

Constructional Features for MCC

	Description	Recommended Specification	Confirmation by the Bidders
	MCC		
	Busbar Chamber	400mm ht	
	Metering Chamber	400mm ht	
	Incoming Compartment	1000mm wide Module Single Tier	
	Overall Height	2100 mm	
	Overall Depth	1300 & 900 mm	
	Overall Length	(To be indicated by the bidder)	
	Construction	IP-52 with louvers for ventilation	
	Current Density	1.25 Amp / Sq.mm	
	Main Bus	1.75 Amp / Sq.mm	
	Branch Bus Rating	75% of aggregate Switches connected. 1.25 Amp / Sq.mm Density	
	Neutral Bus	Half of the size of phase bus	
	Earth Bus	Half of the size of phase bus	

	Description	Recommended Specification	Confirmation by the Bidders
	Incoming and outgoing feeders.	As per SLD	
	AHU Panels		
	Accessibility	front accessible only	
	Overall Depth	300 mm	
	Overall Height	700 mm	
	Incoming compartment	Individually one module of 600mm wide with direct entry of incoming cables with cable busbars for terminating multiple incoming cable. incoming metering units and outgoing cables as per SLD.	

12. GALVANISED STEEL SHEETS/PRE-INSULATED DUCT

- a. Make
- b. Thickness/Gage
- c. Class of Galvanizing

13. GRILLES / DIFFUSERS / DAMPERS

Make, material and gauge of the following :

- a. Fire damper, rating, make of damper motor
- b. Smoke damper, rating, make of damper motor
- c. Grilles/Diffuser
- d. Slot Diffuser
- e. Duct Damper
- f. FA Damper
- g. Access Panel.

14. INSULATION

- a. Manufacturer
- b. Duct acoustic lining material & density
- c. Duct insulation material & density
- d. Pipe insulation material & density

15. TESTING AND BALANCING EQUIPMENT

- a. Name of the Agency
- b. Furnish the complete list of equipment to be used on this Project.

Section 5. APPENDIX-V

IV LIST OF BUREAU OF INDIAN STANDARDS CODES

IS : 277 - 1992	Galvanized steel sheet (Plain & Corrugated) wire for fencing.
IS : 554 - 1985 (Reaffirmed 1996)	Dimensions for pipe threads Where pressure tight joints are Required on the threads.
IS : 655 - 1963 (Reaffirmed 1991)	Metal air ducts.
IS : 659 – 1964 (Reaffirmed 1991)	Air conditioning (Safety Code)
IS : 660 – 1963 (Reaffirmed 1991)	Mechanical Refrigeration (Safety Code)
IS : 694 - 1990 (Reaffirmed 1994)	PVC insulated (HD) electric Cables for working voltage upto And including 1100 volts.
IS : 732 - 1989	Code of practice for electrical wiring.
IS : 780 - 1984	Sluice valves for water works purposes.
IS : 822-1970 (Reaffirmed 1991) welds.	Code of procedure for inspection of welds.
IS : 1239 (Part - I) - 1990	Mild steel tube
IS : 1239 (Part - II) - 1992	Mild steel Tubulars and other Wrought steel pipe fittings.
IS : 1255 - 1983	Code of Practice for installation and maintenance of Power Cables upto and including 33 KV rating (Second Revision)

IS : 1554 - 1988 (Part – I)	PVC insulated (Heavy Duty) electric cables for working voltages upto and including 1100 volts.
IS : 1897 - 1983 (Reaffirmed 1991)	Copper bus bar / strip for electrical purposes
IS : 2379 - 1990	Colour code for the identification of Pipelines.
IS : 2551 - 1982	Danger notice plate
IS : 3043 - 1987	Code of practice for earthing.
IS : 3103 – 1975 (Reaffirmed 1999)	Code of practice for Industrial Ventilation.
IS : 3837 - 1976 (Reaffirmed 1990)	Accessories for rigid steel conduit for electrical wiring.
IS : 4736 – 1986 (Reaffirmed 1998)	Hot-dip zinc coatings on steel tubes.
IS : 4894 - 1987	Centrifugal Fan.

IS : 5133 - 1969 (Part-I) (Reaffirmed 1990)	Boxes for the enclosure of electrical accessories.
IS : 5216 - 1982 (Part-I) (Reaffirmed 1990)	Guide for safety procedure and practices in electrical work.
IS : 5312 (Part-I) - 1984 (Reaffirmed 1990)	Swing - check type reflux Non return valves for water works
IS : 5424 – 1989 (Reaffirmed 1994)	Rubber mats for electrical purposes.
IS : 5578 & 11353-1985	Marking and identification of conductors
IS : 6392 - 1971 (Reaffirmed 1988)	Steel pipe flanges.
IS : 8623 - 1993	Low voltage switchgear and control gear Assemblies (Requirement for type / partly type tested assemblies)
IS : 8623 - 1993 (Part - II)	Bus Bar trunking system
IS : 8828 - 1996	Circuit Breakers for over current protection For house hold and similar installation.
IS : 9537 - 1981 (Part II)	Rigid Steel Conduits for electrical wiring
IS : 10810 - 1988	Methods of test for cables.
IS : 13947-1993 (Part-I)	General rules for low voltage switch gears and control gears.
IS: 13947-1993 (Part-II) IEC 947 - 2	Circuit Breakers
IS: 13947 - 1993 (Part-III)	Switches, disconnectors and fuse For low voltage switch gear and control gear.
IS: 13947 - 1993 (Part-IV)	Low voltage switch gear and control gear

	For contactors and motor starters
IS : 13947 – 1993 (Part-V)	Control Circuit Devices.
BS : EN:779 – 1993	Filters
ASHRAE Hand Books	American Society of Heating Refrigeration & Air-conditioning .
	Refrigeration 2010 Fundamentals 2009. Systems & Equipment 2008 HVAC Applications 2007 ASHRAE Indoor air quality Standard 62.1-2010. ASHRAE Standard 90.1-2007. ASHRAE 52.1-2007. ASHRAE 52.2-2007.
IEC	Relevant Sections
ECBC 2007 <Revised Version May 2008>	

Technical Specifications

1. BASIS OF DESIGN

Location

▪ Site Location	:	Dholera
▪ Geographic Location	:	28.35 Deg. N.
▪ Altitude	:	233 m above mean sea level

1.1 OUTDOOR DESIGN CONDITIONS

Outdoor Design Conditions for Dholera

Summer

Dry Bulb Temperature	:	41.8 Deg.C (110 DegF)
Mean Coincident Wet Bulb Temperature	:	23.6 Deg C (74.5 Deg. F)

Monsoon

Mean Coincident Dry Bulb Temperature	:	33.3 Deg C (92 Deg. F)
Wet Bulb Temperature	:	28.4 Deg.C (83 Deg. F)

Winter

Dry Bulb Temperature	:	6.0 Deg.C (42.8 Deg. F)
Mean coincident Wet Bulb Temperature	:	5.2 Deg C (41.4 Deg. F)

1.2 **INDOOR DESIGN CONDITIONS**

Following indoor design conditions are proposed for various spaces inside the Building.

S.No	Space	Indoor Conditions		Noise Criteria (NC)	Minimum Outdoor Air (CFM)
		Temp °C	RH %		
i.	Double Height Area	23±1°C	Not Exceeding 60%	35 - 40	Exceed ASHRAE Standard 62.1 – 2010 by 30%
ii.	Exhibition Hall-1&2	23±1°C	Not Exceeding 60%	30 - 35	
iii.	Meeting Room	23±1°C	Not Exceeding 60%	30 - 35	
iv.	Conference Room	23±1°C	Not Exceeding 60%	30 - 35	
v.	Auditorium	23±1°C	Not Exceeding 60%	30 - 35	

Mechanical Ventilation

Toilet (Private) : 6 ACPH with equivalent amount of conditioned air from adjacent space. Door under cut of 40 mm or double louvered air transfer grilles shall be provided in main entrance door to the Toilet for achieving the desired result.

Smoke exhaust in all offices above Ground. : 12 ACPH Exhaust
 12 ACPH Make up air

1.3 **OUTDOOR AIR VENTILATION RATE IN BREATHING ZONES**

Following Outdoor Air Ventilation rate for centrally air conditioned spaces are proposed :

Space	Outdoor Air Ventilation Rate Based on ASHRAE 62.1-2010
Double Height Area	(5 CFM/Person + 0.06 CFM/Sqft) plus 30% extra for green building.
Exhibition Hall-1&2	(7.5 CFM/Person + 0.18 CFM/Sqft) plus 30% extra for green building.
Meeting Room	(5 CFM/Person + 0.06 CFM/Sqft) plus 30% extra for green building.
Conference Room	(5 CFM/Person + 0.06 CFM/Sqft) plus 30% extra for green building.
Auditorium	(5 CFM/Person + 0.06 CFM/Sqft) plus 30% extra for green building.

1.4 **BUILDING CONSTRUCTION DATA (Assumed)**

Walls	:	U = 0.40 Watt / Sqm °C (0.08 Btu / Hr Sqft °F)
Roof (Exposed to sun) with thermal Insulation	:	U = 0.30 Watt / Sqm °C (0.06 Btu / Hr Sqft °F)
Glass Specifications	:	Double Glass with following details: U = 1.7 Watt / Sq m °C (0.3 Btu / Hr Sqft °F) Solar heat gain Coefficient: 0.25

Note: 1) The above values shall be fine-tuned based on the actual selection of Glass by Architect.

- 2.) Type & thickness of thermal insulation shall be finalized based on the wall & roof construction details in consultation with the Project Architects and the U-values shall be finalized accordingly.

1.5 **DESIGN PARAMETERS**

VRV System		
Performance rating of the VRV Unit shall be based on following design parameters:		
Refrigerant for VRV Units	:	134A/ 410A
Maximum input power for Air Cooled VRV units at full load	:	1.2 IKW/TR

DParameter for selection of Air Handling Unit and its components shall be as follows:

Maximum face velocity across pre-filters	:	100 M/Min
Maximum face velocity across cooling coils	:	150 M/Min
Maximum fan outlet velocity	:	550 M/Min
Maximum fan speed *		
a. Fan above 300 mm dia	:	900 RPM
b. Fans upto and including 300 mm dia	:	1440 RPM
Maximum fan motor speed	:	1450 RPM

Ventilation Fan		
Maximum fan outlet velocity for fan upto 450 mm dia	:	9.14m/se (1800 fpm)
Maximum fan outlet velocity for fan above 450 mm dia	:	12m/sec(2400 fpm)
Maximum fan speed for fans upto 450 mm dia	:	1440 RPM
Maximum fan speed for fans above 450 mm dia	:	1000 RPM
Duct Design		
Maximum flow velocity in ducts for air conditioning	:	7.5m/sec(1500 fpm)
Maximum flow velocity in ducts for ventilation in pump room, toilet exhaust.	:	7.5 m / sec – 12.5 m / Sec(1500 – 2500 FPM)
Maximum friction	:	0.65 Pa / M run (0.08 inch WG/100 ft run)

STEM DESCRIPTION

1.6.1 VARIABLE REFRIGERANT VOLUME CONTROL

The proposed air conditioning system shall consist of air cooled centralized outdoor unit comprising of multiple scroll compressors for each area. All air conditioned spaces in the building shall be provided with required capacity Ceiling suspended type indoor unit as per client requirement. These indoor units shall be connected to outdoor units through copper refrigerant pipe system. Compressor in the outdoor unit shall be connected to a variable frequency drive whereby refrigerant flow through copper pipe shall be varied based on the AC load. The outdoor unit shall have built-in energy efficiency features like capacity control, oil return operation controls, intelligent defrost control and compressor control etc.

The indoor units shall be similar in operation and appearance as conventional indoor units of split units and provide independent on-off control, temperature setting etc. The system shall provide considerable (nearly 30%) energy saving over traditional air-conditioning system (consisting of split units) due to following features:-

Individual accurate temperature

1. Multiple compressors in outdoor unit (8 HP & Above) in conjunction with inverter drive compressor to modulate refrigerant flow based on requirement.
2. Minimizing heat transfer losses due to superior refrigerant piping system with eco friendly Refrigerant.

Temperature setting of each indoor unit shall be controllable through individual corded micro-processor based controller.

1.6.2 AIR HANDLING UNITS

Constant volume double skin (for noise control) air handling units consisting of centrifugal fan (direct Driven), DX cooling coil (with AHU KIT) and filter section shall be provided for each area. Supply air ducts shall be installed in ceiling spaces. Conditioned supply air shall be discharged through supply air grilles and diffusers. Return air shall be taken back to the air handling unit room generally through return air ducts, or through ceiling spaces (where return air duct is not possible).

2. VARIABLE REFRIGERANT FLOW SYSTEM

2.1 SCOPE

The scope of this section comprises the supply, erection, testing and commissioning of Variable Refrigerant Volume System conforming to these specifications and in accordance with the requirements of Drawings and Schedule of quantities.

2.2 TYPE

Unit shall be air cooled, variable refrigerant volume air conditioner consisting of one outdoor unit and multiple indoor units. Each indoor unit having capability to cool independently for the requirement of the rooms. All indoor units shall be provided with isolation valves so that a particular unit can be isolated and removed for servicing, while system keeps functioning in normal way.

It shall be possible to connect multiple indoor unit on one refrigerant circuit as shown in the drawings or as indicated in schedule of quantities. The indoor units on any circuit can be of different type and also controlled individually. Following type of indoor units shall be connected to the system:

- Ceiling mounted duct able type.

Compressor installed in outdoor unit shall be equipped with capacity control mechanism and capable of changing the rotating speed / mass flow rate of refrigerant by scroll engaging / dis engaging mechanism to follow variations in cooling. Outdoor unit shall be suitable for mix-match connection of all type of indoor units.

The refrigerant piping between indoor units and outdoor units shall be extended upto 100m with maximum 50 m level difference without any oil traps. Oil recovery system shall be managed without disturbance to normal operation cycle of the system / compressor.

Both indoor unit and outdoor unit shall be factory assembled, tested and filled with first charge of refrigerant before delivery at site.

2.3 OUT DOOR UNIT

The outdoor unit shall be factory assembled, weather proof casing constructed from heavy gauge mild steel panels with powder coated finish.

All outdoor units above 5 HP rating shall have minimum two number scroll compressors.

