVICES FIXTURES (WATER) : FITTING REDUCER
SVW_FT_TEE	150	Continuous	0.35	SERVICES FIXTURES (WATER) : FITTING TEE
SVW_GCHNL	200	Continuous	0.35	SERVICES FIXTURES (WATER) : GRAVITY CHANNEL
SVW_GPIPE	200	Continuous	0.35	SERVICES FIXTURES (WATER) : GRAVITY PIPE
SVW_HYDR	200	Continuous	0.35	SERVICES FIXTURES (WATER) : HYDRANT
SVW_METER	200	Continuous	0.35	SERVICES FIXTURES (WATER) : METER
SVW_MNHL	170	Continuous	0.35	SERVICES FIXTURES (WATER) : MANHOLE
SVW_MRKR	130	Continuous	0.35	SERVICES FIXTURES (WATER) : MARKER
SVW_PIPE	170	Continuous	0.35	SERVICES FIXTURES (WATER) : WATER PIPE LINE
SVW_PUMP	200	Continuous	0.35	SERVICES FIXTURES (WATER) : PUMP
SVW_SCSR	200	Continuous	0.35	SERVICES FIXTURES (WATER) : SCADA SENSOR
SVW_SPIPE	200	Continuous	0.35	SERVICES FIXTURES (WATER) : SERVICE PIPE

WATER				
Layer Name	Screen Colour	Line type	Plotted Line weight	Description
SVW_STRG_PT	200	Continuous	0.35	SERVICES FIXTURES (WATER) : STORAGE POINT
SVW_TANK	230	Continuous	0.35	SERVICES FIXTURES (WATER) : TANK
SVW_TANK_FIL_PT	200	Continuous	0.35	SERVICES FIXTURES (WATER) : TANKER FILLING POINT
SVW_TEXT	white	Continuous	0.25	SERVICES FIXTURES (WATER) : ANNOTATION / TEXT

SVW_VALV	160	Continuous	0.35	SERVICES FIXTURES (WATER) : WATER SLUICE VALVE, AIR VALVE, FLOW CONTROL VALVE, SERVICE VALVE, SYSTEM
SVW_WELL	200	Continuous	0.35	SERVICES FIXTURES (WATER) : WELL
SVW_WFAC	200	Continuous	0.35	SERVICES FIXTURES (WATER) : WATER FACILITY
SVW_WMAIN	170	DASHDOT2	0.35	SERVICES FIXTURES (WATER) : WATER MAIN
SVW_WSCON	200	Continuous	0.35	SERVICES FIXTURES (WATER) : WATER SERVICE CONENCTION

A.4.3 Commercial

COMMERCIAL				
Layer Name	Screen Colour	Line type	Plotted Line weight	Description
SVC_TEXT	white	Continuous	0.25	SERVICE FIXTURES (COMMERCIAL) : ANNOTATION / TEXT
SVC_SBDL	white	Continuous	0.25	SERVICE FIXTURES (COMMERCIAL) : SIGNBOARD

COMMERCIAL				
Layer Name	Screen Colour	Line type	Plotted Line weight	Description
SVC_POLE	white	Continuous	0.25	SERVICE FIXTURES (COMMERCIAL) : POST / POLE
SVC_OTHR	white	Continuous	0.25	SERVICE FIXTURES (COMMERCIAL) : OTHER FEATURES
SVC_BBDL	30	Continuous	0.25	SERVICE FIXTURES (COMMERCIAL) : BILLBOARD
SVC_BANK	white	Continuous	0.25	SERVICE FIXTURES (COMMERCIAL) : ATM AND SIMILAR FEATURES

Appendix B – USEFUL TABLES FOR AUTOCAD

Appendix B - Useful Tables for AutoCAD

Table 1 - Model Space Zoom XP Factors (Meters)

Scale of Drawing	Zoom XP Scale
1 : 1000	1
1 : 1250	0.8
1 : 2500	0.4
1 : 5000	0.2
1 : 10000	0.1
1 : 25000	0.04
1 : 50000	0.02
1 : 500	2
1 : 200	5
1 : 100	10
1 : 50	20
1 : 20	50
1 : 10	100
1 : 5	200
1 : 2	500
1 : 1	1000

Table 2 – Model Space Zoom XP Factors (Millimeters)

Scale of Drawing	Zoom XP Scale
1 : 500	0.002
1 : 200	0.005
1 : 100	0.01
1 : 50	0.02
1 : 20	0.05
1 : 10	0.1
1 : 5	0.2
1 : 2	0.5
1 : 1	1

Table 3 - Text Heights for use in Model Space (Meters)

Scale of Drawing	Factor (Multiply)	Text Height		
		0.25 Pen	0.35 Pen	0.5 Pen
1 : 1000	1.00	2.5	3.5	5
1 : 1250	1.25	3.125	4.375	6.25
1 : 2500	2.50	6.25	8.75	12.5
1 : 5000	5	12.5	17.5	25
1 : 10000	10	25	35	50
1 : 25000	25	62.5	87.5	125

Scale of Drawing	Factor (Multiply)	Text Height		
		0.25 Pen	0.35 Pen	0.5 Pen
1 : 50000	50	125	175	250
1 : 500	0.5	1.25	1.75	2.5
1 : 200	0.2	0.5	0.7	1
1 : 100	0.1	0.25	0.35	0.5
1 : 50	0.05	0.125	0.175	0.25
1 : 20	0.02	0.05	0.07	0.1
1 : 10	0.01	0.025	0.035	0.05
1 : 5	0.005	0.0125	0.0175	0.025
1 : 2	0.002	0.005	0.007	0.01
1 : 1	0.001	0.0025	0.0035	0.005

Table 4 - Text Heights for use in Model Space (Millimeters)

Scale of Drawing	Factor (Multiply)	Text Height		
		0.25 Pen	0.35 Pen	0.5 Pen
1 : 500	500	500	1250	1750
1 : 200	200	200	500	700
1 : 100	100	100	250	350
1 : 50	50	50	125	175
1 : 20	20	20	50	70
1 : 10	10	10	25	35
1 : 5	5	5	12.5	17.5
1 : 2	2	2	5	7
1 : 1	1	1	2.5	3.5

Appendix C – DRAWING TYPE AND DRAWING NUMBER SERIES

Appendix C - Project Number

PHASE 1	Project Codes
Shendra-Bidkin Industrial Area	SBIA

Appendix C Originator Code

Originator Code	Design Consultant Name
CH2MHILL	CH2MHill
DMICDC	Delhi Mumbai Industrial Corridor Development Corporation Limited
AITL	Aurangabad Industrial Township Limited
MIDC	Maharashtra Industrial Development Corporation
AARVEE	Aarvee Associates

Appendix C Drawing Type Code

Discipline/ Drawing Type	Title Series	Drawing No.
SK – Sketch Drawings	General Layouts and miscellaneous drawings	0000 - 0249
	Geotechnical	0250 - 0499
	Highways	0500 - 0999
	Site Clearance	1000 - 1499
	Traffic	1500 - 1999
	Street Lighting	2000 - 2499
	Fencing	2500 - 2999
	Grading	3000 - 3999
	Structures	4000 - 4999
	Utility Services Corridors	5000 - 5499
	Surface Water	5500 - 5999
	Foul Sewer	6000 - 6499
	Treated Sewerage Effluent	6500 - 6999
	Potable Water	7000 - 7499
	Fire Water	7500 - 7999
	Electricity	8000 - 8499
GE - General	Drawing Lists	0001 - 0999

GT - Geotechnical	General Notes, Abbreviations & Legends, Location Plan, General Key Plan, etc.	0001 - 0999

	Standard & Miscellaneous Details	7000 - 7999

HW - Highways	General Notes, Abbreviations & Legends, Location Plan, General Key Plan, District, Zone & Municipality Boundaries, Road Corridor etc..	0001 - 0999
	Cross Sections (Detailed and Typical), Pavement Types	1000 - 1999
	Proposed Road Layout & Key Plan	2000 - 2999
	Setting Out Plan (Horizontal Alignment Plan)	3000 - 3999
	Road Profiles	4000 - 4999
	Junction Layout Plan and Levels	5000 - 5999
	Swept Path Analysis For Junctions	6000 - 6999
	Standard & Miscellaneous Details	7000 - 7999
	Detail Road Signs & Markings	8000 - 8999
SC – Site Clearance	General Notes, Abbreviations & Legends, Location Plan, General Key Plan, etc.	0001 - 0999
	Site Clearance Layout & Key plan	2000 - 2999

	Standard & Miscellaneous Details	7000 - 7999
TR - Traffic/ Transport	General Notes, Abbreviations & Legends, Location Plan, General Key Plan, etc.	0001 - 0999
	Traffic Flow	1000 - 1999
	Bus Route	2000 - 2999
	Traffic Signal	3000 - 3999
	Traffic Management Plan	4000 - 4999
	Traffic Diversion Plan	5000 - 5999

	Standard & Miscellaneous Details	7000 - 7999
SL - Street Lighting	General Notes, Abbreviations & Legends, Location Plan, General Key Plan, etc.	0001 - 0999
	Street Lighting Typical Cross Sections	
	Street Lighting Layout & Keyplan	2000 - 2999
	Electrical Work For Road Lighting and Traffic Signs	3000 - 3999
	Standard & Miscellaneous Details	7000 - 7999
FE - Fencing	General Notes, Abbreviations & Legends, Location plan, General Key Plan, etc.	0001 - 0999
	Fencing Layout & Keyplan	2000 - 2999
	Standard & Miscellaneous Details	7000 - 7999
GR - Grading	General Notes, Abbreviations & Legends, Location Plan, General Key Plan, etc.	0001 - 0999
	Existing Grading and Topographic Survey Layout Plan & Keyplan	1000 - 1999
	Proposed Grading Layout & Keyplan	2000 - 2999