In case of outdoor units with multiple compressors, the operation shall not be disrupted with failure of any compressor.

The noise level shall not be more than 60 dB (A) at normal operation measured horizontally 1 m away and 3.5 m above ground level.

The outdoor unit shall be modular in design with possible future expansions.

The unit shall be provided with microprocessor control panel.

2.4 **COMPRESSOR**

The compressor shall be high efficiency scroll type and capable for capacity controlling. It shall change the speed / refrigerant mass flow rate in accordance to the variation in cooling load requirement. Refrigerant mass flow rate can be changed by speed modulation of compressor / mechanical control system. System shall incorporate liquid sub-cooling mechanism with liquid injection at intermediate pressure.

The inverter if used shall be IGBT (insulated gate bipolar transistor) type for efficient and quiet operation.

All outdoor units shall have multiple steps of capacity control to meet load fluctuation and indoor unit individual control. All parts of compressor shall be sufficiently lubricated. Forced lubrication may also be employed.

Oil heater shall be provided in the compressor casing.

2.5 **HEAT EXCHANGER**

The Heat Exchanger shall be constructed with copper tubes mechanically bonded to aluminum fins to form a cross fan coil and larger surface area.

The fins shall have anticorrosion treatment for Heat Exchanger Coil. The treatment shall be suitable for areas of high pollution, moisture and salt laden air.

The casings, fans, motors etc. shall also be with anticorrosion treatment as a standard features.

The unit shall be provided with necessary number of direct driven low noise level propeller type fans arranged for vertical / horizontal discharge. Each fan shall have a safety guard.

2.6 REFRIGERANT CIRCUIT

The Refrigerant Circuit shall include an liquid receiver /accumulator, liquid & gas shut off valves and a solenoid valve. All necessary safety devices shall be provided to ensure the safety operation of the system..

2.7 SAFETY DEVICES

All necessary safety devices shall be provided to ensure safe operation of the system.

Following safety devices shall be part of the outdoor unit : high pressure switch, low pressure switch, fuse, crankcase heater, fusible plug, over current protection for inverter, and short recycling guard timer.

2.8 PIPING

All connections of Refrigerant piping shall be in high grade Copper of Refrigeration quality with Eddy Current Testing and material test Certificates.

All connections, tees, reducers etc. shall be standard make fittings.

Insulation of cold lines shall be carried out with Armaflex / K-Flex insulation sheets and tubes of appropriate thickness so that condensation does not occur.

For individual Piping 50 / 100 mm wide Aluminum Tape shall be used at joints of Piping with Bands for identification.

For outdoor piping, the finish shall be woven GRP Mat finished with coloured Epoxy paints to withstand outside ambient conditions and UV Radiation.

2.9 OIL RECOVERY SYSTEM

Unit shall be equipped with an oil recovery system to ensure stable operation with long refrigerant piping.

System shall be designed for proper oil return to compressor along with the distribution of oil to individual compressor.

The refrigerant piping shall be extended upped 100 M with 50-M level difference without oil traps.

2.10 **INDOOR UNITS**

Units shall be factory assembled, wired, piped and tested.

Units shall have DX coils with copper tubes and bonded aluminium fins for highly efficient heat transfer.

Units shall have Centrifugal fans for adequate amount of Air circulation and low Noise.

Units shall have inlet filters, which are easily cleanable and replaceable.

All components of Units are easily accessible for connection, repairs and maintenance.

Units shall have very low noise.

All units with Factory manufactured Units, Grills shall have auto swing feature for proper Air distribution.

All unit shall be controlled by electronic Expansion Valves only.

All units mounted inside the ceiling shall have fans capable of sustaining duct connections, and special filters if necessary.

Visible indoor units shall have wireless remotes. Price of the same shall be included in cost of unit by default.

Concealed indoor units shall have sensor mounted on supply air grilles / diffusers which can be controlled with wireless remotes.

Anticorrosion treatment for avoiding corrosion of coils.

All units shall have adequate insulation or Lining to avoid condensation.

Cooling coil and refrigeration parameters shall be designed in such a way that supply air temperature shall not be less than 14⁰C or 1⁰C above room dew point temp, whichever is more. Contractor shall guarantee inside conditions with selected supply air temperature.

2.11 CEILING MOUNTED CASSETTE TYPE UNIT (MULTI-FLOW TYPE)

The unit shall be ceiling mounted type. The unit shall include pre-filter, fan section and DX-coil section. The housing of the unit shall be powder coated galvanized steel. The body shall be light in weight and shall be possible to suspend from four corners.

Unit shall have a external attractive panel for supply and return air. Unit shall have four way supply air grilles on sides and return air grille in centre.

Each unit shall have high lift drain pump, fresh air intake provision (if specified), low gas level detection system and very low operating sound.

2.12 CEILING MOUNTED DUCTABLE TYPE UNIT

Unit shall be suitable for ceiling mounted type. The unit shall include pre filter, fan section & DX-coil section. The housing of unit shall be light weight powder coated galvanized steel. The unit shall have high static fan for duct able arrangement.

2.13 HIGH WALL MOUNTED UNITS

The units shall be high wall mounted type. The unit shall include pre-filter, fan section & DX-coil section. The housing of unit shall be light weight powder coated galvanized steel.

Unit shall have an attractive external casing for supply and return air.

2.14 FLOOR MOUNTED UNITS

The unit shall be suitable for floor mounting. The unit shall include, pre-filter fan section, DX. Coil section. The housing of unit shall be light weight powder coated galvanized / anodized aluminium panels. Unit shall have an attractive external casing with supply & return air grilles.

2.15 CENTRAL REMOTE CONTROLLER (OPTION IF SPECIFIED IN BOQ)

A multi-functional microprocessor based centralized controller (central remote controller) shall be supplied as an optional accessory.

The controller shall be able to control upto min. 64 zones of 64 group (each group consisting of max. 16 units) or 128 nos. of indoor units with the following functions.

- Temperature setting for each zone, or group, or indoor unit.
- On/Off as a zone or individual unit.
- Indication of operating condition.
- Select ON of all operation modes for each zone..
- The controller shall have wide screen liquid crystal display and shall be wired by a non-polar 2 wire transmission cable to a distance of 1000m away from the indoor unit.
- The controller shall be integrated to BAS system thru software for monitoring & controlling of all above parameters including start/ stop of each indoor / outdoor unit. All necessary interface cards / units should be supplied as a part of the system to integrate to the BAS Software.

2.16 UNIFIED ON/OFF CONTROLLER (OPTION IF SPECIFIED IN BOQ)

Unified ON / OFF controller shall be supplied as an optional accessory.

The controller shall be able to control minimum 2 groups (each group containing maximum 16 indoor units) or 128 nos. of indoor units with the following functions.

- On / Off as a zone or individual unit.
- Indication of operation condition of each group.
- Select one of 4 operation modes.

The controller shall be wired by a non-polar 2 wire transmission cable to distance of 1 km away from indoor unit.

The controller shall be integrated to BAS system thru software for monitoring & controlling of all above parameters including start/ stop of each indoor / outdoor unit. All necessary interface cards / units should be supplied as a part of the system to integrate to the BAS Software.

2.17 **ELECTRICAL INSTALLATION**

For Variable Refrigerant flow systems, power will be provided near outdoor unit location. HVAC Contractor to provide suitable distribution panel along with 3-phase power to outdoor units and single phase power to all indoor units fed by these outdoor units. Power / control cabling along with supports shall be included.

3. **FANS**

3.1 **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.

3.2 **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.

3.3 **CAPACITY**

The air-moving capacity of fans shall be as shown on Drawings and in Schedule of Quantities.

3.4 **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 shall 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 especially 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.

HP	POWER FACTOR			EFFICIENCY		
	FL	3/4L	1/2L	FL	3/4L	1/2L
0.50	0.71	0.62	0.50	73.00	73.00	68.00
0.75	0.74	0.64	0.50	78.00	78.00	70.00
1.00	0.76	0.67	0.55	82.50	82.50	77.00
1.50	0.77	0.70	0.57	83.80	83.80	80.00
2.00	0.77	0.70	0.57	85.00	85.00	81.00
3.00	0.82	0.74	0.60	86.40	86.40	84.00
5.00	0.82	0.78	0.63	88.30	88.30	86.00
7.50	0.85	0.80	0.71	89.50	88.50	88.00
10.00	0.86	0.83	0.76	90.30	90.30	89.00
12.50	0.84	0.82	0.73	90.50	90.50	88.00
15.00	0.85	0.83	0.76	91.50	91.50	89.50
20.00	0.85	0.83	0.76	92.20	92.20	91.00
25.00	0.85	0.82	0.76	92.40	92.40	91.00
30.00	0.85	0.80	0.72	92.80	92.80	92.00
40.00	0.86	0.85	0.80	93.20	93.20	91.00
50.00	0.87	0.85	0.77	93.60	93.60	91.60
60.00	0.88	0.86	0.78	93.90	93.90	91.90
75.00	0.87	0.85	0.78	94.20	94.20	92.80

- 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.

3.5 **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 aluminum 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.
- b. Motor: shall be energy efficient squirrel-cage, totally-enclosed, fan cooled, standard frame, constant speed, continuous duty, single winding, suitable for 415±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.

- a.
- b.

<u>HP</u>	POWER FACTOR			EFFICIENCY		
	FL	3/4L	1/2L	FL	3/4L	1/2L
0.50	0.71	0.62	0.50	73.00	73.00	68.00
0.75	0.74	0.64	0.50	78.00	78.00	70.00
1.00	0.76	0.67	0.55	82.50	82.50	77.00
1.50	0.77	0.70	0.57	83.80	83.80	80.00

2.00	0.77	0.70	0.57	85.00	85.00	81.00
3.00	0.82	0.74	0.60	86.40	86.40	84.00
5.00	0.82	0.78	0.63	88.30	88.30	86.00
7.50	0.85	0.80	0.71	89.50	88.50	88.00
10.00	0.86	0.83	0.76	90.30	90.30	89.00
12.50	0.84	0.82	0.73	90.50	90.50	88.00
15.00	0.85	0.83	0.76	91.50	91.50	89.50
20.00	0.85	0.83	0.76	92.20	92.20	91.00
25.00	0.85	0.82	0.76	92.40	92.40	91.00
30.00	0.85	0.80	0.72	92.80	92.80	92.00
40.00	0.86	0.85	0.80	93.20	93.20	91.00
50.00	0.87	0.85	0.77	93.60	93.60	91.60
60.00	0.88	0.86	0.78	93.90	93.90	91.90
75.00	0.87	0.85	0.78	94.20	94.20	92.80

- 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 heavy duty spring isolators type.
- f. Accessories : The following accessories shall be provided with all fans :
- i. Outlet cone for static pressure regain.
 - ii. Inlet cone.

Fan silencers may be provided where specifically called for in Schedule of Quantities. Fans shall be factory assembled and shipped with all accessories factory-mounted.

V

Axial Flow Fan shall be AMCA certified for Air and Sound performance in accordance to AMCA 210 and AMCA 300

Axial Flow Fan (for Fire, Smoke)

The fans shall be of the direct drive axial type with cast aluminum aero foil propellers and shall be suitable for mounting in duct or floor/slab as required/indicated on the tender drawings. The casing shall be constructed of continuously welded steel and include integral punched inlet and outlet flanges to prevent air leakage and shall withstand 250 degree 2 hours. The casing and motor base shall be constructed and formed members of heavy gauge steel to prevent vibration and rigidly support the motor. Motor support brackets shall be welded to fan casing for increased strength. Motors for emergency fire, smoke and heat ventilation shall certified according to stand BS EN 12101-3:2002 for 250°C for 2 hours.

Blades shall be aero foil design. Hub and blades shall be a high strength cast aluminum alloy and shall withstand 250°C for 2 hours. Blade pitch shall be manually adjustable without removing from the fan casing. Rotors shall be statically and dynamically balanced.

All Fan casing are with integral punched flanges for sizes up through size 1600mm dia and shall be constructed of rolled steel with a continuous seam weld. Casing to be coated with a minimum of 2 coats of high temperature paint or Powder coated after phosphating process. Motor support framework to be constructed of structural steel that is suitable to handle the weights of the motor and propeller. Motor supports within the fan housing to be welded to the fan casing. Bolted construction is not acceptable. The impeller and fan casing shall be carefully matched and shall have precise running tolerances for maximum performance and operating efficiency.

Complete Fan assembly (Fan Impeller, Fan Casing, Motor base frame along with Motor) shall be tested and approved by Exova Warring ton fire in accordance with BS EN 12101-3:2002 standard for "Powered Smoke and Heat Exhaust Ventilators for Smoke Control Systems" for (250° C) temperature for 2 hours of operation.

3.6 **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 venturi 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 aluminum 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 pre-lubricated 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 bird screen 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 preventers for 3 phase fans.

3.7 **PERFORMANCE DATA**

All fans shall be selected for the lowest operating noise level. Capacity ratings, power consumption, with operating points clearly indicated, shall be submitted and verified at the time of testing and commissioning of the installation.

3.8 **TESTING**

Capacity of all fans shall be measured by an anemometer. Measured air flow capacities shall conform to the specified capacities and quoted ratings. Power consumption shall be computed from measurements of incoming voltage and input current.

4. **AIR DISTRIBUTION**
(FOR DUCTS FABRICATED IN FACTORY)

4.1 **SCOPE AS PER “SMACNA” STANDARDS)**

The scope of this section comprises supply fabrication, installation and testing of all sheet metal / aluminium ducts, supply, installation, testing and balancing of all grilles, registers and diffusers. All to be in accordance with these specifications and the general arrangement shown on the Drawings.

4.2 **DUCT MATERIALS**

4.2.1 **RAW MATERIALS**

Galvanizing shall be Class VII – light coating of zinc, nominal 180gm/sq.m surface area and Lock Forming Quality prime material along with mill test certificates. 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.

4.2.2 **GAUGES, BRACING BY SIZE OF DUCTS**

All ducts shall be factory fabricated from galvanized steel / aluminium of the following thickness, as indicated as below:

4.2.2.1 For Ducts with external SP upto 250 Pa (25mmWg)

Rectangular Ducts G. S.	Pressure 250 Pa		
	Duct Section Length 1.2 m (4 ft)		
Maximum Duct Size	Gauge	Joint Type	Bracing Spacing
1-750 mm	26	C & SS	Nil
751 – 1000 mm	26	4 Bolt Transverse Duct Connector-E (TDC) with built in sealant	Nil
1001 – 1200 mm	24	4 Bolt TDC –E	Nil
1201 – 1500 mm	24	4 Bolt TDC-H	Nil
1501 – 1800 mm	22	4 Bolt TDC-H	Nil
1801 – 2100 mm	20	4 Bolt TDC-J	Zeebar stiffener 1-S
2101 – 2700 mm	18	4 Bolt TDC-J	Zeebar stiffener 1-S

4.3 **FABRICATION STANDARDS & EQUIPMENT**

All duct construction and installation shall be in accordance with SMACNA standards. In addition ducts shall be factory fabricated utilizing the following machines to provide the requisite quality of ducts.

1. Coil (Sheet metal in Roll Form) lines to facilitate location of longitudinal seams at corners/folded edges only, for required duct rigidity and leakage free characteristics. No longitudinal seams permitted along any face side of the duct.
2. All ducts, transformation pieces and fittings to be made on CNC profile cutter for requisite accuracy of dimensions, location and dimensions of notches at the folding lines.
3. All edges to be machine treated using lock formers, flanges and rollers for turning up edges.
4. Kitchen exhaust ducting shall be with 16 G GI welded construction. Suitable access doors shall be provided at every 3m. Provision shall be made for firefighting agency to install duct mounted sprinklers at every 3m. Generally exhaust ducts shall have slope towards kitchen hood.

4.4 **DUCT CONSTRUCTION**

4.4.1 All ducts shall be fabricated and installed in workmanlike manner, conforming to relevant SMACNA codes.

- a) Ducts so identified on the Drawings shall be acoustically lined and insulated from outside as described in the section “Insulation” and as indicated in schedule of Quantities. Duct dimensions shown on drawings, are overall sheet metal dimensions inclusive of the acoustic

lining where required and indicated in Schedule of quantities. The fabricated duct dimensions should be as per approved drawings and care should be taken to ensure that all connecting sections are dimensionally matched to avoid any gaps.

- b) Ducts shall be straight and smooth on the inside with longitudinal seams shall be airtight and at corners only which shall be either Pittsburgh or snap button as per SMACNA practice, to ensure air tightness.
- c) All ducts up to 75cms width within conditioned spaces shall have C&S connector. The internal ends of slip joints shall be in the direction of airflow. Care should be taken to ensure that Cleats are mounted on the longer side of the duct and Cleats on the shorter side. Ducts and accessories within ceiling spaces, visible from air-conditioned areas shall be provided with two coats of mat black finish paint.
- d) Changes in dimensions and shape of ducts shall be gradual (between 1:4 and 1:7). Air-turns (vanes) shall be installed in all bends and duct collars designed to permit the air to make the turn without appreciable turbulence.
- e) Ducts shall be fabricated as per details shown on Drawings. 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.
- f) All sheet metal connection, partitions and plenums, required to confine the flow of air to and through the filters and fans, shall be constructed of 18 gauge GSS / 16gauge aluminum, thoroughly stiffened with 25mm x 25mm x 3mm galvanized steel angle braces and fitted with all necessary inspection doors as required, to give access to all parts of the apparatus. Access doors shall be not less than 45cm x 45cm in size.
- g) Plenums shall be shop/factory fabricated panel type and assembled at site. Fixing of galvanized angle flanges on duct pieces shall be with rivets heads inside i.e. towards GS sheet and riveting shall be done from outside.
- h) Self-adhesive Neoprene rubber / UV resistant PVC foam lining 5mm nominal thickness instead of felt, shall be used between duct flanges and between duct supports in all ducting installation.

4.5 **INSTALLATION PRACTICE**

All ducts shall be installed generally as per tender drawings, and in strict accordance with approved shop drawings to be prepared by the Contractor:

- a) 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
- b) 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 necessary to avoid beams or other structural work, plumbing or other pipes, and conduits, the ducts shall be transformed, divided or curved to one side (the required area being maintained) all as per the site requirements.

- b) If a duct cannot be run as shown on the drawings, the contractor shall install the duct between the required points by any path available in accordance with other services and as per approval of owner's site representative.
- c) All ductwork shall be independently supported from building construction. All horizontal ducts shall be rigidly and securely supported, in an approved manner, as per below duct hanger details (Shedule-1) of galvanized steel rods and galvanized steel angle/channel or a pair of brackets, connected by galvanized steel rod under ducts. The spacing between supports should be not greater than 2.0 meter. All vertical ductwork shall be supported by structural members on each floor slab. Duct supports may be through galvanized steel insert plates left in slab at the time of slab casting. Galvanized steel cleat with a hole for passing the hanger rods shall be welded to the plates. Trapeze hanger formed of galvanized steel rods shall be hung through these cleats. Wherever use of metal insert plates is not feasible, duct support shall be through dash/anchor fastener driven into the concrete slab by electrically operated gun. Hanger rods shall then hang through the cleats or fully threaded galvanized rods can be screwed into the anchor fasteners.
- d) Alternatively, if mentioned in the BoQ, all ductwork shall be independently supported from building construction. All horizontal ducts shall be rigidly and securely supported, in an approved manner, with trapeze hangers formed of galvanized steel rods and galvanized steel angle/channel or a pair of brackets, connected by galvanized steel rod under ducts. The spacing between supports should be not greater than 2.0 meter. All vertical ductwork shall be supported by structural members on each floor slab. Duct supports may be through galvanized steel insert plates left in slab at the time of slab casting. Galvanized steel cleat with a hole for passing the hanger rods shall be welded to the plates. Trapeze hanger formed of galvanized steel rods shall be hung through these cleats. Wherever use of metal insert plates is not feasible, duct support shall be through dash/anchor fastener driven into the concrete slab by electrically operated gun. Hanger rods shall then hang through the cleats or fully threaded galvanized rods can be screwed into the anchor fasteners.
- e) Ducting over furred ceiling shall be supported from the slab above, or from beams after obtaining approval of Owner's site representative. In no case shall any duct be supported from false ceiling 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.
- f) Where ducts pass through brick or masonry openings, it shall be provided with 25mm thick **TF quality expanded polystyrene around the duct and totally covered with fire barrier mortar for complete sealing.**
- g) 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. Flexible connections shall be constructed of fire retarding flexible heavy canvas sleeve at least 10cm long securely bonded and bolted on both sides. Sleeve shall be made smooth and the connecting ductwork rigidly held by independent supports on both sides of the flexible connection. The flexible connection shall be suitable for pressure at the point of installation.
- h) Duct shall not rest on false ceiling and shall be in level from bottom. Taper pieces shall taper from top.

4.6 **DAMPERS**

- a. Dampers : All duct dampers shall be opposed blade louver dampers of robust 16 G GSS construction and tight fitting. The design, method of handling and control shall be suitable for the location and service required.
- b. Dampers shall be provided with suitable links levers and quadrants as required for their proper operation. Control or setting device shall be made robust, easily operable and accessible through suitable access door in the duct. Every damper shall have an indicating device clearly showing the damper position at all times.
- c. Dampers shall be placed in ducts at every branch supply or return air duct connection, whether or not indicated on the Drawings, for the proper volume control and balancing of the air distribution system.
- e. Pressure relief dampers: Pressure relief dampers shall be constructed with 18G Aluminum construction with parallel blade construction. Leafs shall be 100% air tight upon closure. Leafs shall be loaded with spring pressure of stiffness (k value) corresponding to set point pressure.
- f. Non return damper (Back draft damper) : Non return damper shall be constructed out of 16G GSS. Blades shall ensure 100% air leak proof performance on closure. Design shall ensure that no rattling noise is produced at design duty.

4.7 **FIRE & SMOKE DAMPERS**

- a. All supply and return air ducts at AHU room crossings and at all floor crossings or as indicated in the drawings shall be provided with Motor operated Fire & smoke damper of at least 90 minutes rating. 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. The dampers shall meet the requirements of NFPA90A, 92A and 92B. Dampers shall have a fire rating of 1.5 Hrs. in accordance with latest edition of UL555 and shall be classified as Leakage Class 2 smoke damper in accordance with latest version of UL555S. Each fire/smoke damper shall be AMCA licensed and bear the AMCA seal for air Performance. Pressure drop shall not exceed 7.5Pa when tested at 300m/min face velocity on 600x600mm size damper. Actuator shall be UL listed.
- b. Each damper shall be supplied with factory mounted sleeve of galvanized steel of thickness as per SMACNA and of minimum 500mm long or as specified in schedule of quantities depending up on the wall thickness. The damper shall be fitted in to sleeve either using welding or self-tapping screws. All welded joints shall be finished using heat resistance steel paint . UL listed and approved Silicon sealant shall be applied at all corners as well as at joints between damper frame and sleeve. Damper Frame shall be a roll formed structural hat channel , reinforced at corners, formed from a single piece of 1.6mm galvanized steel . Damper blades shall be airfoil shaped (equivalent to 2.3mm thickness strength) roll formed using 0.8mm thick single piece of galvanized sheet. Bearings shall be of stainless steel fitted in an extruded hole in the damper frame. Blade edge seals shall be silicone rubber and galvanized steel mechanically locked in to the blade edge (adhesive type seals are not acceptable).

Side Jam seals of stainless steel and Top and bottom seals of galvanized steel shall be provided. All galvanized steel used shall be with minimum 180GSM Zinc coating Bigger size Dampers shall be supplied in Multiple modules of sizes not exceeding in dimensions of certified module, jack shafted together. Multiple actuators shall be provided for large dampers with higher torque requirements as prescribed in UL.

- 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. Electric Actuator of suitable Torque and as approved by UL shall be factory mounted and tested. The actuator shall be suitable for 24V AC supply. In addition actuator shall have elevated temperature rating of 250 deg.F. Electric Actuator shall have been energized hold open tested for a period of at least one year with no spring return failure. Each fire/smoke damper shall be equipped with a heat actuated release device which shall allow controlled closure of damper rather than instantaneous to prevent accident.(Electrical fusible link).The EFL shall allow the damper to reopen automatically after a test, smoke detection or power failure condition. The damper shall be equipped with a device to indicate OPEN and CLOSE position of Damper blades through a link mounted on the damper blade.
- 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 it's 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 and installation 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.

4.8 FIRE DAMPERS

- a. Whenever a supply/return duct crosses from one fire zone to another, it shall be provided with approved fire damper of at least 1½ hour fire rating as per UL555/1995 tested by CBRI. This shall be curtain type fire damper.
- b. Fire damper blades shall be one piece folded high strength 16 gage galvanised steel construction. In normal position, these blades shall be gathered and stacked at the frame head providing maximum air passage and preventing passing air currents from creating noise or chatter. The blades shall be held in position through fusible link of temp 70° C. The HVAC contractor shall supply UL classified Fire Dampers meeting or exceeding the specifications. Fire Dampers shall be furnished and installed at locations shown in Drawings and as described in Schedule of quantities. Fire Dampers shall have a fire rating of 1.5/3 Hrs.as specified in BOQ, in accordance with latest edition of UL555. Each Fire damper shall be AMCA licensed and shall bear the AMCA seal for air performance.

Damper shall be equipped with UL labeled Fusible Link with Temperature setting 165 or 212deg. F or as specified in Bill of quantities. Fire dampers shall have been tested to close under dynamic air flow conditions with pressure up to 1000 pa and velocities up to 10.2 m

/sec. Fire damper shall be approved for Horizontal or vertical installation as may be required by the location shown in the drawings.

Damper Frame shall be a roll formed structural hat channel, reinforced at corners, formed from a single piece of 1.6mm galvanized steel. Damper blades shall be roll formed 3-v groove (1.6mmthick) or airfoil shaped in case of 3 Hrs. fire rating (equivalent to 2.3mm thickness strength) roll formed using 0.8mm thick single piece of galvanized sheet. Bearings shall be of stainless steel fitted in an extruded hole in the damper frame. All galvanized steel used shall be with minimum 180GSM Zinc coating Bigger size Dampers shall be supplied in Multiple modules of sizes not exceeding in dimensions of certified module jack shafted together.

Fire damper shall be equipped with a electric limit switch to indicate open and close position of the damper blades.

Fire Damper shall be installed in wall or floor opening using galvanized steel sleeve of minimum 435mm length of sheet thickness as per SMACNA and as per Installation instruction of Manufacturer.

- c. In case of fire, the intrinsic energy of the folded blades shall be utilized to close the opening. The thrust of the suddenly released tension shall instantly drive the blades down and keep it down without the use of springs, weights or other devices subject to failure.
- d. Fire damper sleeves and access doors shall be provided within the duct in accordance with the manufacturer's recommendation.
- e. The contractor shall also furnish to the Owner, the necessary additional fusible links (spares), as recommended by the manufacturer, at the time of commissioning of the installation.

4.9 **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 Anodised 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 anodised 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 anodised in black color 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 anodised aluminium in mat black shade.

4.10 **SUPPLY AND RETURN AIR DIFFUSERS**

Supply and return air diffusers shall be as shown on the Drawings and indicated in Schedule of Quantities. Mild steel diffusers/dampers shall be factory coated with rust-resistant primer. Aluminium diffusers shall be powder coated & made from extruded aluminium section as specified in schedule of quantities.

- a. Rectangular Diffusers shall be steel / extruded aluminium construction, square & rectangular diffusers with flush fixed pattern for different spaces as per schedule of quantities These shall be selected in consultation with the Architect. These shall be procured only after obtaining written approval from Architect for each type of diffuser.
- b. Supply air diffusers with shall be equipped with fixed air distribution grids, removable key-operated volume control dampers, and anti-smudge rings as required in specific applications, and as per requirements of schedule of quantities. All extruded aluminium diffusers shall be provided with removable central core and concealed key operation for volume control damper.
- c. Linear Diffuser shall be extruded aluminium construction with removable core, one or two way blow type. Supply air diffusers shall be provided with volume control/ balancing dampers within the supply air collar. Diffusers for different spaces shall be selected in consultation with the Architect, and provided as per requirements of schedule of quantities. All diffusers shall have volume control dampers of extruded aluminum construction anodized in mat black shade.
- d. Slot Diffuser shall be extruded aluminium construction multislot type with air pattern controller provided in each slot. Supply air diffusers shall be provided with Hit & Miss volume control dampers in each slot of the supply air diffusers. Diffusers for different spaces shall be selected in consultation with the Architect and provided as per requirement of Schedule of Quantities.