	Standard & Miscellaneous Details	7000 - 7999

ST - Structures	General Notes, Abbreviations & Legends, Location Plan, General Key Plan, etc.	0001 - 0999
	GAD of Structures	1000 - 1999

	Standard & Miscellaneous Details	7000 - 7999

UC - Utility Services Corridor	General Notes, Abbreviations & Legends, Location Plan, General Key Plan, etc.	0001 - 0999
	Utility Cross Sections	1000 - 1999
	Combined Utilities Plan Layout	2000 - 2999

	Standard & Miscellaneous Details	7000 - 7999

PW - Potable Water	General Notes, Abbreviations & Legends, Location Plan, General Key Plan, etc.	0001 - 0999
	Potable Water Network Plan	
	Proposed Potable Water Layout & Keplan	2000 - 2999
	Longitudinal Sections (Profiles)	3000 - 3999
	GAD of MBR and Pump Houses, SLD for the pumping arrangement from MBR, GAD of ESRs	4000 - 4999

	Standard & Miscellaneous Details	7000 - 7999
	SCADA system for Potable water distribution network	8000 - 8999
RW - Recycle Water	General Notes, Abbreviations & Legends, Location Plan, General Key Plan, etc.	0001 - 0999
	Recycle Water Network Plan	1000 - 1999
	Proposed TSE Layout & Keyplan	2000 - 2999
	Longitudinal Sections (Profiles)	3000 - 3999

	Standard & Miscellaneous Details	7000 - 7999

FS - Foul Sewer/ Sewerage	General Notes, Abbreviations & Legends, Location Plan, General Key Plan, etc.	0001 - 0999
	Sewer Collection Network	1000 - 1999
	Sewer Layout & Keyplan	2000 - 2999
	Longitudinal Sections (Profiles)	3000 - 3999

	Standard & Miscellaneous Detail	7000 - 7999
	General Notes, Abbreviations & Legends, Location Plan, General Key Plan, etc.	0001 - 0999
	Industrial Effluent Network Plan	1000 - 1999
	Proposed Industrial Effluent Layout & Keplan	2000 - 2999

IE- Industrial Effluent	Longitudinal Sections (Profiles)	3000 - 3999

	Standard & Miscellaneous Details	7000 - 7999

SW - Surface Water	General Notes, Abbreviations & Legends, Location Plan, General Key Plan, etc.	0001 - 0999
	Surface Water Network Plan	1000 - 1999
	Proposed Surface Water Layout & Keyplan	2000 - 2999
	Longitudinal Sections (Profiles)	3000 - 3999

	Standard & Miscellaneous Details	7000 - 7999

EL - Electricity	General Notes, Abbreviations & Legends, Location Plan, General Key Plan, Cluster layout, zoning etc.	0001 - 0999
	Sub-station & network Layout, Single line diagram, General Arrangement etc.	1000 - 1999
	Extra High Voltage Electricity Supply Layout & Keyplan	2000 - 2999
	High Voltage Electricity Supply Layout & Keyplan	3000 - 3999
	Medium Voltage Electricity Supply Layout & Keyplan	4000 - 4999
	Low Voltage Electricity Supply Layout & Keyplan	5000 - 5999

	Standard & Miscellaneous Details	7000 - 7999

EN - Environmental	General Notes, Abbreviations & Legends, Location Plan, General Key Plan, etc.	0001 - 0999
	Existing Site Features	1000 - 1999
	Sensitive Receptors	2000 - 2999
	Surveys & Investigations	3000 - 3999
	Monitoring Locations	4000 - 4999

	Standard & Miscellaneous Details	7000 - 7999

Schedule R - Guideline for Health, Safety and Environment Plan

(See Clause 3.1.7 (l))

The Contractor shall provide a General and Administrative HSE Procedures that will engage the welfare of labor, staff and others abiding by the rules and regulations and provide for records to the Employer's Engineer.

The Contractor shall prepare specific HSE plans based on the specific construction procedures to be adopted specifically for this project to address complexity, safety and welfare of labor/staff/equipment as per the details given below.

Contents

1. HSE Standards
2. Legislation
3. HSE Management System
4. HSE Risk Management
5. Hazard identification and control
6. Environmental Management
7. HSE PERSONNEL
8. Competence and Training
9. HSE Orientation Training
10. ID card & Booklet
11. Intervention
12. Medical fitness to work
13. HSE Communications and Meetings
14. HSE Performance Reporting
15. Target and Objective setting
16. HSE Incident Management
17. Emergency Preparedness and Response
18. HSE Audits, Reviews and Inspections
19. HSE Records
20. Sub-Contractor Management
21. Project HSE plan
22. Substance abuse

HSE Standards

The contractor shall ensure that all personnel engaged (including sub-contractors) with the project shall be conversant with and at all times comply with the HSE standards for the project. The HSE standards shall include the relevant India HSE legislation, relevant IS (Bureau of Indian Standards) & Project HSE documents. (documents prepared by the PMNC with regards to HSE). See Annexure-I

1. **Legislation**

For the purposes of the project relevant Indian HSE legislations shall apply to the project as dictated by the various Ministries including but not at the least – Ministry of Labor & Employment; Department of Labor – Government of Maharashtra; Ministry of Environment, Forest and Climate Change.

2. **HSE Management System**

The contractor shall ensure that they will have an HSE policy and an HSE Management system (including safe work procedures) that is documented, visibly endorsed by the company's top management and implemented & maintained at the project.

The scope of the contractors HSE Management system (including safe work procedures) shall cover all areas of work on the project and shall include any work to be performed by the contractor personnel or any of their sub-contractor, interfaces with the PMNC & Client.

3. **HSE Risk Management**

The contractor shall ensure that they employ best practice methods and meet all legal requirements in identifying, assessing and controlling HSE hazards. They shall document these methods and the outcomes.

4. **Hazard identification and control**

The contractor shall identify hazards and their control measures through a formal hazard identification process. The contractor shall also ensure that they have a written safe work procedure for all the works to be undertaken on the project. Any works that do not have a written work procedure shall have a detailed method statement & job safety analysis (JSA)/risk assessment in place.

The contractor shall submit written summaries of upcoming work (Two week look ahead) tasks and associated risk control measures to the PMNC to discuss the risks of upcoming work tasks and the planned mitigation measures in the weekly progress/HSE meetings.

5. **HSE Enforcement**

The PMNC or its representatives shall have the right at any time to audit or inspect Contractor facilities, procedures, and safety management systems. The Contractor shall fully co-operate in such

Cholera on EPC basis

reviews and shall implement recommendations at its own cost where Project HSE Standards or statutory rules and regulations are contravened. Contractor shall ensure the timely closing out of issues raised via these HSE assessments.

The PMNC will bring to the attention of Contractor any situation where the PMNC observes, or is informed of, a contravention of the HSE rules and procedures or unsafe acts; or a situation where those contraventions or unsafe acts identified are not considered likely to present an immediate risk, but are likely to lead to injury, ill health or damage to the environment.

If the PMNC observes, or is informed of, a contravention of the safety rules and procedures or unsafe acts, and if those contraventions or unsafe acts identified are considered likely to present an immediate risk to personnel, then they shall have the authority to stop such work until remedial actions have been addressed to prevent such unsafe acts from recurring.

If contraventions or unsafe acts persist or present an imminent risk of serious injury or ill health to the persons involved, PMNC will have the right to stop work being performed and to order a suspension of the execution of any new work in that part or parts of the Works affected by Contractor's HSE violation or negligence.

Suspension of work shall be measured from the date of issue of an instruction from PMNC to Contractor to suspend work on that particular part of the Works until the unacceptable safety violation has been fully rectified. In such an instance, Contractor shall have no right to claim for any extension of time or to claim for compensation for the suspension of the work or for the waiving of the liquidated damages.

Contractor shall not resume provision of the Works affected until the PMNC is satisfied that the non-compliance has been rectified.

In addition to enforcement requirements stated in HSE legislations, Contract Requirements and Project HSE standards, the PMNC may require the removal any person from the site, who in the opinion of PMNC, fails to observe HSE procedures. That person shall not be employed again on the project or any of the sites without the written approval of the PMNC.

The Contractor shall be responsible for enforcing the Site HSE Rules and Regulations upon its Subcontractors and all other persons entitled to be on any work sites.

6. Environmental Management

The contractor shall specify in their HSE plan measures applied to avoid harm to the environment.

7. HSE PERSONNEL

The contractor shall ensure that adequate HSE personnel are appointed on the project. No HSE personnel on the project shall be appointed without prior written permission from PMNC. The Contractor shall ensure that all HSE personnel meet the requirements as dictated by the project HSE standards.

8. Competence and Training

The contractor shall ensure that that all personnel are competent, capable and qualified to a level that allows them to work without creating unnecessary risk for themselves and others. All personnel shall have and maintain the necessary HSE competencies to perform work on the project to the required HSE standards.

The contractor shall ensure that all supervisory personnel have formal training in supervisory activities and specialist HSE training to conduct their duties.

The contractor shall ensure that a project HSE training matrix is produced. The training matrix shall include the various positions on the project and detail the HSE training that is required for each position.