- e. Data centers shall be provided with floor grilles. Grilles shall be of nominal size of 600mm x 600mm and shall be fitted in floor tile of false floor. Grille shall be with dampers for flow control. Grill shall be heavy duty 16G Aluminium and shall take care of human traffic load. Damper shall be operable in situ without requirement of removal of grille.

4.11 **FIRE RATED DUCTWORK**

Ducting for kitchen exhaust & fire evacuation shall be fire rated as per following specifications.

- a. All fire rated ductwork constructed for mechanical or dual ventilation / pressurization / basement car park / smoke extract systems and kitchen exhaust shall be fabricated from Lock Forming Quality grade prime Galvanized Steel Sheet, constructed to enhanced SMACNA American/DW144 European standard to either low, medium or high velocity/ pressure.
- b. Test requirement of fire rated ductwork should be tested to BS476: Part 24 [1987] and ISO 6944 providing required fire rating for Stability and Integrity.
- c. Stability: the ability of a duct, ductwork & the support system to remain intact & fulfill their intended function for a specified period of time, when tested to the requirements of BS476: Part 24 and ISO 6944.
- d. Integrity: the ability of a duct or ductwork to remain free of cracks, holes or openings out side the compartment in which the fire is present for a specified period of time, when tested to the requirements of BS476 Part 24 ISO 6944.
- e. Insulation: the ability of a duct or ductwork to maintain its separating function without developing temperatures on its external surface outside the compartment in which the fire is present, which exceeds, (i) 140^oC as an average value above ambient & or, (ii) 180^oC as maximum value above ambient at any point, when tested for a specified period of time to the requirements of BS476: Part 24 ISO 6944.
- f. Its important that the fire rated ductwork has a smooth internal surface in order to minimize the pressure loss within the fire rated ductwork system thereby reduce the power requirements.
- g. All fire rated ducts for Smoke Extract Duct shall have Stability / Integrity and Insulation for smoke temperatures up to 300^oC upto 1.5 hrs, restriction of the duct due to twisting or buckling after the fire test shall not cause 25% or more reduction in cross sectional area proven by certification from an independent test house.
- h. Each duct shall have fire rated coating. Fire rated coating compound used for construction of fire rated ductwork shall be protected with minimum 0.7mm to 1mm nominal thickness tested to properties as per the requirements of BS 476: 6 & 7, including non-combustibility Class O and fire propagation - Class 1 surface spread of flame & materials in accordance with Building Regulations.
- i. Fire duct to be tested / assessed to BS476: Part 24 for all sizes up to 25 meters x 3 meters cross-sectional area and fully certified to vertical and horizontal plane.
- j. Fire rated duct fabricated to Method 3 of BS 5588: Part 9, factory produced. The coating compound shall be applied either offsite or onsite on the ground, dried and cured.
- k. Fire duct expansion under fire conditions shall not exceed following,
 - at 430^oC an expansion of 0.006106mm per mm
 - at 600^oC an expansion of 0.00852mm per mm
 - at 1100^oC an expansion of 0.01562mm per mm.

4.12 BRAIDED (WIRE) ROPE SUPPORT

Braided (Wire) Hangers shall be used to suspend all static mechanical, electrical and HVAC services.

Braided (Wire) Rope Hangers shall consist of a pre-formed wire rope sling with either a ferruled loop, permanently fixed threaded M8 stud, or permanently fixed nipple end with toggle, at one end or hook or eyelet or any other end fixture type or size as per manufacturers recommendation. The end fixings and the wire must be of the same manufacturer. The system is secured and tensioned with a wire rope Hanger self-locking grip at the other end.

Only wire and/or supports supplied and/or approved, shall be used with the system.

- a. Braided (Wire) Rope Hangers have been independently tested by Lloyds Register. APAVE, TUV, UL, CSA and SMACNA, approved by ULC and CSA and comply with the requirements of DW/144 and BSRIA – wire Rope Suspension systems. Wire rope is manufactured to BSEN 12385: 2002.
- b. The contractor shall select the correct specification of wire Hanger to use for supporting each particular service from table 1 below. Each size is designated with a maximum safe working load limit.

The correct specification of Braided (Wire) Rope Hanger required is determined using the following formula.

Weight per meter of object suspended (kg) X distance between suspension points (m) = weight loading per Braided (Wire) Rope Hanger suspension point (kg).

The contractor shall select the correct length of Braided (Wire) Rope required to support the service. Lengths from 1-10m lengths. No in–line joints should be made in the rope.

Table. 1

size	minimum breaking load of Braided (Wire) Rope	Braided (Wire) Rope construction	tensile strength(Nmm2)	working load limit (kg/lbs)
No. 1	80kg/176 lbs	7 x 7 (6/1)	1770	0-10 kg / 0-22 lbs
No. 2	260kg/572 lbs	7 x 7 (6/1)	1770	10-45 kg / 23-100 lbs
No. 3	580kg/1276 lbs	7 x 7 (6/1)	1770	45-90 kg / 101-200 lbs
No. 4	1500kg/3300 lbs	7 x 19 (12/6/1)	1770	90-225 kg / 210-495 lbs
No. 5	2160kg/4752 lbs	7 x 19 (12/6/1)	1770	225-325 kg / 496-715 lbs

The standard range of Braided (Wire) Rope Hanger Kits shall be used which contains galvanized high tensile steel wire rope, the minimum specification is as above and shall be manufactured to BS 302 (1987), BSEN12385.

Ducting Supports: All duct work shall be independently supported from building construction. All horizontal ducts shall be adequately secured and supported. In an approved manner, with trapeze Hangers formed of galvanized steel wire rope in a cradle support method under ducts at no greater than 2 meter centre. All vertical duct work shall be supported by structural members on each floor slab. Duct support shall be through dash / anchor fastener driven into the concrete slab by electrically operated gun. Hanger wire shall then hang around the ducting. Rigid supports shall be used in conjunction with wire rope hangers to assist with alignment of services. Rigid support must also be used in conjunction with wire rope hangers with duct work at each change of direction or connection. Support ducting in accordance with Schedule I.

Ducting over furred ceiling shall be supported from the slab above or from beams after obtaining approval of Construction manager/consultant. In no case shall any duct be supported from false ceiling 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.

Piping Supports: Rigid supports shall be used in conjunction with wire rope hangers to assist with alignment of services. Rigid support must also be used in conjunction with wire rope hangers with pipe work at each change of direction or connection. For insulated pipe, provide protective sleeve to protect the entire circumference of the pipe insulation. All supports of pipe shall be taken from structural slab/wall by means of fastener. Support piping in accordance with Schedule II at the end of this Section.

Electrical Cable Tray/Raceway Supports: Y-Fit solution shall be used to a maximum width of 500mm tray. For Tray over 500mm cradle support method or independent Gripple supports must be taken as appropriate based on load. Rigid supports shall be used in conjunction with wire rope hangers to assist with alignment of services. Any other Gripple solution can be used based on manufacturer's recommendation on site conditions after prior approval.

Refer to manufacturers catalogue and installation guide for further technical information. **Comply with manufacturer's load ratings and recommended installation procedures.**

Schedule I: Duct Hanger Schedule

For ducts with external SP upto 250 Pa			For ducts with external SP upto 500 Pa		
Maximum Duct Size (mm)	Gauge	Gripple Hanger No.	Maximum Duct Size (mm)	Gauge	Gripple Hanger No.
1 - 751	26	2	1-600 mm	26	2
751-1000	26	2	601-750 mm	26	2
1001-1200	24	3	751-1000 mm	24	3
1201 - 1500	24	3	1001-1200 mm	22	4
1501 - 1800	22	4	1201-1300 mm	20	4
1801-2100	20	4	1301-1500 mm	18	4
2101-2700	18	4	1501-1800 mm	18	4
			1801-2100 mm	18	4
			2101-2250 mm	18	4

All supports shall be at 2400 mm interval.

Schedule II: Pipe Hanger Schedule

Pipe Size (mm)	Weight of pipe + fluid (kgs/rmts)	Weight of pipe + fluid per Rmt with sand cement plaster (kgs/rmts)	Spacings (pipe + fluid+insulation) between supports (mts)	Spacings (pipe + fluid+plaster) between supports (mts)	Total Weight of pipe + fluid with insulation (kgs/rmts)	Total Weight of pipe + fluid with sand cement plaster (kgs/rmts)	Gripple Hanger No. with insulation (kgs/rmts)	Gripple Hanger No. with sand cement plaster (kgs/rmts)
12-35	11.73	14	1.5	1.5	18	21	2	2
40-65	11.73	14	2	2	23	28	2	2
80-125	34.73	41.67	2	2	69	83.34	3	3
150-250	112	134	2	1.5	224	201	4	4
300 - 350	180	215	1.5	1.5	270	322.5	5	5
400-500	320	383	1.5	-	480	-	6	-

4.13 **DOCUMENTATION & MEASUREMENTS FOR DUCTING**

All ducts fabricated and installed should be accompanied and supported by proper documentation viz:

- a) Bill of material/Packing list for every duct section supplied.

Measurement sheet covering each fabricated duct piece showing dimensions and external surface area along with summary of external surface area of duct gauge-wise.

Each and every duct piece to have a tag number, which should correspond to the serial number, assigned to it in the measurement sheet. The above system will ensure speedy and proper site measurement and verification.

Unless otherwise specified, measurements for ducting for the project shall be on the basis of centreline measurements described herewith

Ductwork shall be measured on the basis of external surface area of ducts. Duct measurements shall be taken before application of the insulation. The external surface area shall be calculated by measuring the perimeter comprising overall width and depth, including the corner joints, in the center of each duct section, multiplying with the overall length from flange face to flange face of each duct section and adding up areas of all duct sections. Plenums shall also be measured in a similar manner.

For tapered rectangular ducts, the average width and depth shall be considered for perimeter, whereas for tapered circular ducts, the diameter of the section midway between large and small diameter shall be adopted, the length of tapered duct section shall be the centerline distance between the flanges of the duct section.

For special pieces like bends, tees, reducers, branches and collars, mode of measurement shall be identical to that described above using the length along the centerline.

The quoted unit rate for external surface of ducts shall include all wastage allowances, flanges and gaskets for joints, nuts and bolts, hangers and angles with double nuts for supports, rubber strip 5mm thick between duct and support, vibration isolator suspension where specified or required, inspection chamber/access panel, splitter damper with quadrant and lever for position indication, turning vanes, straightening vanes, and all other accessories required to complete the duct installation as per the specifications. These accessories shall NOT be separately measured nor paid for.

- b. Special Items for Air Distribution shall be measured by the cross-section area perpendicular to air flow, as identified herewith :
 - i. Grilles and registers - width multiplied by height, excluding flanges. Volume control dampers shall form part of the unit rate for registers and shall not be separately accounted.

- ii. Diffusers - cross section area for air flow at discharge area, excluding flanges. Volume control dampers shall form part of unit rate for supply air diffusers and shall not be separately accounted.
- iii. Linear diffusers - shall be measured by cross-sectional areas and shall exclude flanges for mounting of linear diffusers. The supply air plenum for linear diffusers shall be measured with ducting as described earlier.
- iv. Fire dampers - shall be measured by their cross sectional area perpendicular to the direction of air flow. Quoted rates shall include the necessary collars and flanges for mounting, inspection pieces with access door, electrical actuators and panel. No special allowance shall be payable for extension of cross section outside the air stream.
- v. Flexible connection - shall be measured by their cross sectional area perpendicular to the direction of air flow. Quoted rates shall include the necessary mounting arrangement, flanges, nuts and bolts and treated-for-fire requisite length of canvas cloth.
- vi. Kitchen Hoods - shall be measured by their cross sectional area at the capture point of fumes, parallel to the surface of kitchen equipment. Quoted rates shall include the grease filters, provision for hood light, suspension arrangement for the hood, profile to direct the air to ventilation ducts and provision for removable drip tray.

4.14 **FLEXIBLE DUCT:**

Insulated flexible duct should be UL 181 CLASS I AIR DUCT LISTED AND LABELLED WITH NFPA 90A & 90B AND SEAL OF AIR DIFFUSION COUNCIL with double lamination of tough polyester which encapsulates steel helix wire forms the air tight inner core, double layer core wrapped in a multiple thickness of fiberglass wool with R Value 4.2 , Green guard certification of fiberglass wool must. , Reinforced and sheathed in a rugged and durable tri directionally reinforced metalized polyester jacket.

Flexible duct connections should be made as per UL181 listing procedure with proper flexible right forming brace connection allowing right connections for flexible duct into energy efficient . and Strapping the flexible duct connections with flexible duct strap ties.

4.15 **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.

5. INSULATION

5.1 SCOPE

The scope of this section comprises the supply and application of insulation conforming to these specifications.

5.2 MATERIAL

Thermal insulation material for Duct insulation shall be closed cell Elastomeric Nitrile Rubber or cross linked polyethylene of Thermal conductivity of the insulation material shall not exceed 0.038 W/m²K or 0.212 BTU / (Hr-ft²-°F/inch) at an average temperature of 30°C. Density of the nitrile rubber shall be 30-60 Kg/m³. The product shall have temperature range of -40 °C to 105°C. The insulation material shall be fire rated for Class 0 as per BS 476 Part 6 : 1989 for fire propagation test and for Class 1 as per BS 476 Part 7, 1987 for surface spread of flame test. Water vapour permeability shall be not less than 0.024 per inch (2.48 x 10⁻¹⁴ Kg/m.s.Pa i.e. μ>7000: Water vapour diffusion resistance).

Thickness of the insulation shall be as specified for the individual application. Each lot of insulation material delivered at site shall be accompanied with manufacturer's test certificate for thermal conductivity values, density, water vapour permeability, and fire properties. Samples of insulation material from each lot delivered at site may be selected by Owner's site representative and gotten tested for thermal conductivity and density at Contractor's cost. Adhesive used for sealing the insulation shall be non-flammable, vapor proof adhesive strictly as per manufacturer's recommendations.

Ducting insulation thickness shall be as per table below.

Ducting position	Thk.
SA & return duct	19 mm
Exposed Duct	25mm

5.3 DUCT ACOUSTIC LINING

Duct acoustic lining material shall be Acoustic lining inside ducts using Non Fibrous fire retardant cross-linked polyethylene foam of 30+/- 3 Kg/m³ density & thickness of 12mm having porous surface

on one side & a flat surface on other side using Synthetic rubber based Adhesive preferably Low VOC & high strength characteristic (Initial portion of ducting and main plenum) as per specifications.

Thickness of the material shall be 12 mm thick specified for the individual application. The insulation should be installed as per manufacturer's recommendation.

- The Random Incidence Sound Absorption Coefficient (RISAC); tested as per ISO 354, should be minimum as per following 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	0.40	0.90	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

5.4 **DUCT ACOUSTIC LINING**

Ducts so identified and marked on Drawings and included in Schedule of Quantities shall be provided with 15 mm thick acoustic lining of thermal insulation material for a distance of minimum 5 meters (or 30% of the duct length whichever is more).

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.

5.5 **ACOUSTIC LINING OF MECHANICAL ROOMS**

The walls and ceiling of air conditioning plant room and air handling unit rooms may be provided with 30 mm thick acoustic lining.

Installation Procedure

The wall surface shall be cleaned and required surface preparation shall be done for applying adhesive. Rubber based contact adhesive recommended by the manufacturer shall be used. The foam sheets shall be cut to required size and a thin layer of adhesive shall be applied to both the surfaces; wall and i. When it is tack dry, it is should applied / stuck with enough pressure to the

walls/ceiling. Minimum 5 fasteners with washer (of G.I Sheet 2.5 inch x 2.5 inch) / square meter, 4 at corners & 1 at centre shall be put immediately after sticking with the help of adhesive. The length of the fastener should be minimum 75 mm.

5.6 **DUCT INSULATION**

External thermal insulation shall be provided as follows :

The thickness of nitrile rubber shall be as shown on drawing or identified in the schedule of quantity. Following procedure shall be adhered to:

Duct surfaces shall be cleaned to remove all grease, oil, dirt, etc. prior to carrying out insulation work. Measurement of surface dimensions shall be taken properly to cut closed cell elastomeric rubber sheets to size with sufficient allowance in dimension. Cutting of nitrile rubber sheets shall be done with adjustable blade to make 90° cut in thickness of nitrile rubber sheet. Hackshaw or blades are not acceptable tools for cutting the insulation.

Material shall be fitted under compression and no stretching of material shall be permitted. A film of adhesive shall be applied on the back of the insulating material sheet and then on to the metal surface. When adhesive is tack dry, insulating material sheet shall be placed in position and pressed firmly to achieve a good bond. All longitudinal and transverse joints shall be sealed by providing 6 mm thick 50 mm wide nitrile rubber tape. The adhesive shall be strictly as recommended by the manufacturer.

5.7 **PROTECTIVE COATING OVER INSULATION**

To provide mechanical strength and protection from damage all pipe / duct insulated with nitrile rubber shall be covered with thermal insulation protecting coating with alkali resistance glass fibre fabric of weight 200 GSM and 7 mil minimum thickness reinforcement. The coating non-volatile content shall be as per guideline of ASTM 1644-01 and Water permanence (perms) as per guideline ASTM E-96. The coating flammability, surface burning characteristics shall be as per ASTM E-84 and UL 723.

Insulated pipes & ducts exposed to UV rays shall be covered with fibre glass fabric. Over fabric one coat of fire proof epoxy or acrylic compound shall be applied. The coat shall be allowed to cure to non-stick state. Subsequently second coat of compound shall be applied to give a tough and smooth finish to the insulated surface.

5.8 **UNDERDECK INSULATION**

Under deck insulation shall be 50mm thick TF Quality expanded polystyrene (32 Kg/m³) or 30mm thick phenotherm. Under deck surface of ceiling shall be cleaned and made dirt free. Insulation panels

shall be pasted on this surface with black CPRX compound. 28g wire net shall be tightened around insulation so as to avoid any kind of sagging. Ends of net shall be overlapping by at least 25mm. Overlaps shall be screwed with galvanized screws to avoid rusting.

5.9 MEASUREMENT OF INSULATION

Unless otherwise specified measurement for duct and pipe insulation for the project shall be on the basis of center line measurements described herewith

- a. Pipe Insulation shall be measured in units of length along the center line of the installed pipe, strictly on the same basis as the piping measurements described earlier. The linear measurements shall be taken before the application of the insulation. It may be noted that for piping measurement, all valves, orifice plates and strainers are not separately measurable by their number and size. It is to be clearly understood that for the insulation measurements, all these accessories including cladding, valves, orifice plates and strainers shall be considered strictly by linear measurements along the center line of pipes and no special rate shall be applicable for insulation of any accessories, fixtures or fittings whatsoever.
- b. Duct Insulation and Acoustic Lining shall be measured on the basis of surface area along the center line of insulation thickness. Thus the surface area of externally thermally insulated or acoustically lined be based on the perimeter comprising center line (of thickness of insulation) width and depth of the cross section of insulated or lined duct, multiplied by the center-line length including tapered pieces, bends, tees, branches, etc. as measured for bare ducting.

6. ELECTRICAL INSTALLATION

6.1 SCOPE

The scope of this section comprises of fabrication, supply, erection, testing and commissioning of Motor Control Centre (MCC), wiring and earthing of all air-conditioning equipment, components and accessories.

6.2 GENERAL

All motor control centres shall be suitable for operation on 3 Phase/single phase, 415/240 volts, 50 cycles, 4 wire system with neutral grounded at transformer. All MCCs shall be CPRI tested design and manufactured by a approved manufacturer. CPRI certificate shall be made available.

MCCs shall comply with the latest Relevant Indian Standards and Electricity Rules and Regulations and shall be as per IS-13947-1993. MCCs / starter panels for outdoor equipment shall be suitable for outdoor duty application.

6.3 **CONSTRUCTIONAL FEATURES**

The Motor Control Centre (MCC) shall be of 2 mm thick sheet steel cabinet and suitable for indoor installation, dead front, floor mounting/wall mounting type and shall be form 3b construction. The Distribution panels shall be totally enclosed, completely dust and vermin proof and shall be with hinged doors and folded covers, Neoprene gasket, padlocking arrangement and bolted back. All removable/ hinged doors and covers shall be grounded by flexible standard connectors. MCC shall be suitable for the climatic conditions as specified in Special Conditions. Steel sheets used in the construction of panels shall be 2 mm thick and shall be folded and braced as necessary to provide a rigid support for all components. Joints of any kind in sheet metal shall be seam welded, all welding, slag shall be rounded off and welding pits wiped smooth with plumber metal. The general construction shall conform to IS-8623-1977 (Part-1) for factory built assembled switchgear & control gear for voltage upto and including 1100 V AC.

All MCCs/panels and covers shall be properly fitted and square with the frame, and holes in the panel correctly positioned. Fixing screws shall enter into holes tapped into an adequate thickness of metal or provided with wing nuts. Self threading screws shall not be used in the construction of Distribution panels. A base channel of 75 mm x 40 mm x 5 mm thick shall be provided at the bottom for floor mounted panels. Minimum operating clearance of 275 mm shall be provided between the floor of panels and the lowest operating height.

The MCC shall be of adequate size with a provision of spare feeders as per single line diagram. Feeders shall be arranged in multi-tier. Knockout holes of appropriate size and number shall be provided in the Motor Control Centre in conformity with the location of cable/conduit connections. Removable sheet steel plates shall be provided at the top to make holes for additional cable entry at site if required.

Every cabinet shall be provided with Trifoliate or engraved metal name plates. All panels shall be provided with circuit diagram mounted on inside of door shutter protected with Hylam sheet. All live accessible connections shall be shrouded and minimum clearance between phase and earth shall be 20 mm and phase to phase shall be 25 mm.

6.4 **WIRING SYSTEM**

All L T power cabling between MCC and motors shall be carried out with 1100 volts grade PVC insulated, overall PVC sheathed aluminium conductor armoured cables above 25 sq.mm size, where as all cables below 25 sq.mm. size shall be of copper conductor. Cables shall be sized by applying proper derating factor. All control wiring shall be carried out by using PVC insulated copper conductor wires in conduits. Minimum size of control wiring shall be 1.5 sq mm. Minimum size of conductor for power wiring shall be 4 sq.mm 1100 volts grade PVC insulated copper conductor wires in conduit.

6.5 **CIRCUIT COMPARTMENT**

All components for each feeder shall be housed in a separate compartment and shall have steel sheets on top and bottom of compartment. Sheet steel hinged lockable door shall be duly interlocked with the breaker in the "ON" position. Safety interlocks shall be provided to prevent the breaker from being drawn-out when the breaker is in 'ON' position. The door shall not form an integral part of the draw-out portion of the panel. Sheet steel barriers shall be provided between the tiers in a vertical section.

All MCCs shall be provided with feeders of appropriate capacity as per Single Line Diagram. All MCCs shall be completely factory wired, ready for connection. All the terminals shall be of proper current rating and sized to suit individual feeder requirements. Each circuit shall be clearly numbered from left to right to correspond with wiring diagram. All the switches and circuits shall be distinctly marked with a small description of the service installed.

Continuous earth bus sized for prospective fault current shall be provided with arrangement for connecting to station earth at two points. Hinged doors/ frames shall be connected to earth through adequately sized flexible braids.

6.6 **INSTRUMENT ACCOMMODATION**

Adequate space shall be provided for accommodating instruments, indicating lamps, control contactors and control MCBs. These shall be accessible for testing and maintenance without any danger of accidental contact with live parts of the circuit breaker and bus bar 'ON' lamps shall be provided on all outgoing feeders.

6.7 **BUS BAR CONNECTIONS**

Bus bar and interconnections shall be of high conductivity electrolytic grade aluminium / copper as indicated in the bill of quantities complying with requirement of IS : 5082 – 1981 and of rectangular cross section suitable for carrying the rated full load current and short circuit current and shall be extendable on either side. Bus bars and interconnections shall be insulated with heat shrinkable sleeve of 1.1 KV grade and shall be colour coded. Bus bars shall be supported on glass fiber reinforced thermosetting plastic insulated supports at regular intervals to withstand the force arising from in case of short circuit in the system. All bus bars shall be provided in a separate chamber and all connections shall be done by bolting. Additional cross sectional area to be added to the bus bar to compensate for the holes. All connections between bus bars and breakers shall be through solid copper / aluminium strips of proper size to carry full rated current and insulated with insulating sleeves. Maximum current density for the busbars shall be 0.8 A/sq.mm for aluminium and 1.4 A/sq.mm for copper busbars. Maximum allowable temperature for the Bus bar to be restricted to 85 deg C

6.8 **TEMPERATURE - RISE LIMIT**

Unless otherwise specified, in the case of external surface of enclosures of bus bar compartment which shall be accessible but do not need to be touched during normal operation, an increase in the temperature rise limits of 25° C above ambient temperature shall be permissible for metal surface and of 15° C above ambient temperature for insulating surfaces as per IS 8623(Part-2) 1993.

6.9 **CABLE COMPARTMENTS**

Cable compartment of adequate size shall be provided in the panel for easy clamping of all incoming and outgoing cables entering from the top/bottom. Adequate supports shall be provided in cable compartment to support cables as per approved for construction shop drawing.

6.9.1 **AIR CIRCUIT BREAKERS (ACB)**

The ACB shall conform to the requirements of IEC 60947-2 / IS 13947-2 and shall be type tested & certified for compliance to standards from CPRI, ERDA/ any accredited international lab. The circuit breaker shall be suitable for 415 V \pm 10%, 50 Hz supply system.

Air Circuit Breakers shall be with moulded housing flush front, draw out type and shall be provided with a trip free manual operating mechanism or as indicated in drawings and bill of quantities with mechanical "ON" "OFF" "TRIP" indications.

The ACB shall be 3/ 4 pole with modular construction, draw out, manually or electrically operated version as specified. The circuit breakers shall be for continuous rating and service short Circuit Breaking capacity (Ics) shall be as specified on the single line diagram and should be equal to the Ultimate breaking capacity(Icu) and short circuit withstand values(Icw) for 1 sec.

Circuit breakers shall be designed to 'close' and 'trip' without opening the circuit breaker compartment door. The operating handle and the mechanical trip push button shall be at the front of the breakers panel. Inspection of main contacts should be possible without using any tools. The ACB shall be provided with a door interlock. i.e. door should not be open when circuit breaker is closed and breaker should not be closed when door is open.

All current carrying parts shall be silver plated and suitable arcing contacts with proper arc chutes shall be provided to protect the main contacts. The ACB shall have double insulation (Class-II) with moving and fixed contacts totally enclosed for enhanced safety and in accessibility to live parts. All electrical closing breaker shall be with electrical motor wound stored energy spring closing mechanism with mechanical indicator to provide ON/OFF status of the ACB.

The auxiliary contacts blocks shall be so located as to be accessible from the front. The auxiliary contacts in the trip circuits shall close before the main contacts have closed. All other contacts shall close simultaneously with the main contacts. The auxiliary contacts in the trip circuits shall open after the main contacts open. Minimum 4 NO and 4 NC auxiliary contacts shall be provided on each breaker.

Rated insulation voltage shall be 1000 volts AC.

6.9.2 **CRADLE**

The cradle shall be so designed and constructed as to permit smooth withdrawal and insertion of the breaker into it. The movements shall be free from jerks, easy to operate and shall be on steel balls/rollers and not on flat surfaces.

There shall be 4 distinct and separate position of the circuit breaker on the cradle.
Racking Interlock in Connected/Test/Disconnected Position.

Service Position : Main Isolating contacts and control contacts of the breaker are engaged.

Test Position : Main Isolating contacts are isolated but control contacts are still engaged.

Isolated Position : Both main isolating and control contacts are isolated.

There shall be provision for locking the breaker in any or all of the first three positions.

The following safety features shall be incorporated :

- a. Withdrawal or engagement of Circuit breaker shall not be possible unless it is in open condition.
- b. Operation of Circuit breaker shall not be possible unless it is fully in service, test or drawn out position.
- c. All modules shall be provided with safety shutters operated automatically by movement of the carriage to cover exposed live parts when the module is withdrawn.
- d. All Switchgear module front covers shall have provision for locking.
- e. Switchgear operating handles shall be provided with arrangement for locking in 'OFF' position.