9. HSE Orientation Training

The Contractor shall ensure that all personnel working at the project receive an induction HSE training explaining the nature of the work, the hazards that may be encountered during the site work and the particular hazards attached to their own function within the operation on the first day of work on the project. The training shall cover the contents as detailed within the Project HSE standards.

The contractor shall ensure that any new personnel are informed in an equal manner.

10. ID card & Booklet

The contractor shall ensure that all personnel working on the project (including sub-contractors) be issued with a photo identity card duly signed by the authorized representative of the contractor before they are engaged for any work.

The contractor shall also issue a personal HSE handbook in a language known to the workers, which provides information on HSE and emergency procedures that all working personnel are required to know and need to follow. Contractor shall ensure that this is distributed and its content introduced to all personnel working at the site.

11. Intervention

The contractor shall have implemented a system that assures competence (including HSE) of personnel. For those roles where no suitable recognized competence standards exist, the contractor shall provide, upon the PMNC's request, information on the selection criteria and/or method used to provide assurance of individual competence.

The contractor shall establish and agree with the PMNC a key list of personnel undertaking taking HSE critical roles. The list shall identify these key individuals by name and by (key) role. For every role on this list, the contractor shall define minimum requirements for HSE competences and qualifications relevant to the work.

The contractor shall minimize turn-over of HSE personnel, where possible, to ensure established competence levels and to minimize role discontinuity. The contractor shall obtain the PMNC's written approval prior to replacing any personnel on the list.

The contractor shall have implemented a system that records the training of personnel. The contractor shall keep training records up-to-date and shall furnish information about the system and/or records of training upon request by PMNC.

12. Medical fitness to work

The contractor shall ensure that all personnel engaged on the project are medically fit for the job to be undertaken. Where required, the contractor shall be able to demonstrate that personnel, selected for key positions are evaluated for their fitness to work on the project.

13. HSE Communications and Meetings

The contractor shall ensure efficient and effective HSE communication and consultation with all personnel involved on the project. This includes but is not limited to toolbox meetings prior to the start of work, regular worksite HSE meetings with all parties involved (including subcontractors).

The contractor shall participate in any HSE meetings as organized by the PMNC.

14. HSE Performance Reporting

The contractor shall submit on a monthly basis an HSE performance report to the PMNC. This report shall contain as a minimum the following data, as related to the project:

- A list, including a brief description, of all incidents (including near misses and potential incidents);
- Number of Fatalities (FAT);
- Number of Lost Workday Cases (LWC);
- Number of Restricted Workday Cases (RWC);
- Number of Medical Treatment Cases (MTC);

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- Number of First Aid Cases (FAC);
- Number of Environmental Non-conformances;
- Number of Environmental Spills;
- Leading performance indicators as agreed with the PMNC.
- Additional project specific HSE performance data, as to be agreed with the PMNC.

The format & content for the HSE performance report shall be agreed with the PMNC prior to the commencement of the project.

15. **Target and Objective setting**

The contractors HSE goal shall be "Target Zero" to reflect the projects commitment to an accident free workplace. The contractor's targets and objectives shall be focused on leading indicators and pro-active efforts to reduce the likelihood and severity of incidents.

16. **HSE Incident Management**

The contractor shall report any HSE incident and/or accident, related to contractor activities or personnel, to the PMNC & National or Local authorities as required by relevant legislation.

The contractor shall also notify the PMNC immediately of any HSE incident, including near misses and significant potential incidents, arising from the contractors or sub-contractors activities associated with the project, related to:

- Harm to contractor and or Sub Contractor personnel or Third Party;
- Harm to the environment,
- Damage to, or loss of, contractor or sub-contractor /Third party assets;
- Harm to Client/PMNC/Contractor reputation.

The contractor shall fully investigate any incidents on the project and cooperate with the PMNC and participate as necessary in any investigation of HSE incidents as required by the project HSE standards.

17. **Emergency Preparedness and Response**

The contractor shall maintain a documented, robust fit-for-purpose Emergency Response Plan for the project. The contractor shall also provide fit-for-purpose survival equipment, first-aid equipment, life-saving equipment, fire-fighting equipment and oil/chemical spill equipment. The contractor shall ensure that involved personnel are trained and competent in its use.

The contractor shall develop and maintain a programme of training and exercises to ensure competency of all individuals and teams involved in the emergency response teams in accordance with the project HSE standards.

18. HSE Audits, Reviews and Inspections

The contractor shall perform audits, reviews and inspections on the project as required by project HSE standards. During these audits, reviews and inspections, the contractor shall verify that they have fulfilled any and all legal obligations, including conditions and stipulations in all relevant licenses, consents and permits and that the work on the project is performed in accordance.

The contractor shall develop a detailed HSE inspection & audit schedule for the project and submit copies of the reports to the PMNC.

19. HSE Records

The contractor shall retain all relevant HSE records resulting from work on the project in line with relevant legislation & project HSE standards.

20. Sub-Contractor Management

The contractor shall ensure that all sub-contractors comply with all the HSE standards relevant to the project (including these conditions).

The contractor shall be accountable for the sub-contractors HSE performance.

21. Project HSE plan

The contractor shall prepare and submit to the PMNC a project HSE plan which covers all work under the project. This project HSE plan shall be reviewed by the contractor at regular intervals of not less than 6 months.

22. Substance abuse

The contractor shall ensure that that all personnel working on the project do not at any time partake of, be under the influence of drugs, alcohol, sedatives or other similar intoxicating substances, other than for bona fide medical reasons.

Any personnel found contravening with the above will be removed from the project with immediate effect and handed over to the authorities.

Contractor HSE Plan Template

Contents

- Section 1 - Project Details
- Section 2 - Information and Training for People on Site
- Section 3 - Contractor Management Selection of Plant
- Section 4 - Emergency Procedures
- Section 5 - Arrangements for Controlling Significant site Risks
- Section 6 - Environmental Management

Template for Contractor HSE Plan

This plan is provided as a guidance template for the Contractor to include in their HSE plan. The sections mentioned in this HSE plan template will be the minimum standards that the Contractors HSE plan will be assessed against.

Section No	Titles of sections	Details of what is required in each section
Contractor must ensure that these sections are included in their Construction HSE plan. The details in the sections are provided as guidance.		
3 Section 1 - Project Details		
1.1	Project Specific Details	Contractor to provide contact information for Key Contractor personnel. Contact information to include Name, Mobile number, email id. Key personnel include: • Contractor Project Director • Contractor Project manager • Contractor Construction manager • Contractor HSE Manager • Contractor General Foremen.
1.2	Details of other Consultants	Details as above of any consultants that the contractor may employ on the project.
1.3	Project Security	Contractor to detail the site security arrangements that will be in place on the project. Suggestions as below: • Site entrance control points • Identity card system • Vehicle barrier types • Visitors to site procedures • Delivery vehicle procedures • Vehicle parking restrictions • Need for 24hr cover etc

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1.4	Welfare Arrangements	Contractor to detail what arrangements will be made on site to ensure that appropriate welfare facilities are provided and maintained according to the size of the workforce and nature of the work. As a minimum, an assessment must be carried out to determine specific welfare requirements and arrangements throughout the project, from day one to the last day persons are on site. Consideration must be given to any requirements for male / female changing, showers or disabled facilities, etc. Details to be included: • What type and size of facilities are required, • When they will be operational, • State what the initial set up is and what the subsequent set up will be • Where they are located. Produce clear layout drawing • Who provides and maintains each facility. • Expected standards and monitoring requirements.
1.5	Project Organization Chart	Contractor to include a detailed organization chart with names, designations & contact numbers for the project.
1.6	Arrangements for communication	Contractor to detail how they plan to communicate HSE with the different parties on the project. For example what kinds of HSE meetings will be held on the project, how often, who will attend etc. Suggestions HSE Communication include: • Regular team meeting. • Early morning meetings with key personnel. • Formal correspondence (e.g. Appointment Letters). • Management Walks • Tool box talks • Trainings
1.7	Project Goals	Contractor to detail what are the project HSE goals.
1.8	HSE Compliance	Contractor to detail how HSE compliance monitoring will be

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	monitoring	conducted, who will conduct, how often this will be conducted.
1.9	Senior Management HSE monitoring	Contractor to detail how Senior management on the project will be involved in HSE monitoring, How often will they be involved, what is the process.
4 Section 2 - Information and Training for People on Site		
2.1	Inductions & Trainings	Contractor to detail the methods by which they will check that people on site have been satisfactorily inducted & trained. Suggestions include: - • Arrangements for delivery – i.e. who does the induction? Who does the training? • Arrangements by which management are informed of new starters; • Arrangements for recording of inductions/trainings? • Any passes, or other identification issued after induction • Arrangements for re-induction or safety updating as the contract enters a new phase or persons are transferred to a different section. • What are the training arrangements for the project?
2.2	Site Safety Rules	Contractor to detail what site safety rules will be developed or is available for the project.
5 Section 3 - Contractor Management		
3.1	Selection of Contractors	Contractor to detail how they will select sub-contractors on the project. • How will they ensure that only competent HSE contractors are on site • How do they plan to communicate HSE issues with the sub-contractors • How do they plan to coordinate the works with the sub-contractors
3.2	Selection of	Contractor to detail how they will ensure that only safe plant &

	Plant	equipment is bought to the project. • How will they check the plant & equipment • How often • Who will check
6 Section 4 - Emergency Procedures		
4.1	First Aid	• Contractor to detail what are the first aid arrangements that will be made on site. For example: • Locations of first aid boxes • Names of First aid personnel and their locations • Location of First Aid room • Numbers of First Aider's required • Location of accident book
4.2	Fire and Emergency Procedures	Contractor to detail what are the fire safety arrangements that will be available on site. For example: • Fire points – How many, where will they be located • What kind of extinguishers will be available • What kind of training will be available • What will the emergency actions be for the project
4.3	Accident & Incident reporting	Contractor to detail what are the accident & incident reporting procedures for the project. For example: • How will accidents be reported? • To whom? • Who will coordinate? • How will they be recorded?
7 Section 5 - Arrangements for Controlling Significant site Risks		
5.1	Production of Method Statements	Contractor to detail how method statements will be checked for HSE hazards & risks?

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5.2	Risk Assessments	Contractor to detail how risk assessments will be produced? • Who will produce these? • How will they be reviewed? • Methods of communicating to the workforce on the content of the risk assessments? • How will sub-contractor risk assessments be checked for the above?
Section 6 - Environmental Management		
6.1	Environmental Management Strategy	The contractor to detail how they plan to manage the environmental aspects of the project. Suggestions include: • Environmental management plan. • Project specific Environmental processes • Environmental aspects & impact register
6.2	Waste Management Planning	Contractor to detail how they plan to manage waste (construction, hazardous & non-hazardous). Suggestion include: • How will waste be collected on site? • How do they plan to dispose the waste? • Who will dispose it, where?
6.3	Environmental Emergency plans	Contractor to detail what are the environmental emergency plans for the project. Suggestion include: • Who will initiate action? • Who will report? To whom? • What are the foreseen emergencies?

**Annexure- I: Construction HSE Management procedures
(Schedule – R)**

1. SECTION 1: INTRODUCTION

This document describes how Health, Safety & Environment (HSE) will be managed on the SBIA Programme. This document is provided to ensure that the appointed Package Contractor, Engineers, Consultants and another Stakeholder(s) who are working closely on the SBIA Programme understand the HSE standards on the programme. This document should be read along with the SBIA 'Health Safety Environment Execution Plan' (PMC-657466-HSE-S01-PRC-015).

- The standards laid down by this document is mandatory for all on the SBIA Programme.
- All Package Contractor/Consultants must familiarise themselves with these standards and also ensure that these standards are adhered to by any subcontractors/suppliers and any self-employed persons working within their workforce.
- These standards will assist the contractor in their planning and provision of satisfactory HSE resources on projects.
- These standards will be audited in accordance with set performance measurement procedures as per specific audit schedule completed for every project.
- Poor or non-compliance with these standards may result in the contractor being removed from the project.

1.1. Purpose

The purpose of this document is to provide a systematic framework to:

- Implement & Manage HSE on the SBIA Programme.
- Achieve the overall HSE objectives of the SBIA Programme.
- Ensure open and transparent communication of HSE on the SBIA Programme.

1.2. Scope & Applicability

The scope of this document is limited to the SBIA Programme and covers the programme projects, programme site office, and everyone working on any aspect of the SBIA Programme Delivery. The Programme Manager for New Cities (PMNC) HSE Manager will review this document every year as a minimum, ensuring that it keeps abreast with any changes of/on the SBIA Programme. Stakeholders including Package Contractors are responsible to ensure that they have the latest version of this document. Copies of any forms and templates mentioned in this document is available with the PMNC HSE Manager and shall be made available on request.

1.3. Legal and Other Requirements

All parties involved on the SBIA Programme shall comply with all local legislations, Client/SBIA Programme/ PMNC's HSE requirements. Where legal requirements conflict with those set out in any other Client/SBIA Programme/ PMNC's HSE document, the more stringent requirement will apply.

All works will be carried out in compliance with the HSE rules, acts & regulations set out by the following:

- The Government of India, Ministry of Labour & Employment (<http://labour.gov.in/>)
- Department of Labour – Government of Maharashtra (<https://mahakamgar.maharashtra.gov.in/index.htm>)
- Ministry of Environment, Forest and Climate Change (<http://www.moef.nic.in/>)
- DMICDC (<http://www.dmicdc.com/>)
- Maharashtra Industrial Development Corporation (<http://www.midcindia.org/>)
- Aurangabad Industrial City (AURIC) (<http://www.auric.city/>)
- Bureau of Indian Standards (<http://www.bis.gov.in/index.asp>)
- Contractually specified international standards and codes of practice
- Relevant industry standards and guidelines
- Contractual standards, procedures, and work instructions

The PMNC HSE Manager maintains a non-comprehensive HSE legislative list, Package Contractors are encouraged to refer to this list (as and when required). Alternatively, all HSE legislations governed by government organizations in India can be accessed in thru their respective websites.

1.4. Programme HSE Aims and Objectives

The PMNC has set specific objectives to achieve the overall SBIA programme vision. Key HSE objectives include, but are not limited to, the following:

- Visible commitment to HSE from leadership on the SBIA programme including Clint, PMNC & Package Contractor.
- Apply robust HSE principles across the SBIA programme.
- Apply zero tolerance for HSE violations.
- Include HSE as an agenda item at all formal meetings.
- Implement HSE best practice initiatives.
- Continually learn and improve approaches should accidents and incidents occur.

2. Section 2: Management structure, appointments and responsibilities

2.1. Management Responsibilities

2.1.1. Contractor Senior Management Responsibilities

- Ensure and maintain the HSE of all those who are affected by the SBIA Programme.

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- Ensure that the arrangements and resources on the SBIA Programme are adequate and reviewed as necessary.
- Maintain a reporting structure for HSE matters and ensure that reporting lines and responsibilities of line management are clearly defined.
- Attend or support appropriate HSE management or steering groups as necessary.
- Ensure that HSE is the first agenda point of all meetings
- Ensure that resources are available to maintain an effective HSE performance, including budgetary, suitably trained staff and competent staff with clear lines of command and responsibility.
- Carry out HSE tours on a regularly defined basis.
- Be aware of the principles of the current HSE legislation and developments and ensure that their staffs are aware of their accountability for HSE.
- Ensure that all accidents and incidents reported on the SBIA Programme are fully investigated and actions closed out.
- Ensure that appropriate support has been offered to those affected by incidents.
- **All Contractor Senior Management will lead by example.**

2.1.2. Contractor Line Management Responsibilities

- Be aware of the HSE requirements of applicable to the SBIA Programme.
- Ensure that during planning, construction and production, maintenance and repair, sufficient allowance is made for safe systems of work, adequate welfare facilities & supervision.
- Ensure that the management team is adequately staffed with suitably trained and experienced personnel with clearly understood and defined responsibilities that allow for close and effective supervision of operations.
- Ensure that a competent staff member will be present at all times when work is being undertaken under their control.
- Liaise with their HSE team on SBIA Programme HSE requirements.
- Ensure that they understand the requirements of the SBIA Programme HSE Plans & Procedures and that the plan is communicated and implemented effectively on site.
- Ensure that safety critical appointments are made in writing and persons appointed are suitable for the role.
- Arrange/chair/attend the site HSE meetings.
- Ensure that overall and specific risk assessments & method statements are produced, submitted and communicated to relevant parties on time.

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- Ensure that Package Contractor(s) are suitably managed.
- Implement HSE systems to remove confusion over areas of responsibilities.
- Ensure that work is carried out as planned, relevant legislation is complied with and that high standards of professionalism, site tidiness and access are maintained at all times.
- Ensure inspection and monitoring under their areas of control are carried out and any action points raised are closed out.
- Commend those who maintain high standards of HSE and discipline those who consistently fail to achieve the required standard.
- Ensure that legal requirements relating to the involvement of the workforce are implemented to promote HSE compliance.
- Review reporting and investigation of all accidents, dangerous occurrence and environmental incidents in conjunction with HSE staff and ensure that appropriate remedial actions are taken to prevent recurrence
- **All Contractor Line Management must set and lead by example**

2.1.3.Responsibilities of Contractor supervisors

- Be familiar with legal principles, safe working practices, method statements, risk assessments applicable to their work and ensure they are enforced.
- Incorporate HSE instruction in their routine orders and see that they are carried out.
- Suitably brief men under their control so that work is carried out in a safe & controlled manner without undue risks.
- Avoid improvisation or deviation from method statements & risk assessments for tasks being undertaken.
- Ensure that all operatives are trained for the task in which they are engaged.
- Ensure that new employees are inducted and made aware of the hazards and controls in their workplace.
- Ensure that project employees not under their direct control are protected from the consequences of the work under them.
- Check plant & equipment and ensure that they are in good working order.
- Ensure that all operatives are provided with appropriate PPE for the tasks they are undertaking.
- Ensure that workplaces are safe, tidy & organised at all times.
- Ensure that plant & equipment is switched off when not in use and kept in a safe condition
- Ensure that welfare facilities are maintained in a clean condition.

- Prevent horseplay and discipline those who consistently fail to consider their own wellbeing and that of others around them.
- Report all accidents/incidents/near- misses to the site HSE department.
- **All Contractor supervisors must set a personal example**

2.1.4. Responsibilities of workforce

- Take all reasonable care to ensure your own safety and that of any others who may be affected by your work.
- Attend the site induction, tool box talks and other HSE communications as required by the project.
- Avoid improvisations or deviations from approved method statements & risk assessments.
- Use the specified tools and equipment for the job.
- Take personal responsibility for your actions.