6.9.3 **PROTECTIONS**

The breaker should be equipped with micro-controller based , communicable type release with RS 485 port for communication to offer accurate and versatile protection with complete flexibility and shall offer complete over current protection to the electrical system in the following four zones :

- Long time protection.
- Short time protection with intentional delay.
- Instantaneous protection.
- Ground fault protection.

The protection release shall generally have following features and settings however for exact requirement of protection releases, reference shall be made to SOQ:

a. True RMS Sensing

The release shall sample the current at the rate of 16 times per cycle to monitor the actual load current waveform flowing in the system and shall monitor the true RMS value of the load current. It shall take into account the effect of harmonics also.

b. Thermal Memory

When the breaker shall reclose after tripping on overload, then the thermal stresses caused by the overload if not dissipated completely, shall get stored in the memory of the release and this thermal memory shall ensure reduced tripping time in case of subsequent overloads. Realistic Hot/Cold curves shall take into account the integrated heating effects to offer closer protection to the system.

c. Defined time-current characteristics :

A variety of pick-up and time delay settings shall be available to define the current thresholds and the delays to be set independently for different protection zones thereby achieving a close-to-ideal protection curve.

d. Trip Indication

Individual fault indication for each type of fault should be provided by LEDs for faster fault diagnosis.

e. Self-powered

The release shall draw its power from the main breaker CTs and shall require no external power supply for its operation.

f. Zone Selective Interlocking

The release shall be suitable for communication between breakers to enable zone selective interlocking. This feature shall be provided for both short circuit and ground fault protection zones to offer intelligent discrimination between breakers. This feature enables faster clearance of fault conditions, thereby reducing the thermal and dynamic stresses produced during fault conditions and thus minimizes the damage to the system. To implement ZSI manufacturer should supply all related equipment like power supply, wiring etc.

On-Line change of settings should be possible. It should be possible to carry out testing of release without tripping the breaker.

g. The release shall meet the EMI / EMC requirements.

h. The setting range of release shall be generally as follows :

Type of Protection	SETTING RANGE OF RELEASE	
	PICK-UP CURRENT	TIME DELAY
Long Time	0.4 to 1.0 times I_n (I_r) Steps : 0.4, 0.5, 0.55, 0.60, 0.65, 0.70, 0.75, 0.80, 0.85, 0.90, 0.95, 1.00. Operating Limit : 1.05 to 1.2 times I_r	0.5 to 30 sec at 6 I_r Steps 0.5,1, 2,4, 6, 8,12,18,24 and 30 secs Tolerance: Corresponding to $\pm 10\%$ of current.
Short Time	2 to 10 times I_r Steps : 2,3,4,5,6,7,8,9 & 10 Tolerance : $\pm 10\%$	20 ms to 600 ms Steps :0,60,100,160,200,260,300 400,500 and 600 ms Tolerance : $\pm 10\%$ or 20ms whichever is higher
Instantaneous	2 to 12 times I_n Steps : 2,3,4,6,8,10,12 Tolerance : $\pm 10\%$	
Ground Fault	0.2 to 0.6 time I_n Steps : 0.2,0.3,0.4,0.5,0.6 Tolerance : $\pm 10\%$	100 ms to 400 ms Steps : 100,200,300,400ms Tolerance: $\pm 10\%$ or 20 ms whichever is higher.

All **incomer** ACBs shall have following additional protections other than mentioned above.

- Under and over voltage
- Under and over frequency
- Restricted Earth Fault protection
- Trip Circuit supervision with PS class CT's.
- Undercurrent, (for DG set only)
- Reverse power (for DG set only)
- Phase sequence reversal (for DG set only)
- Load shedding and reconnection thru programmable contacts.
- Release should display the Contact wear indication.

The release should provide local indication of actual %age loading at any instant. The release should be able to communicate on MODBUS RTU protocol using inbuilt RS485 port and shall be integral part of supply with trip unit. Parameters of the Protection Release should be changeable from Release as well as thru communication network. Release should have graphical LCD for display of power parameters. The release of incoming breakers should provide comprehensive metering with the following parameters

- Phase currents (running, avg & max) – All parameters in single window.
- Release should be able to capture short circuit current on which ACB has tripped. The last ten trips and alarms shall be stored in memory with the date & time stamping along with type of fault and alarm. The sensing CT Should be Rogowsky type with measurement precision of 1%.
- Release should be self-powered .
- Release should have facility to select different type of IDMTL protection(DT,SIT,VIT,EIT,HVF) for better co-ordination with HT Breaker/Fuse.
- Phase voltages (running, avg & max)
- Energy & power parameters (active, reactive and apparent)
- PF
- Frequency
- Maximum Demand (KVA & KW)
- Total Harmonics distortion

All O/G ACBs shall have following functions.

Protection

- The ACB control unit shall offer the following protection functions as standard:
- Long-time (LT) protection with an adjustable current setting and time delay;
- Short-time (ST) protection with an adjustable pick-up and time delay; instantaneous (INST) protection with an adjustable pick-up and an OFF
- Position.
- Current and time delay setting shall be indicated in amperes and seconds respectively
- On a digital display.
- Earth-fault protection with an adjustable pick-up and time delay shall be provided if indicated on the appended single-line diagram.

Measurements

- An ammeter with a digital display shall indicate the true rms values of the currents for each phase. Release shall acknowledge the current & time delay settings done by user on the LCD display.
- A LED bar graph shall simultaneously display the load level on the three phases.
- A maxi meter shall store in memory and display the maximum current value observed since the last reset. The data shall continue to be stored and displayed even after opening of the circuit breaker.

6.9.4 **SAFETY FEATURES**

- I. The safety shutter shall prevent inadvertent contact with isolating contacts when breaker is withdrawn from the Cradle.
- II. It shall not be possible to interchange two circuit breakers of two different thermal ratings. For Draw-out breakers, an arrangement shall be provided to prevent rating mismatch between breaker and cradle.
- III. There shall be provision of positive earth connection between fixed and moving portion of the ACB either thru connector plug or sliding solid earth mechanism. Earthing bolts shall be provided on the cradle or body of fixed ACB.
- IV. The incoming panel accommodating ACB shall be provided with indicating lamps for ON-OFF positions, digital voltmeter, and ammeter of size not less than 96 mm x 96 mm, selector switches, MCB for protection circuit and measuring instrument circuits.
- V. It shall be possible to bolt the draw out frame not only in connected position but also in TEST and DISCONNECTED position to prevent dislocation due to vibration and shocks.
- VI. Draw out breakers should not close unless in distinct Service/Test/Isolated positions.
- VII. The insulation material used shall conform to Glow wire test as per IEC60695.
- VIII. The ACB shall provide in built electrical and mechanical anti-pumping.

- IX. All EDO ACB`s Shall have Ready to Close Contact to ensure that the ACB gets a command only when it is ready to close for applications of Remote Control, AMF, Synchronization and Auto Source Change Over Systems.

6.10 **MOULDED CASE CIRCUIT BREAKER (MCCB)**

The MCCB should be current limiting type with trip time of less than 10 msec under short circuit conditions. The MCCB should be either 3 or 4 poles as specified in BOQ. MCCB shall comply with the requirements of the relevant standards IS13947 – Part 2/IEC 60947-2 and should have test certificates for Breaking capacities from independent test authorities CPRI / ERDA or any accredited international lab.

MCCB shall comprise of Quick Make -break switching mechanism, arc extinguishing device and the tripping unit shall be contained in a compact, high strength, heat resistant, flame retardant, insulating moulded case with high withstand capability against thermal and mechanical stresses

The breaking capacity of MCCB shall be as specified in the schedule of quantities. The rated service breaking capacity (Ics) should be equal to rated ultimate breaking capacities (Icu). MCCBs for motor application should be selected in line with Type-2 Co-ordination as per IEC-60947-2, 1989/IS 13947-2. The breaker as supplied with ROM should meet IP54 degree of protection.

6.10.1 **Current Limiting & Coordination**

- The MCCB shall employ maintenance free minimum let-through energies and capable of achieving discrimination up to the full short circuit capacity of the downstream MCCB. The manufacturer shall provide both the discrimination tables and let-through energy curves for all.

Protection Functions

- MCCBs with ratings up to 200 A shall be equipped with Thermal-magnetic (adjustable thermal for overload and fixed magnetic for short-circuit protection) trip units
- Microprocessor MCCBs with ratings 250A and above shall be equipped with microprocessor based trip units.
- Microprocessor and thermal-magnetic trip units shall be adjustable and it shall be possible to fit lead seals to prevent unauthorized access to the settings
- Microprocessor trip units shall comply with appendix F of IEC 60947-2 standard (measurement of RMS current values, electromagnetic compatibility, etc.)
- Protection settings shall apply to all poles of circuit breaker.
- All Microprocessor components shall withstand temperatures up to 125 °C

6.10.2 **Testing**

- a) Original test certificate of the MCCB as per IEC 60947-1 &2 or IS13947 shall be furnished.
- b) Pre-commissioning tests on the switch board panel incorporating the MCCB shall be done as per standard specifications.

6.10.3 Interlocking

Moulded, case circuit breakers shall be provided with the following interlocking devices for interlocking the door of a switch board.

- a) Handle interlock to prevent unnecessary manipulations of the breaker.
- b) Door interlock to prevent the door being opened when the breaker is in ON position.
- c) Defeat-interlocking device to open the door even if the breaker is in ON position.
 - The MCCB shall be current limiting type and comprise of quick make – Break switching mechanism. MCCBs shall be capable of defined variable overload adjustment. All MCCBs rated 200 Amps and above shall have adjustable over load & short circuit pick-up both in Thermal magnetic and Microprocessor Trip Units.
 - All MCCB with microprocessor based release unit, the protection shall be adjustable Overload, Short circuit, and earth fault protection with time delay.

The trip command shall override all other commands.

6.11 **MOTOR PROTECTION CIRCUIT BREAKER (MPCB)**

Motor circuit breakers shall conform to the general recommendations of standard IEC 947 -1,2 and 4 (VDE 660, 0113 NF EN 60 947-1-2-4, BS 4752) and to standards UL 508 and CSA C22-2 N°14.

The devices shall be in utilization category A, conforming to IEC 947-2 and AC3 conforming to IEC 947-4. MPCB shall have a rated operational and insulation voltage of 690V AC (50 Hz) and MPCB shall be suitable for isolation conforming to standard IEC 60947-2 and shall have a rated impulse withstand voltage (Uimp) of 6 kV. The motor circuit breakers shall be designed to be mounted vertically or horizontally without derating. Power supply shall be from the top or from the bottom. In order to ensure maximum safety, the contacts shall be isolated from other functions such as the operating mechanism, casing, releases, auxiliaries, etc, by high performance thermoplastic chambers. The operating mechanism of the motor circuit breakers must have snap action opening and closing with free tripping of the control devices. All the poles shall close, open, and trip simultaneously. The motor circuit breakers shall accept a padlocking device in the “isolated” position.

The motor circuit breakers shall be equipped with a “PUSH TO TRIP” device on the front enabling the correct operation of the mechanism and poles opening to be checked. The auxiliary contacts shall be front or side mounting, and both arrangements shall be possible. The front-mounting attachments shall not change the breaker surface area. Depending on its mounting direction the single pole contact block could be NO or Call the electrical auxiliaries and accessories shall be equipped with terminal blocks and shall be plug-in type. The motor circuit breakers shall have a combination with the downstream contactor enabling the provision of a perfectly co-ordinated motor-starter. This combination shall

enable type 1 or type 2 co-ordination of the protective devices conforming to IEC 60947-4-1. Type 2 co-ordination shall be guaranteed by tables tested and certified by an official laboratory: LOVAG (or other official laboratory). The motor circuit breakers, depending on the type, could be equipped with a door-mounted operator which shall allow the device setting. The motor circuit breakers shall be equipped with releases comprising a thermal element assuring overload protection and a magnetic element for short-circuit protection. In order to ensure safety and avoid unwanted tripping, the magnetic trip threshold (fixed) shall be factory set to an average value of 12 Ir.

All the elements of the motor circuit breakers shall be designated to enable operation at an ambient temperature of 60°C without derating. The thermal trips shall be adjustable on the front by a rotary selector. The adjustment of the protection shall be simultaneous for all poles. Phase unbalance and phase loss detection shall be available. Temperature compensation (-20°C to +60°C)

6.12 **MINIATURE CIRCUIT BREAKER (MCB)**

Miniature Circuit Breaker shall comply with IS-8828-1996/IEC898-1995. Miniature circuit breakers shall be quick make and break type for 240/415 VAC 50 Hz application with magnetic thermal release for over current and short circuit protection. The breaking capacity shall not be less than 10 KA at 415 VAC. MCBs shall be DIN mounted. The MCB shall be Current Limiting type (Class-3). MCBs shall be classified (B,C,D ref IS standard) as per their Tripping Characteristic curves defined by the manufacturer. The MCB shall have the minimum power loss (Watts) per pole defined as per the IS/IEC and the manufacturer shall publish the values. MCB shall ensure complete electrical isolation & downstream circuit or equipment when the MCB is switched OFF.

The housing shall be heat resistant and having a high impact strength. The terminals shall be protected against finger contact to IP20 Degree of protection. All DP, TP, TPN and 4 Pole miniature circuit breakers shall have a common trip bar independent to the external operating handle.

6.13 **PAINTING**

All sheet steel work shall undergo a process of degreasing, pickling in acid, cold rinsing, phosphating, passivating (seven tank processing) and then painted with electrostatic paint (Powder coating). The shade of colour of panel inside/outside shall be as per relevant BIS code.

6.14 **LABELS**

Engraved PVC labels shall be provided on all incoming and outgoing feeder. Circuit diagram showing the arrangements of the circuit inside the control panel shall be pasted on inside of the panel door and covered with transparent plastic sheet.

6.15 **METERS**

- i. All voltmeters and indicating lamps shall be through MCB's.
- ii. Meters and indicating instruments shall be plug type.
- iii. All CT's connection for meters shall be through Test Terminal Block (TTB).
- iv. CT ratio and burdens shall be as specified on the Single line diagram.

6.16 **CURRENT TRANSFORMERS**

Current transformers shall be provided for Control panels carrying current in excess of 60 amps. All phase shall be provided with current transformers of suitable VA burden with 5 amps secondary's for operation of associated metering.

The CTs shall conform to relevant Indian Standards. The design and construction shall be dry type, epoxy resin cast robust to withstand thermal and dynamic stresses during short circuits. Secondary terminals of CTs shall be brought out suitable to a terminal block which shall be easily accessible for testing and terminal connections. The protection CTs shall be of accuracy class 5P10 and measurement CTs shall be of accuracy class I.

6.17 **SELECTOR SWITCH**

where called for, selector switches of rated capacity shall be provided in control panels, to give the choice of operating equipment in selective mode.

6.18 **STARTERS**

Each motor shall be provided with a starter of suitable rating. Starters shall be in accordance with relevant IS Codes. All Star Delta Starters shall be fully automatic. Motors up to 10HP shall be provided by Direct on Line (DOL) starter, motors above 10 HP and up to 45 HP shall be provided by star/delta starter and motors above 45 HP shall be provided by soft starter.

6.19 **CONTACTOR**

Contactors shall be built into a high strength thermoplastic body and shall be provided with an arc shield for quick arc extinguishing. Silver alloy tips shall be provided to ensure a high degree of reliability and

endurance under continuous operation. The magnet system shall consist of laminated yoke and armature to ensure clean operation without hum or chatter.

Starter's contactors shall have 3 main and 2 Nos. NO / NC auxiliary contacts and shall be air break type suitable for making and breaking contact at minimum power factor of 0.35. For design consideration of contactors the starting current of connected motor shall be assumed to be 6 times the full load current of the motor in case of direct-on-line starters and 3 times the full load current of the motor in case of Star Delta and Reduced Voltage Starters. The insulation for contactor coils shall be of Class "E."

Coil shall be tape wound vacuum impregnated and shall be housed in a thermostatic bobbin, suitable for tropical conditions and shall withstand voltage fluctuations. Coil shall be suitable for 220/415±10% volts AC, 50 cycles AC supply.

6.20 **THERMAL OVERLOAD RELAY**

Thermal over load relay shall have built in phase failure sensitive tripping mechanism to prevent against single phasing as well as on overloading. The relay shall operate on the differential system of protection to safeguard against three phase overload, single phasing, and unbalanced voltage conditions.

Auto-manual conversion facility shall be provided to convert from auto-reset mode to manual-reset mode and vice-versa at site. Ambient temperature compensation shall be provided for variation in ambient temperature from -5° C to +55°C.

All overload relays shall be of three elements, positive acting ambient temperature compensated time lagged thermal over load relays with adjustable setting. Relays shall be directly connected for motors upto 35 HP capacity. C.T. operated relays shall be provided for motors above 35 HP capacities. Heater circuit contactors may not be provided with overload relays.

6.21 **TIME DELAY RELAYS**

Time delay relays shall be adjustable type with time delay adjustment from 0-180 seconds and shall have one set of auxiliary contacts for indicating lamp connection.

6.22 **INDICATING LAMP AND METERING**

All meters and indicating lamps shall be in accordance with relevant IS standard specification. The meters shall be flush mounted type. The indicating lamp shall be of LED type. Each MCC and control

panel shall be provided with voltmeter 0-500 volts with three ways and off selector switch, CT operated ammeter of suitable range with three nos. CTS of suitable ratio with three ways and off selector switch, phase indicating lamps, and other indicating lamps as called for. Each phase indicating lamp shall be backed up with 5 amps fuse. Other indicating lamps shall be backed up with fuses as called for in Schedule of Quantities.

6.23 **TOGGLE SWITCH**

Toggle switches, where called for in Schedule of Quantities, shall be in conformity with relevant IS Codes and shall be of 5 amps rating.

6.24 **PUSH BUTTON STATIONS**

Push button stations shall be provided for manual starting and stopping of motors / equipment Green and Red color push buttons shall be provided for 'Starting' and 'Stopping' operations. 'Start' or 'Stop' indicating flaps shall be provided for push buttons. Push Buttons shall be suitable for panel mounting and accessible from front without opening door, Lock lever shall be provided for 'Stop' push buttons. The push button contacts shall be suitable for 6 amps current capacity.

6.25 **CONDUITS**

Conduits and Accessories shall conform to latest edition of Indian Standards IS-9537 part 1 & 2. 16/14 (16 gauge upto 32mm diameter & 14 gauge above 32 mm diameter) gauge screwed GI or MS conduits as specified on schedule of quantities shall be used. Joints between conduits and accessories shall be securely made by standard accessories, as per IS-2667, IS-3837, and IS-5133 to ensure earth continuity. All conduit accessories shall be threaded type only.

Only approved make of conduits and accessories shall be used.

Conduits shall be delivered to the site of construction in original bundles and each length of conduit shall bear the label of the manufacturer.

Note. : Whatever materials required to be billed by the Contractor should come on site with proper Chelan Numbers and quantity mentioned in each such Chelan...

Maximum permissible numbers of 1100 volt grade PVC insulated wires that may be drawn into metallic Conduits are given below:

Size of wires Nominal Cross Section Area (Sq. mm.)	Maximum number of wires within conduit size(mm)				
	20	25	32	40	50
1.5	5	10	14	--	--
2.5	5	8	12	--	--
4	3	7	10	--	--
6	2	5	8	--	--
10	--	3	5	6	--
16	--	2	3	6	6
25	--	--	2	4	6
35	--	--	--	3	5

Maximum permissible number of 1100 volt grade PVC insulated wires that may be drawn into rigid non metallic or PVC Conduits are given below:

Size of wires Nominal Cross Section Area (Sq. mm.)	Maximum number of wires within conduit size(mm)				
	20	25	32	40	50
1.5	7	12	16	--	--
2.5	5	10	14	--	--
4	4	8	12	--	--
6	3	6	8	--	--
10	--	4	5	6	--
16	--	3	3	6	6
25	--	--	2	4	6
35	--	--	--	3	5

6.26 **CABLES**

The MV cables shall be cross linked polyethylene (XLPE) insulated PVC inner sheathed and HR PVC / FRLS PVC outer sheath of 1100 volts grade as asked for in the schedule of quantities. Cables upto 16 sq.mm shall be with copper conductor and 25 sq.mm and above shall be with aluminium conductor and suitable for lying in trenches, ducts, and on cable trays as required. M.V. Cables shall be termite resistant. Cable glands shall be double compression glands. Control cables and indicating panel cables shall be multi core PVC insulated copper conductor and armoured cables.

6.27 **CABLE LAYING**

Cables shall be laid by skilled and experienced workmen using adequate rollers to minimize stretching of the cable. The cable drums shall be placed on jacks before unwinding the cable. Great care shall be exercised in laying cables to avoid forming kinks.

6.27.1 **Laying of Cables on Cable Trays**

The relative position of the cables, laid on the cable tray shall be preserved and the cables shall not cross each other. At all changes in direction in horizontal and vertical planes, the cable shall be bent smooth with a radius as recommended by the manufacturers. All cables shall be laid with minimum one diameter gap and shall be clamped at every meter to the cable tray. Cables shall be tagged for identification with aluminum tag and clamped properly at every 20M. Tags shall be provided at both ends and all changes in directions both sides of wall and floor crossings. All cable shall be identified by embossing on the tag the size of the cable, place of origin and termination.

All cables passing through holes in floor or walls shall be sealed with fire retardant Sealant and shall be painted with fire retardant paint upto one meter on all joints, terminations and both sides of the wall crossings by "VIPER CABLE RETARD."

6.27.2 **Laying of Cables in Ground**

The width of trench for laying single cable shall be minimum 350 mm. Where more than one cable is to be laid in horizontal formation, the width of the trench shall be workout by providing 200 mm gap between the cables, except where otherwise specified. There shall be clearance of 150 mm between the end cable and the side wall of the trench. The minimum depth of the cable trench shall not be less than 750 mm for single layer of cables. When the cables are laid in more than one tier the depth of the trench shall be increased by 300 mm for each additional tier.

Excavation of trenches: The trenches shall be excavated in reasonably straight lines. Wherever there is a change in direction, suitable curvature shall be provided. Where gradients and changes in depth are unavoidable, these shall be gradual. The excavated soil shall be stacked firmly by the side of the trench such that it may not fall back into the trench. The bottom of the trench shall be leveled and shall be made free from stone, brick bats etc. The trench shall then be provided with a layer of clean, dry sand cushion of not less than 100 mm in depth. Prior to lying of cables, the cores shall be tested for

continuity and insulation resistance. The cable drum shall be properly mounted on jacks, at a suitable location, making sure that the spindle, jack etc. are strong enough to carry the weight of the drum and the spindle is horizontal. Cable shall be pulled over rollers in the trench steadily and uniformly without jerks and strains. The entire drum length shall be laid in one stretch. However, where this is not possible the remainder of the cable shall be removed by 'Flaking' i.e. By making one long loop in the reverse direction. After the cable has been uncoiled and laid into the trench over the rollers, the cable shall be lifted off the rollers beginning from one end by helpers standing about 10 meters apart and laid in a reasonably straight line. Cable laid in trenches in a single tier formation shall have a cover of clean, dry sand of not less than 150 mm. above the base cushion of sand before the protective cover is laid. In the case of vertical multi-tier formation after the first cable has been laid, a sand cushion of 300 mm shall be provided over the initial bed before the second tier is laid. Finally the cables shall be protected by second class bricks before back filling the trench. The buried depth of uppermost layer of cable shall not be less than 750mm.

Back Filling : The trenches shall be back filled with excavated earth free from stones or other sharp edged debris and shall be rammed and watered, if necessary, in successive layers not exceeding 300 mm. Unless otherwise specified, a crown of earth not less than 50 mm in the centre and tapering towards the sides of the trench shall be left to allow for subsidence.

6.28 **WIRE AND WIRE SIZES**

1100 volts grade PVC insulated copper conductor wires in conduit shall be used.

For all single phase/ 3 phase wiring, 1100 volts grade PVC insulated copper conductor FRLS/ZHFR wires shall be used. The equipment inside plant room and AHU room shall be connected to the control panel by means of insulated copper conductor wires of adequate size in exposed conduits. Final connections to the equipment shall be through wiring enclosed in galvanized flexible conduits rigidly clamped at both ends and at regular intervals.

An isolator shall be provided near each motor/equipment wherever the motor/equipment is separated from the supply panel through a partition barrier or through ceiling construction. PVC insulated copper conductor wires shall be used inside the control panel for connecting different components and all the wires inside the control panel shall be neatly dressed and plastic beads shall be provided at both the ends for easy identification of control wiring.

The minimum size of control wiring shall be 1.5 sq. mm PVC insulated stranded soft drawn copper conductor wires drawn through conduit to be provided for connecting equipment and control panels.

Power wiring, cabling shall be of the following sizes:

- | | | |
|-----|--------------------------------|--------------------------------------|
| i. | Upto 5 HP motors/ 5 KW heaters | 3 x 4 sq. mm copper conductor wires. |
| ii. | From 6 HP to 10 HP motors | 3 x 6 sq. mm copper |

	6 KW to 7.5 KW heaters	conductor wires.
iii.	From 12.5 HP to 15 HP motors	2 Nos. 3 x 6 sq. mm copper conductor wires
iv.	From 20 HP to 25 HP motors	2 Nos. 3 x 10 sq. mm copper conductor wires
v.	From 30 HP to 35 HP motors	2 nos. 3 x 16 sq. mm aluminium conductor armoured cable.
vi.	From 40 HP to 50 HP motors	2 Nos. 3 x 25 sq. mm. aluminium conductor armoured cable.
vii.	From 60 HP to 75 HP motors	1 No. 3 x 70 sq. mm aluminium conductor armoured cable.
viii.	100 HP motors	1 No. 3 x 150 sq. mm. aluminium conductor armoured cable
ix.	150 HP motor	1 No. 3 x 240 sq. mm. aluminium conductor armoured cable.
x.	250 HP motor	2 Nos. 3 x 240 sq. mm. aluminium conductor armoured cable.
xi.	400 HP motor	3 Nos. 3 x 240 sq. mm. aluminium conductor armoured cable.
xii.	600 HP motor	3 Nos. 3 x 400 sq. mm. aluminium conductor armoured cable.

All the switches, contactors, push button stations, indicating lamps shall be distinctly marked with a small description of the service installed. The following capacity contactors and overload relays shall be provided for different capacity motors or as per manufacturer's recommendation.

	TYPE OF STARTER	CONTACTOR CURRENT CAPACITY	OVERLOAD RELAY RANGE
5 HP Motors	D O L	16 amps	6-10 amps
7.5 HP motors	D O L	16 amps	9-15 amps
10 HP Motors	D O L	25 amps	9-15 amps
12.5 HP Motors	Automatic Star Delta	16 amps	9-15 amps
15 HP Motors	Automatic Star Delta	25 amps	9-15 amps
20 HP Motors	Automatic Star Delta	32 amps	14-23 amps
25 HP Motors	Automatic Star Delta	32 amps	14-23 amps
30 HP Motors	Automatic Star Delta	40 amps	20-33 amps
35 HP Motors	Automatic Star Delta	40 amps	20-33 amps
40 HP Motors	Automatic Star Delta	40 amps	30-50 amps
50 HP Motors	VFD / soft	70 amps	30-50 amps
60 HP Motors	VFD/ soft	110 amps	30-50 amps
75 HP Motors	VFD / soft	110 amps	90-150 amps
100 HP Motors	VFD / soft	200 amps	CT operated relay
125 HP Motors	VFD / soft	200 amps	CT operated relay
150 HP Motors	VFD / soft	200 amps	CT operated relay
150 HP Motors	VFD / soft	300 amps	CT operated Relay.
200 HP Motors	VFD / soft	300 amps	CT operated Relay.
250 HP Motors	VFD / soft	400 amps	CT operated Relay.
300 HP Motors	VFD / soft	400 amps	CT operated Relay.
400 HP Motors	VFD / soft	600 amps	CT operated Relay.
600 HP Motors	VFD / soft	900 amps	CT operated Relay.

Two speed motors when specified, shall be provided with DOL starter irrespective of it rating.

6.29 **CABLE TRAYS**

Ladder and perforated type Cable Trays shall be of Hot dip Galvanized type and factory fabricated out of CRCA sheet with standard accessories like tee, bends, couplers etc. for different loads and number and size of cables as given below :

Cable trays shall be galvanized as per Specifications..