3. Section 3: Planning

3.1. Package Contractor HSE Plan

Package Contractors shall prepare a HSE Plan that shall define their HSE intend and how they plan to manage HSE on the SBIA Programme. The HSE plan shall not only take into consideration all the activities that the Package Contractor will undertake, but shall also consider any interface with governmental agencies, other package contractors, area locals etc. The HSE Plan shall be submitted to the PMNC for review & comments at least one month prior to mobilization.

The Package Contractor shall review and amend their HSE Plan, as conditions related to the SBIA Programme/Project Site (s) or the works change, but as a minimum, the HSE plan shall be revised and resubmitted to the PMNC on a yearly basis. Package Contractors shall not commence any construction activities until its HSE Plan has been reviewed & commented upon by the PMNC.

3.2. Responsibility for HSE

Package Contractors shall be responsible for the HSE of all its employees and Subcontractors' employees and the environmental impact of their assigned work. The Package Contractor shall at all times comply with and ensure that its employees, Subcontractors comply with all HSE rules, regulations and standards (as mentioned in section 1.3).

The Package Contractor shall take, or cause to be taken, any additional measures, which the Governmental/Client/PMNC may direct to protect against injury or death of any person or damage

to or loss of any property or to the environment during/after the Package Contractor's performance of the works.

Submittal of any documentation to the Client or PMNC does not relinquish the Package Contractor of its direct responsibility for the HSE of persons and the protection of the environment.

3.3. Project HSE Risk Assessment

Before commencement of an onsite project work, the Package Contractor shall ensure that a robust 'Project HSE Risk Assessment' of the works to be undertaken is conducted. The Project HSE Risk Assessment shall be a systematic assessment of the HSE hazards & risks that the Package Contractor could encounter and shall also detail the means to control these. The Package Contractor shall ensure that a copy of the Project Risk Assessment is submitted to the PMNC for review and comments.

The Package Contractor will be expected to recognize HSE hazards, evaluate them with the help of competent people, and to communicate to workers on how to control these hazards during the execution of the works.

The Package Contractor will be expected to use different types of hazard analyses to ensure that work progresses in a manner that does not endanger persons, property, process and the environment. Examples of these include:

- Phase Hazard Analysis;
- Emergency Procedures;
- Job/Task Hazard Analysis;
- HAZID's;
- Critical Task Analysis;
- Field Level / Daily Risk Assessment;
- Behavioral Based Safety.

The Contractor shall review the Project HSE Risk Assessment upon any change in the scope of work and/or at predetermined intervals during the execution of works.

3.4. Aspects & Impacts Register

The Package Contractor shall develop an 'HSE Aspects and Impacts Register' that is relevant to the construction activities and based on their specific construction method statements and the location /sensitivity of their works. The Package Contractor in his 'HSE Aspects and Impacts Register' shall identify any significant HSE impact that could result from his works, ensure adequate control measures are in place and that the residual risks are acceptable.

The Package Contractor shall ensure that the 'Aspects & Impacts Register' is regularly updated and copies submitted to the PMNC for review and comments.

3.5. Readiness Review Go/No-Go

The HSE Readiness Review is a meeting among key PMNC and the Package Contractors personnel and functional support to confirm that all necessary planning and actions have been addressed enable the successful execution of the works. The HSE Readiness Review serves as a management tool in determining the readiness or preparedness of the Package Contractors team to mobilize/execute the works/activity. This is an important activity because it is used to identify gaps in the Package Contractors preparatory activities that could result in failure of the works. The review shall highlight the deficiencies, and focuses the delivery team on correcting those deficiencies.

The Package Contractor shall be responsible to conduct this HSE Readiness Review and invite the PMNC key staff. Additional reviews may be required if deemed necessary by the PMNC at various project phases or project milestones.

The HSE review should be conducted by the Package Contractor at least two weeks prior to mobilizing personnel to the field and at each critical project task/milestone/activity. All Package Contractors shall demonstrate that they are ready to execute their activities in the safest manner. The following documents, as a minimum, shall be checked during the review:

- Related procedures or plans of the Contractor;
- Method statements;
- Risk assessments;
- Internal and external permits for the activity (if necessary);
- Competency approval documents (personnel certificates such as welder, operator, etc.);
- Training records;
- Site layout;
- Medical fitness records of employees; and
- Driver permits.
- **If the Package Contractor fails to demonstrate readiness to the satisfaction of the PMNC the relevant activity shall not commence.**

4. Section 4: Arrangement for Controlling Significant Risks

4.1. Method Statements

The Package Contractor shall ensure that suitable 'Method Statements' are produced for all significant works. These method statements shall details the sequence or steps involved in executing the works and also the methodologies. The Package Contractor shall ensure that the method statements shall be accompanied by a Hazard Identification & Risk Assessment' (HIRA) as below.

The Package Contractor shall ensure that no work is started on site without an approved & agreed Method Statement.

4.2. Hazard Identification & Risk Assessment

The Package Contractor shall ensure that a 'Hazard Identification & Risk Assessment' (HIRA) is available before any works are executed on the site. The Package Contractor shall also ensure that the HIRA shall be attached to the method statement and both documents shall be referred to as a source of safe work methods. The HIRA shall not be the sole responsibility of the Package Contractor HSE team but shall be produced/documented with the Package Contractor construction team in lead.

The Package Contractor shall ensure that the four basic stages in conducting a HIRA are considered:

- selecting the task to be analyzed
- breaking the task down into a sequence of steps
- identifying potential hazards
- determining preventive measures to overcome these hazards

The Package Contractor shall review the HIRA upon any change in the scope of work and/or at predetermined intervals during the project. A copy of the HIRA shall also be made available on site at the time of an HSE inspection (as required).

All HIRAs will be submitted to the PMNC for review & comments at least 3 weeks prior to a task starting on site.

The Package Contractor shall ensure that no work is started on site without an approved & agreed HIRA.

4.3. Permit to work

Where the risks are high and the use of a method statement and risk assessment alone does not necessarily ensure that a safe system of work is followed, the Package Contractor shall ensure that a

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permit to work is implemented. As a minimum, Package Contractors shall ensure that the following works are controlled by a permit to work:

Permit-to-Dig	Demolition Permit
Hot Works Permit	Confined Space Permit
Electrical and Mechanical Permit/LOTO	General permit to work

The need for a permit to work system will be identified in the risk assessment for the activity. Examples of jobs that are typically covered under a permit shall include but not be limited to hot works (cutting, grinding, welding etc.), elevated works (anything above 4 meters), confined space entry, work on electrical systems, non-routine lifts.

Package Contractors shall ensure that they nominate a person as the permit coordinator who shall have the responsibility to oversee the permit to work procedure. All permits shall be valid for a single shift only. Records of any permits issued shall be kept in the permit coordinators office for further inspection.

4.4. Personal Protective Equipment

The Package Contractor shall ensure that Personal Protective Equipment (PPE) is provided as identified in the Method Statements & Risk Assessments. Notwithstanding the PPE described in the Method Statements & Risk Assessments, the Package Contractor shall ensure that as a minimum standard Safety Helmet, Hi-Viz Jackets, Safety Goggles, and Safety Shoes (with penetration protection) is available to all undertaking works on the project.

All PPE supplied on the project shall meet or exceed the specifications as dictated by Indian Standards Institute or the Contract documents. Where there is a conflict the more stringent standard shall apply.

5. Section 5: Training, Awareness & Competence

All project employees must receive appropriate HSE training upon engagement. These trainings shall be delivered by the individual Package Contractors to their personnel and to any subcontractor/third party engaged by them. HSE trainings will include - Induction Training, Tool Box Talks (TBT's), Work/Topic specific training, which will be determined by the Programme/Project HSE Training Matrix, and will be dependent on the tasks scheduled to be performed.

5.1. Minimum Requirements

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The Package Contractor shall ensure that all their personnel (including sub-contractors & any third party contracted to them) complete the following fundamental trainings:

- New Project HSE Induction – this module will orient employees in the basic HSE Policies and Procedures relevant at the project.
- Position specific HSE training – this will include training that depends upon the position the individual holds on the project. For example, if the person is designated as a rigger, he will have to attend rigger training and a slinging & lifting training. These trainings can be conducted either in-house by the individual Package contractors or by an Approved Third Party. The Package Contractor shall also be aware that Project employees may be required to complete additional specialized HSE training, provided by commercial training specialists. Such training shall be identified in the project training matrix.
- Tool Box Talks – These will be conducted on daily/weekly basis as dictated by the activities/tasks that groups of people are undertaking.

The Package Contractor shall ensure that all HSE training conducted on the SBIA programme is documented and tracked.

5.2. Project HSE Induction

The Package Contractor shall conduct an HSE Induction for all project employees (this shall include all personnel employed by the contractor, their sub-contractors, Third Party, Visitors etc.) so that they remain aware of appropriate precautions that apply to them whilst on the work site. This HSE induction shall be conducted prior to being authorization to enter the site and/or commencing work. As a minimum, this training shall include a presentation of the site hazards, safety and security rules and emergency procedures. Depending on the appreciation of the level of risk for the contracted work, other relevant HSE subjects will be presented.

The site HSE induction shall be conducted by the Individual Package Contractor HSE Manager and shall be conducted in a language understood by the site personnel. All Package Contractors shall ensure that their 'Project HSE Induction' training is submitted to the PMNC for review and approval.

As the project progresses, the Project HSE induction shall be reviewed by the Package Contractor HSE Manager at regular intervals to reflect site conditions.

5.3. Tool Box Talks & Daily Briefings

The Package Contractor shall ensure that daily/weekly toolbox meetings and other daily briefings are conducted on a regular basis. These where possible shall be conducted by the foreman and site in-charge.

5.4. Emergency Response Plan Training

The Package Contractor shall ensure that all project employees are aware of the Project Emergency Response Plan. The Package Contractor shall ensure that training to familiarize project employees on the Project emergency response plans is conducted at regular intervals of not less than 6 months. The Project emergency response plan training will include the procedures for reporting to external emergency response organizations (e.g., police, fire department, ambulance services, hospitals, rescue services, and hazardous material response services), building or site evacuation, designated evacuation assembly areas, and methods of accounting for staff upon evacuation. Emergency drills will be performed periodically, but at least twice per year.

5.5. Training Documentation

The Package Contractor shall ensure that all HSE training shall be documented. Documentation and certificates verifying completion will be maintained by the Package Contractor on site.

6. Section 6: HSE Communications

6.1. HSE Communication Program

The Package Contractor shall establish an effective communication network to disseminate HSE information to all Project Personnel, to ensure support to the HSE programme.

Meetings between the PMNC and Package Contractor will be held regularly to pass out and receive information and to discuss HSE matters, which will be communicated to all Project staff.

The table below gives an overview of the HSE communication methods that the Package Contractor shall adopt on the project.

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Method	Frequency
Pre-start meetings	Minimum once prior to commencement of works
Progress meetings	As required by the project or as a minimum once a month.
HSE Meetings	As required by the project or as a minimum once a month.
Daily briefings	Daily
HSE Inductions	As required by the project.
Tool Box Talks	As required by the project or as a minimum Weekly.
Safety Alerts	As required.

6.2. HSE Meeting Program

Safety meetings provide a method for maintaining safety awareness and providing safety-related information and training to employees. The Package Contractor's shall plan and include/indicate in their HSE Plan the types and frequency of HSE meetings that it will conducted during the Project, including but not limited to:

- Daily Toolbox Meetings;
- Weekly Safety Meetings;
- HSE Committee Meetings.

The Package Contractor shall invite the PMNC representatives to attend all meetings and shall provide copies of HSE meeting minutes. The Package Contractor shall keep records of all matters discussed and decisions made at each meeting, records of Site inspections performed, register of work permits issued, records of attendance of participants, etc.

The Package Contractor shall ensure that Construction Manager shall attend these meetings.

The Package Contractors HSE meeting program shall:

- Review and discuss all Site HSE matters of the employees;

- Review safe work practices;
- Co-ordinate jobs so that the work does not pose as a hazard to others;
- Co-ordinate movement and storage of hazardous materials;
- Inform Personnel of potentially dangerous Works operations on the Site;
- Review progress of Works and work permit control;
- Review training requirements;
- Review work procedures and method statements;
- Review incidents and near misses.

The Package Contractor shall ensure that all major decisions and actions proposed by the meetings are effectively communicated for implementation.

6.3. HSE Promotion and Awareness

The Package Contractor will actively promote HSE awareness amongst the project employees by implementing a HSE awareness programme. HSE awareness will be promoted both generally and specifically as relevant to particular areas or activities. A key feature of the awareness programme will be generating communication on HSE matters across organizational boundaries. These will be achieved through various means including, as a minimum:

- HSE notice boards: HSE specific, regularly serviced and updated;
- HSE incentive scheme: performance acknowledged and rewards communicated;
- Regular bulletins: HSE specific information on any task item, including updates on new hazards, changes to any activity or condition, alteration to procedures, etc.;
- Posting of minutes of meetings on HSE issues: update on action items, current performance, new information, items of general awareness for communication;
- Regular HSE workplace walkabouts by both Senior and Line Management: will be performed on both an informal and formal recorded basis. These will be high profile will include constructive discussion with all personnel as necessary.

7. Section 7: Monitoring

7.1. HSE Inspections

The Package Contractor shall carry out HSE inspections at regular intervals, covering not only its works on the project but also other areas under their control such as camps/mess facilities. These HSE inspections shall be led by the Package Contractor HSE team but shall also be attended by the Package Contractor Construction team. The Package Contractor shall ensure that Project HSE Inspections are carried out at least once a week. Inspections of other areas

such as campsites/mess areas shall be carried out at a suitable frequency and agreed with the PMNC. Where necessary, the PMNC representatives will join these inspections.

The Package Contractor shall ensure that inspections of temporary works such as shoring of form work, excavation, trenches, cranes and scaffolds shall be carried out after inclement weather.

Copies of such inspections reports shall be submitted to the PMNC for review & comments.

7.2. Senior Management HSE Site Walks

The PMNC shall conduct a Senior Management HSE site walk once a month with each individual Package Contractor. The Package Contractor shall ensure that Senior Members from its Project team are available for these site walks.

7.3. HSE Audits

The Package Contractor shall establish and maintain an HSE audit program to be carried out on its operations to evaluate the efficiency of its HSE management systems in place. The results of audits, identified corrective actions and determined root causes shall be submitted to the PMNC for review and comments.

The Package Contractor shall appoint an independent appropriately qualified external auditor to audit the Package Contractor's compliance with its HSE Plan and HSE management systems of the Works at least once every twelve (12) months. In addition, the Package Contractor shall carry out internal safety audits to verify whether safety activities comply with the HSE Plan and the HSE management systems. Where it is deemed necessary, the PMNC shall be entitled to engage an independent external auditor at the Package Contractors cost to audit the Package Contractor's HSE Management System.

7.4. HSE Observation Program

The Package Contractor will encourage and educate the project staff to observe and identify safe and at-risk conditions and behaviors. Staff are also encouraged to report near misses in order to look for trends and tackle issues before accidents and incidents occur.

7.5. Reporting Unsafe Conditions

All personnel on the SBIA Programme must report any situation, practice, or condition which might jeopardize the safety of the projects. All unsafe conditions or unsafe practices will be corrected immediately. The SBIA Programme will have zero tolerance of unsafe conditions or unsafe practices.

The following reporting procedures will be followed by Package Contractor/Project Personnel.

- Upon detection of any unsafe condition or practice, the responsible worker will bring the unsafe condition or practice to the attention of the worker's direct supervisor, unless the unsafe condition or practice involves the worker's direct supervisor. If so, the Package Contractor's HSE Manager needs to be notified at once by the responsible worker.
- If a responsible worker feels that they have been mistreated by any Package Contractor personnel throughout the process of reporting/correcting an unsafe condition or practice, they will report this complaint to the PMNC representative for immediate attention.
- No project employee will be disciplined for reporting unsafe conditions or practices.

7.6. HSE Stop Works

All personnel working on the SBIA Programme shall have the authority to 'Stop Works' if they feel them or their colleagues are at risk of getting hurt. Work on the SBIA Programme shall be undertaken without fear of being reprimanded for stopping work on HSE grounds.

8. Section 8: Incident reporting & Investigation

8.1. General

The Package Contractor shall in his HSE plan establish procedures to identify, record, investigate and analyze all accidents/incidents, dangerous occurrences, near misses, which occur on the Project. The investigation and analysis shall identify the root cause and contributory causes of these events and formulate measures accordingly to prevent future recurrence of similar incidents. The Package Contractor shall ensure that copies of all such reports are submitted to the PMNC for review and comments.

8.2. Reporting of Incidents

Package Contractors shall ensure that all incidents are reported to the PMNC at the earliest. The initial notification time in any case shall not be more than one (1) hour from the time of the incident. Following the initial notification, the Package Contractor shall (within 24hrs) ensure that a written notification is sent to the PMNC.

Package Contractors shall ensure that all accident/incident reports are submitted to the PMNC within an agreed timeframe. This time frame shall be agreed with the PMNC HSE Manager.

For the purpose of reporting, on the SBIA Programme the following definitions shall be adopted by all Package Contractors:

- **Lost Time Injury:** Any accident/incident that results in an employee not being able to work on the day following the accident.
- **Medical Treatment Case:** Any work related accident/incident where the employee has to receive medical treatment in a facility outside project first aid. This can be a clinic or hospital.
- **First Aid Case:** A minor work related injury that requires the person to seek medical attention at the project first aid clinic.
- **Near Miss:** An unplanned event or condition that occurred in the project which although didn't result in an injury or damage property but had the potential to do so.
- **Major Accident/Incident/Near-Miss:** Categorized / defined as one which meets or exceeds the following consequences:-
 - Harm to People: Major injury or health effects (including permanent disability) - Affecting work performance; on longer term, e.g. prolonged absence from work. - Irreversible health damages without loss of life, e.g. noise induced hearing loss, chronic back injuries.
 - Property Damage: Damage to any Project property in excess of INR 50000.00 or will take more than 2 days of to rectify.
 - Environmental Effect: Any damage to the environment which costs an upwards of INR 50000.00 to clean up.
 - Work Related: Any injury (however small) that has happened to a personnel whilst he was working on the project site.

8.3. Report Documentation

The Package Contractor shall ensure that the accident/incident report that is submitted to the PMNC as a minimum will have the following described details/sections.

- **Details of the investigation Team:** List of investigation team members
- **Background of the Incident:** The environment of the accident before the accident occurred
- **The Incident:** Detailed description of what happened in detail, the actions taken by the Package Contractor.
- **Immediate Cause:** Direct and indirect causes of the incident.
- **Root Cause:** Complete root cause analysis of what caused the incident/accident.
- **Investigation Findings:** Sketch of the incident scene, photographs, diagrams and physical evidence, persons with information and statements

- **Statements of eye witnesses**
- **Statements of accident victims**
- **Recommendations:** Immediate and long term corrective actions, risk mitigation measures and target completion dates
- **Lessons learned**
- **Supporting documents such as any medical records, clean up records.**

9. Section 9: Emergency Response

9.1. General

Package Contractors shall as a part of their HSE Plan have a written Emergency Response Plan (ERP). The Package Contractor's ERP will consider potential emergencies that may arise during the performance of the Works and develop procedures to deal with the emergencies. The Package Contractor shall consider the following emergency scenarios for development in the ERP.

- Fatalities or serious injuries
- Major construction incidents not involving injury (e.g. structural collapse, collapse of excavations, tower crane failure, vehicle collision)
- Fire and explosion
- Bomb alert
- Environmental incidents, including chemical spillage / toxic release
- Security violations
- Property damage
- Extreme weather.

Emergency procedures developed by the Package Contractor shall ensure that Package Contractor's Site Manager or most senior supervisor present takes charge and directs the handling of the emergency. Package Contractor shall conduct weekly inspections of escape routes, fire brigade access, firefighting facilities and work areas to ensure that the requirements stipulated in the Emergency Response Plan are complied with.

9.2. Emergency Response Plan (ERP)

Prior to commencing work on site, the Package Contractor shall prepare an ERP. The objectives of the plan shall be to:

- Provide a framework for planning for, responding to and recovering from emergency situations that may occur within the Package Contractor's area of responsibility;
- Allocate sufficient resources and facilities to manage and mitigate emergency situations;

When planning ERP's, the Package Contractor shall ensure that the following shall be taken into account:

- Site size, characteristics of the site and the work being undertaken;
- Means of raising the alarm under those conditions;
- Plant and equipment to be used in the event of an emergency;
- Location of nearest emergency services and their capabilities;
- Access to the site for emergency services.

The ERP's developed by the Package Contractor shall be specific to the Package Contractor's work package. Topics to be addressed in the plan shall include, but are not necessarily limited to the following:

- A list of all key emergency response personnel on site showing responsibilities and contact details, including all-hours telephone numbers;
- Details of emergency services (police, fire, ambulance, spill clean-up etc.);
- Communications strategy, including liaison with emergency services and the PMNC's representative;
- Emergency provisions on site, including fire prevention, detection and fighting systems, spill prevention and response equipment and first aid facilities;
- Protocols and procedures to be implemented in the event of specific emergency situations;
- Emergency response training;

The Package Contractor shall ensure that the ERP's are submitted to the PMNC for review and approval within 2 weeks of mobilization and prior to any works starting on site. The Package Contractor shall also review and ensure the adequacy of the ERP's as the works progress to accommodate the changes to the site conditions. The Package Contractor will ensure that all changes to the ERP's are approved by the PMNC.

9.3. Emergency communication

The Package Contractor shall ensure that the ERP is reviewed at regular not less than every six months. The Package Contractor shall also bring the contents of the ERP to the attention of the Project personnel during Project Inductions, Tool Box Talks, Safety talks etc. These briefings shall as a minimum include:

- Emergency procedures for different scenarios;

- Location of emergency equipment and supplies;
- Local emergency contacts, hospital routes, evacuation routes, and assembly points;
- Communication methods;
- Names of personnel trained in first-aid and CPR;
- Procedures for contacting Package Contractor and PMNC key personnel.

9.4. Reporting of an emergency

The Package Contractor shall ensure that all emergencies are reported to the PMNC Representative as soon as reasonably practicable. In any state this time frame shall not exceed 1 hour from the time of the incident.

9.5. Emergency Preparedness

The Package Contractor will ensure that an ERP drill is carried out at regular intervals, these intervals shall not be greater than six months. The Package Contractor shall ensure that emergency drills are conducted for all the scenarios that have been identified in the ERP. The Package Contractor shall also ensure that emergency staff including first aid and emergency responders are available and that they participate in the emergency drills. Upon completion of each drill, an evaluation shall be made of the ERP to determine its effectiveness. Any problems or concerns identified during the evaluation will be corrected.

9.6. Emergency Response Team

The Package Contractor shall maintain a nominated team for managing and responding to emergencies throughout the lifecycle of the project. The Emergency Response Team shall consist of project employees who are trained (by a competent third party where required) to respond in emergencies. The Package Contractor shall also ensure that the Emergency Response Team is available on the project on all shifts and that they have ready access to the emergency equipment at all times. Contact details of key personnel within the response team are to be posted on the project to facilitate communication flow in the event of an emergency.

9.7. Emergency Resources

The Package Contractor shall ensure that emergency resources including equipment, materials, transport and personnel, for managing potential emergencies on site are available on the project at all times. This shall include an appropriate number of first aid personnel along with a fully equipped first aid room and/or clinic as well as industry standard firefighting equipment, fire/smoke detection systems, alarms and any other emergency equipment as identified by the ERP.

All incident response resources shall be suitable for the site and activity under consideration.

Equipment, including emergency response PPE, spill kits and firefighting systems, are to be

installed at all locations where high risk activities are being carried out and must be inspected, tested and maintained regularly by the Package Contractor. If any equipment is missing or damaged, it shall be replaced.

10. Section 10: Site Welfare Facilities

The Package Contractor shall ensure that adequate and appropriate arrangements exist for welfare facilities such as first aid, canteen/mess, rest areas, drinking water and toilets. These facilities shall be provided and maintained by Package Contractors. Welfare facilities onsite must be as close as practical to the working locations. Large sites may require multiple facilities to avoid long distance travel.

The Package Contractor is required to develop a specific temporary facilities and welfare plan detailing specific arrangements. This plan must be submitted to the PMNC for review and approval.

10.1. First Aid Room

The Package Contractor shall make adequate arrangements for a first aid room, equipped and staffed to the extent required. The first aid room as a minimum meet the requirements below but in any case will meet any requirements as laid down by local regulations.

- Designated first aid room shall not be used for any other purpose other than for first aid or medical purposes;
- The room shall be identified clearly through first aid signage;
- It shall be located in a way to allow easy access and egress during emergency;
- Shall be spacious enough to accommodate a wheel chair or a stretcher;
- Shall be equipped with adequate facilities and equipment, well illuminated, ventilated, sufficient air conditioning and made up of a surface that is easy to clean;
- Arrangements exist for the disposal of refuse;
- Shall be clearly identified in the emergency plan / layout;
- Shall be equipped with a phone or other means of communication to contact ambulance /hospital/ doctor on call/Company representatives.

10.2. First Aid Box

The Package Contractor shall depending upon the size and location of the site, ensure that first aid boxes are provided at strategic locations & shall be suitably identifiable, and access to them shall be ensured throughout the working hours. The Package Contractor shall also regularly inspect these first aid boxes to ensure that it is fully stocked and items inside are not expired. Records of such inspections shall be maintained and produced to the PMNC during HSE inspections (as required).

10.3. First aider's

The Package Contractor shall ensure that adequate personnel trained on first aid through an approved agency are available on the programme. A copy of the qualification certificate shall be maintained by the Package Contractor for records and this certificate made available upon request from the PMNC (during HSE inspections as required).

Names of the qualified first aid personnel shall be exhibited near the first aid box and other prominent locations on the project and site offices with immediate contact details.

10.4. Nurse/Doctor on call

The Package Contractor shall make appropriate arrangements to attend to the emergency medical situations through the appointment of a male/female nurse/Doctor onsite (as required contractually). Alternatively, the Package Contractor shall ensure that provision is made to ensure that medical assistance is given to any injured person as quickly as possible through a contractual arrangement that may be made with a clinic / approved hospital.

The name/information about the hospital shall be exhibited at prominent locations within the project/site offices and shall be brought to the attention of the project personnel at the time of the induction.

10.5. First Aid Treatment Records

Records of the first aid containing the details of the treatment given, name of the treated person, date and time of accident, place and circumstances, details of injury and treatment given and name of person rendering treatment shall be maintained by the Package Contractor and provided to the PMNC (during HSE inspections as required).

10.6. Canteen/Mess

The Package Contractor shall make adequate arrangements to ensure that project personnel can consume food in a clean & hygienic environment. Canteen/mess facilities shall be established at the site for providing food and beverages to the project personnel. Food may be prepared at the site or pre prepared food may be made available.

The Package Contractor shall ensure that eating areas are suitable for the project personnel using them. For example if the local culture is to consume food whilst sitting on the floor, then the canteen/mess facility shall ensure that there is provision for project personnel to sit on the floor. The canteen/mess facility shall be adequate for the number of personnel and shall accommodate all users.

The Package Contractor shall consider the following when setting up a canteen:

Food preparation area	Sinks – for washing up / hand washing
Drinking water supplies as appropriate	Cold / Hot running water
Washing up liquid	Easy cleaning access
Cutlery & Crockery	Shade
Food storage	Fire extinguisher matched to risk and associated training
Means of escape	Rubbish collection
Rubbish bins with liners	Electrical items tested / certificated

10.7. Rest Areas

The Package Contractor shall ensure that adequate rest areas are provided to its project employees. These rest areas shall be walking distances from the work areas for its project employees. In areas where this is not feasible, the Package Contractor shall provide alternative means for transport such as busses or cars to transport the project employees to the rest areas. The Package Contractor shall ensure that the rest areas are sufficiently covered and shaded. They shall be of sound construction and of suitable materials to be secure, safe and weatherproof. Internally, walls and ceilings shall be constructed of durable materials and shall have lightly coloured, smooth, and easy to clean surfaces. The Package Contractor shall ensure that the ambient temperature in these rest areas are comfortable for the people who use it.

10.8. Drinking water

Adequate drinking water shall be provided to the project employees by the Package Contractor. The Package Contractor shall take into consideration the requirement of drinking water points to be available around the Project site. The drinking water points around the site shall be easily accessible by the project employees. Adequate signage shall be put up to differentiate drinking water from non-drinking water.

10.9. Toilets

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The Package Contractor shall ensure that toilets are provided to for the project employees. Consideration shall be given to male & female toilets (where required). These toilets shall be constructed of solid material which can be washed, is weather proof and must provide adequate privacy. The toilet facilities shall have adequate ventilation such that foul smells do not travel onto nearby work areas. The following rate of provision shall be considered:

- Male: 1 WC and 1 wash basin per 10 men (up to 100)
- However where urinal are provided 1 WC per 25 men (up to 100) and 1 urinal and 1 wash basin per 10 men (up to 100)
- Female: 1 WC and 1 wash basin per 10 women (up to 100)

10.10. Water Tanks

The Package Contractor shall ensure that all water storage tanks are cleaned on a regular basis. The Package Contractor shall ensure that all portable water tanks are cleaned once every three (3) months as a minimum and that the water quality is tested and deemed fit for consumption.

11. Section 11: HSE Enforcement

The Package Contractor is fully responsible to ensure that they comply with all the HSE legislations & contractual HSE requirements. However, the PMNC have the right at any time to audit/inspect the Package Contractors facilities, procedures and safety management systems. The Package Contractor shall fully co-operate in such reviews and shall implement recommendations at its own cost where the PMNC or statutory rules and regulations are contravened. The Package Contractor shall ensure the timely closing out of issues raised via these HSE assessments.

In addition to enforcement requirements stated in legislation and contract requirements, The PMNC will have the advice the Package Contractor to remove from the project of any person who, in the opinion of PMNC, fails to observe HSE procedures. The Package Contractor shall ensure that any persons who have been asked to be removed from the project on HSE grounds is not employed without the written approval from the PMNC.

Where the PMNC observes or is informed of a contravention of the HSE rules/procedures or unsafe acts and if those contraventions/unsafe acts identified are not considered likely to present an immediate risk, but are likely to lead to injury or ill health, the PMNC shall bring these to the attention of Package Contractor.

Where the PMNC observe or is informed of a contravention of the safety rules/procedures or unsafe acts and if those contraventions/unsafe acts identified are considered likely to present an immediate

risk to Personnel then the PMNC shall have the authority to stop such work until remedial actions have been addressed to prevent such unsafe acts from recurring. If contraventions/unsafe acts persist or present an imminent risk of serious injury or ill health to the persons involved, the PMNC shall have the right to stop the work from being performed. In such case, the Package Contractor shall be responsible to take any remedial action at his own time and cost and shall no right to claim for any extension of time or to claim for compensation for the suspension of the work or for the waiving of the liquidated damages. Suspension of work will be measured from the date of issue of an instruction from the PMNC to the Package Contractor to suspend work on that particular part of the Works until the unacceptable safety violation has been fully rectified. In such an instance, Contractor shall not resume provision of the works affected until the PMNC is satisfied that the HSE non-compliance has been rectified.

12. Section 12: HSE Staff

12.1. HSE Personnel

The Package Contractor shall appoint only qualified and suitable HSE personnel to the project. The Package Contractor shall ensure that the Curriculum Vitae (CV) and HSE certifications of the HSE Personnel is submitted to the PMNC prior to mobilizing the individual to the project. No HSE personnel shall be appointed on the programme without written approval from the PMNC.

12.2. Conduct and Competency

The conduct and functioning of the Package Contractor HSE personnel shall be monitored by the PMNC. The Package Contractor shall ensure that all such personnel are competent to perform the job assigned to them. In the event that Package Contractor is unable to demonstrate the competency of any person whose activities can directly affect the Project HSE performance, the PMNC will ask the Package Contractor to remove that person from the Site without any procedural formalities. In cases, where the Package Contractor is unable to find a suitable replacement. The PMNC shall recommend a suitable replacement at the Package Contractors time & cost. Any difference in costs will have to be borne by the Package Contractor. The Package Contractor shall not be entitled to claim any costs or compensation incurred.

12.3. Prohibition of performance of Other Duties

The Package Contractor shall ensure that no HSE personnel shall be required or permitted to do any work that is unrelated to, inconsistent with, or detrimental to the performance of the HSE duties.

12.4. Facilities to be provided to HSE personnel

The Package Contractor shall provide all HSE personnel with the facilities, equipment, and information that are necessary to allow the HSE personnel to carry out his duties effectively. The Package Contractor shall ensure that as facilities and equipment as mentioned below is provided to the HSE department as a minimum.

Minimum Equipment to be Provided to HSE Department		
	Equipment	Specific Details (if any)
1	Digital camera with flash	At least 4 mega pixels & 1 camera per HSE staff
2	Computer (with standard configuration)	Should be available for use at all times and not shared with other departments
3	Colour printer	Access to printer at all times; printer could be a shared resource
4	Communication facility (mobile phone)	1 per staff
5	Communication device (walkie-talkie – capable of being used in hazardous zones – as required)	Minimum 2 pieces
6	Sound level meter	1
7	Lux level meter	1

13. Section 13: Operational Control

The HSE Construction Management underpins how HSE will be managed on SBIA, its Vision & Policies. It will be implemented and managed through a combination of communications, training, monitoring, audit, and review.

Operational control procedures and processes are required in cases where it is foreseeable that, in the absence of such procedures and processes, work activities could be conducted in an unsafe manner, which could then result in accidents or incidents. The PMNC will continue to develop HSE procedures and processes that cover all phases of the programme, these will be sent out through the programme correspondence. Package Contractors are encouraged to contact the PMNC, to ensure that they have the latest version of any HSE process or procedure.

Schedule S - Project Management Requirements

(See Clause 3.1.7 (m))

Project Management requirements.....

Project Management Requirements:

The Contractor shall perform all the Project Management activities necessary for proper planning, management and control of the work. Below are the project management requirements which Contractors needs to comply at different stage of the projects:

1. Participate in the project kick-off workshop with project stakeholders designated by Employer/ PMNC. The kick-off workshop shall accomplish the following objectives:
 - Common understanding of the project goals and objectives
 - Define respective roles and responsibilities and
 - Agree on the methods of communication and reporting throughout the project duration.
2. Participate in monthly project status review meetings and present the project progress update in the meeting. The frequency of project status review meetings may change based on actual requirements.
3. **Schedule:** The Contractor shall submit a Level 3 schedule that cover's the full scope of Contractor's work within 30 calendar days of date of appointment. This will be reviewed within 15 calendar days by Employer/PMNC. The Contractor shall incorporate the comments and resubmit the schedule no later than 15 calendar days after receiving the comments from Employer/ PMNC. Upon approval the level 3 schedule will become the baseline schedule for all the future monitoring and tracking.

The Contractor should keep to the following guidelines

- i) Develop and incorporate a detailed Work Breakdown Structure (WBS) for all project schedules that are submitted.
- ii) All schedules shall be created, maintained and submitted to Employer /PMNC in the latest version of Oracle Primavera P6 or equivalent in an electronic format.
- iii) All schedules shall follow the Critical Path Method (CPM) of scheduling and shall have meaningful and realistic logical ties and relationships between activities.
- iv) The use of negative lags is not permitted in the baseline and all other versions of the schedule.
- v) The schedule must contain all the long lead procurement items identified.
- vi) Shall exercise reasonableness while assigning constraints in schedule and milestones

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- vii) Upon approval, the copy of the Baseline schedule will become the first Current Schedule.
 - viii) The Current schedule shall be actively updated and maintained by the Contractor every month.
 - ix) The updated Primavera P6 or equivalent schedule file should be submitted every month along with Monthly progress report in electronic format. A pdf copy of the updated schedule with all activities also needs to be submitted
 - x) A schedule narrative document shall accompany the updated electronic schedule describing the work performed in the reporting period.
 - xi) The contractor should also submit a level 4 schedule within 60 calendar days from approval of baseline level 3 schedules.
 - xii) In the level 4 schedule activity durations should be reasonable (typically no more than 15 days duration except for project management tasks, procurement activities for long lead items or any other activity that obviously needs to be of longer duration).
4. **Cash Flow:** Prepare project cash flow at the start of the project. Prepare monthly statements to show the actual versus plan spending; update the cost periodically
 5. **Lessons Learned Database:** The Contractor shall develop and actively maintain a “lessons learned” database on a monthly basis (to be included in the monthly project report) and submit it to Employer/ PMNC at the end of the project during closeout.
 6. **Risk Register:** Maintain an active risk register addressing the risks and mitigation measures (could be in excel format) that lists the project risks related to their Scope of Work.
 7. **Inter-Project Links:** Identify potential inter-project links, inter-dependencies or conflicts/ interference to work or work areas and narrate them in the monthly progress report.
 8. **Monthly Progress Report:** Prepare and submit a monthly progress report (standard format and template will be provided by Employer /PMNC at a later date). Items 3 to 7 mentioned above shall be the minimum information that will need to be included in the monthly progress report.
 9. For better collaboration, Contractor shall use the Programme and Document Management system that will be provided by Employer/PMNC at a later date and pay for the cost of procuring licenses to use the system.

Monthly payments are subject to timely submission of monthly progress report and the monthly updated electronic schedule file in the required and acceptable format.