- a. 1500 mm wide
 - Runners 25 x 100 x 25 x 3 mm
 - Rungs 2# 20 x 40 x 20 x 3 mm 250 mm C/C
 - Suspenders 2 Nos. 40 x 40 x 5 mm GI angle 1500 mm C/C with base support of 40x 40 x 5mm GI angle.

- b. 1200 mm wide
 - Runners 25 x 100 x 25 x 3 mm
 - Rungs 2# 20 x 40 x 20 x 3 mm 250 mm C/C
 - Suspenders 2 Nos. 40 x 40 x 5 mm GI angle 1500 mm C/C with base support of 40x 40 x 5mm GI angle.

- c. 1000 mm wide
 - Runners 25 x 100 x 25 x 3 mm
 - Rungs 2# 20 x 40 x 20 x 3 mm 250 mm C/C
 - Suspenders 2 Nos. 40 x 40 x 5 mm GI angle 1500 mm C/C with base support of 40x 40 x 5mm GI angle.

- d. 750 mm wide
 - Runners 20 x 75 x 20 x 2.5 mm
 - Rungs 20 x 30 x 20 x 2.5 mm 250 mm C/C
 - Suspenders 2 Nos. 32 x 32 x 5 mm GI angle 1800 mm C/C with base support of 40x 40 x 5mm GI angle.

- e. 600 mm wide
 - Runners 20 x 75 x 20 x 2.5 mm
 - Rungs 20 x 30 x 20 x 2.5 mm 250 mm C/C
 - Suspenders 2 Nos. 32 x 32 x 5 mm GI angle 1800 mm C/C with base support of 40x 40 x 5mm GI angle.

- f. 450 mm wide
 - Runners 20 x 75 x 20 x 2.5 mm
 - Rungs 20 x 30 x 20 x 2.5 mm 250 mm C/C
 - Suspenders 2 Nos. 25 x 25 x 4 mm GI angle 1800 mm C/C with base support of 40x 40 x 5mm GI angle.

- g. Supply and fixing of perforated type cable trays of the following sizes of pre-galvanized iron.
 - i. 600 x 40 x 40 x 2 mm thick

- i. 450 x 40 x 40 x 2 mm thick
- i. 300 x 40 x 40 x 2 mm thick
- ii. 150 x 40 x 40 x 2 mm thick

Note: Suitable length of 10 mm dia GI rod suspenders at 1800 mm interval shall be included in the item for perforated type cable tray.

6.30 **SPECIFICATION FOR HOT DIP GALVANIZING PROCESS**

(for Mild Steel Used For Earthing, Cable Trays Or Junction Boxes For Electrical Installation.)

General Requirements

I. Quality of Zinc

Zinc to be used shall conform to minimum Zn 98 grade as per requirement of IS:209-1992.

II. Coating Requirement

Minimum weight of zinc coating for mild steel flats with thickness upto 6 mm in accordance with IS:6745-1972 shall be 400 g/sqm.

The weight of coating expressed in grams per square metre shall be calculated by dividing the total weight of Zinc by total area (both sides) of the coated surface.

The Zinc coating shall be uniform, smooth, and free from imperfections as flux, ash, and dross inclusions, bare patches black spots, pimples, lumpiness, runs, rust stains bulky white deposits, blisters.

Mild steel flats / wires shall undergo a process of degreasing pickling in acid, cold rinsing and then galvanizing.

6.31 **FIRE RETARDANT CABLE PAINT & FIRE BARRIER**

The fire retardant paint / barrier shall be listed by independent test agencies such as UL, FM or OPL and be tested to, and pass the criteria of ASTM E 814 (UL1479) standard test method for fire test through- penetration fire stops and ASTM E 1996 (UL 2079) standard test method for fire resistive joint system/

6.31.1 **Fire retardant cable Paint**

The Fire resistant cable coating / painting shall be intumescent / ablative, water based compound, and the coating shall expand up to 10 times, supplied in a manufacturer seal container indicating manufacturing and expiry dates. The coating material shall be non-toxic, asbestos free, & halogen free and shall have good mechanical strength. The color of paint shall be white and density of coating shall be 1.3kg/ltr , coating shall have a snap time of 30 minutes, the expansion shall begin at 230 deg.C and it shall have a oxygen index of 41%.

Coating shall be applied by ordinary paint brush after cleaning the cables of dust and oil deposition. A minimum textured finish of 3 mm wet film thickness shall be achieved by applying the material in 2-3 layers leaving intervals of 2 to 8 hours depending upon the moisture and thickness, moisture and temperature hours between each coat.

6.31.2 **Fire Barrier sheet for floor and wall sealing**

The framing & fixing part of fire barrier sheet shall be very simple & directly fixed around walls & floors by help of anchored bolts & washer. For 2 hour fire rating the fire barrier sheet shall be minimum 7.62 mm thick and shall be cut as per the profile of penetration and opening. The small gap left around the penetration shall be closed with fire rated soft & mouldable putty. Fire barrier must be design on the intumescent technology to seal larger penetration through the fire rated walls & floors. Fire barrier must be a composite construction with the quality incorporated with organic/ inorganic fire resistive elastomeric sheet with specific gravity of 1.6 gm/ cubic centimeter.

6.32 **TESTING OF CABLES**

Cables shall be tested at works for all routine tests as per IS including the following tests before being dispatched to site by the project team.

- f) Insulation Resistance Test.
- g) Continuity resistance test.
- h) Sheathing continuity test.
- i) Earth test.(in armoured cables)
- j) Hi Pot Test.

Test shall also be conducted at site for insulation between phases and between phase and earth for each length of cable, before and after jointing. On completion of cable laying work, the following tests shall be conducted in the presence of the Owner's site representative.

- b) Insulation Resistance Test(Sectional and overall)
- b) Continuity resistance test.

- c) Sheathing continuity test.
- d) Earth test.

All tests shall be carried out in accordance with relevant Standard Code of Practice and Electricity Rules. The Contractor shall provide necessary instruments, equipment and labor for conducting the above tests and shall bear all expenses in connection with such tests. All tests shall be carried out in the presence of the Owner's site representative, results will be noted and signed by all present and record be maintained.

6.33 **EARTHING**

Earthing shall be provided in accordance with IS : 3043 – 1987 and shall be copper strips /wires .The main panel shall be connected to main earthing system of the power supply. All single phase metal clad switches and control panels be earthed with minimum 3 mm diameter copper conductor wire. All 3 phase motors and equipment shall be earthed with 2 numbers distinct and independent copper wires / tapes as follows:

- i. Motor upto and including 10 HP rating. 2 Nos. 3 mm dia copper wires.
- ii. Motor 12.5 HP to 40 HP capacity. 2 Nos. 4 mm dia copper wires.
- iii. Motor 50 to 75 HP capacity. 2 Nos. 6 mm dia copper
- iv. Motor above 75 HP. 2 Nos. 25 mm x 3 mm **copper tapes.**

All switches shall be earthed with two numbers distinct and independent copper wires' tapes as follows:

- i. 3 phase switches and control panels upto 60 amps rating. 2 nos. 3 mm dia copper wires.
- ii. 3 phase switches, and control panels 63 amps to 100 amps rating. 2 Nos. 4 mm dia copper wires.
- iii. 3 phase switches and control panels 125 amps to 200 amps rating. 2 Nos. 6 mm dia copper wires.

- | | | |
|-----|--|-----------------------------------|
| iv. | 3 phase switches, control panels, bus ducts, above | 2 Nos. 3 mm x 25 mm copper tapes. |
|-----|--|-----------------------------------|

200 amps rating.

The earthing connections shall be tapped off from the main earthing of electrical installation. The overlapping in earthing strips at joints where required shall be minimum 75 mm. These straight joints shall be riveted with brass rivets & brazed in approved manner. Sweated lugs of adequate capacity and size shall be used for all termination of wires. Lugs shall be bolted to the equipment body to be earthed after the metal body is cleaned of paint and other oily substance, and properly tinned.

6.34 **DRAWINGS**

Shop drawings for control panels and for wiring of equipment showing the route of conduit & cable shall be submitted by the contractor for approval of Architect/Consultant before starting the fabrication of panel and starting the work. On completion, four sets of complete "As-installed" drawings incorporating all details like, conduits routes, number of wires in conduit, location of panels, switches, junction/pull boxes and cables route etc. Shall be furnished by the Contractor.

6.35 **TESTING**

Before commissioning of the equipment, the entire electrical installation shall be tested in accordance with relevant BIS codes and test report furnished by a qualified and authorized person. The entire electrical installation shall be gotten approved by Electrical Inspector and a certificate from Electrical Inspector shall be submitted. All tests shall be carried out in the presence of Owner's site representative. Testing of the panels shall be as per relevant BIS Codes :

6.36 **PAINTING**

All sheet steel work shall undergo a process of degreasing, thorough cleaning, and painting with a high corrosion resistant primer. All panels shall then be baked in an oven. The finishing treatment shall be by application of powder coating of approved shade.

6.37 **MEASUREMENT OF ELECTRICAL CONTROL PANELS**

Panels shall be counted as number of units. Quoted rates shall include as lump sum (NOT measurable lengths) for all internal wiring, power wiring and earthing connections from the control panel to the starter and to the motor, control wiring for interlocking, power and control wiring for automatic and safety controls, and control wiring for remote start/stop as well as indication as per the specifications. The quoted rate of panel shall also include all accessories, switchgear, contactors, indicating meters and lights as per the Specifications and Schedule of Quantities.

6.38 **RUBBER MAT**

Rubber mat shall be provided in front to cover the full length of all panels. Where back space is provided for working from the rear of the panel, rubber mat shall also be provided at the back of the panel also to cover the full length of panel. Rubber mats provided shall be as per IS 15652-2006

7. VARIABLE FREQUENCY DRIVES FOR HVAC SYSTEMS

7.1 GENERAL REQUIREMENTS

- a. This specification covers complete variable frequency drives (Vedas) designated on the drawing schedules to be variable speed. All standard and optional features shall be included within the VFD.
- b. The frequency converter shall not be a general purpose product, but a dedicated HVAC engineered product.
- c. The VFD and its options shall be factory mounted and tested as a single unit under full load before dispatch.
- d. The VFD shall be tested to UL 508C. The appropriate UL label shall be applied.
- e. The VFD shall be CE marked and conform to the European Union Electro Magnetic Compatibility directive.
- f. The VFD shall be UL listed for a short circuit current rating of 100 kA and labeled with this rating.

7.2 TECHNICAL REQUIREMENTS

- 7.2.1 The VFD shall convert incoming fixed frequency three-phase AC power into an adjustable frequency and voltage for controlling the speed of three-phase AC motors. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for the driven load and to eliminate the need for motor derating.

When properly sized, the VFD shall allow the motor to produce full rated power at rated motor voltage, current, and speed without using the motor's service factor. Vedas utilizing sine weighted/coded modulation (with or without 3rd harmonic injection) must provide data verifying that the motors will not draw more than full load current during full load and full speed operation.

7.2.2 VFD shall be installed within panel, suitable for operating conditions.

- 7.2.3 The VFD shall include an input full-wave bridge rectifier and maintain a fundamental (displacement) power factor near unity regardless of speed or load.

- 7.2.4 The VFD shall have a dual 5% impedance DC link reactor (harmonic filters) on the positive and negative rails of the DC bus to minimize power line harmonics and protect the VFD from power line transients. The chokes shall be non-saturating. Swinging chokes that do not provide full harmonic filtering throughout the entire load range are not acceptable.

- 7.2.5 Vedas with saturating (non-linear) DC link reactors shall require an additional 3% AC line reactor to provide acceptable harmonic performance at full load, where harmonic performance is most critical.
- IEEE519, 1992 recommendations shall be used for the basis of calculation of total harmonic distortion (THD) at the point of common coupling (PCC). On request VFD manufacturer shall provide THD figures for the total connected load. The contractor shall provide details of supply transformer rating, impedance, short circuit current, short circuit impedance etc to allow this calculation to be made.
- 7.2.6 All Vedas shall contain integral EMC Filters to attenuate Radio Frequency Interference conducted to the AC power line. The Vedas shall comply with the emission and immunity requirements of IEC 61800-3: 2004, Category C1 with 50m motor cable (unrestricted distribution). The suppliers of Vedas shall include additional EMC filters if required to meet compliance to this requirement.
- 7.2.7 The Veda's full load output current rating shall meet or exceed the normal rated currents of standard IEC induction motors. The VFD shall be able to provide full rated output current continuously, 110% of rated current for 60 seconds and 120% of rated torque for up to 0.5 second while starting.
- 7.2.8 The VFD shall provide full motor torque at any selected frequency from 20 Hz to base speed while providing a variable torque V/Hz output at reduced speed. This is to allow driving direct drive fans without high speed derating or low speed excessive magnetization, as would occur if a constant torque V/Hz curve was used at reduced speeds. Breakaway current of 160% shall be available.
- 7.2.9 A programmable automatic energy optimization selection feature shall be provided as standard in the VFD. This feature shall automatically and continuously monitor the motor's speed and load to adjust the applied voltage to maximize energy savings.
- 7.2.10 The VFD must be able to produce full torque at low speed to operate direct driven fans.
- 7.2.11 Output power circuit switching shall be able to be accomplished without interlocks or damage to the VFD.
- 7.2.12 An Automatic Motor Adaptation algorithm shall measure motor stator resistance and reactance to optimize performance and efficiency. It shall not be necessary to run the motor or de-couple the motor from the load to perform the test.
- 7.2.13 galvanic isolation shall be provided between the Veda's power circuitry and control circuitry to ensure operator safety and to protect connected electronic control equipment from damage caused by voltage

spikes, current surges, and ground loop currents. Vedas not including either galvanic or optical isolation on both analog I/O and discrete digital I/O shall include additional isolation modules.

7.2.14 VFD shall minimize the audible motor noise through the used of an adjustable carrier frequency. The carrier frequency shall be automatically adjusted to optimize motor and VFD operation while reducing motor noise. Vedas with fixed carrier frequency are not acceptable.

7.2.15 The VFD shall allow up to at least 100 meters of SWA (Single Wire Armour) cable to be used between the FC and the motor and allow the use of MICS (Mineral Insulated Copper Sheath) cable in the motor circuit for fire locations.

7.3 **PROTECTIVE FEATURES**

7.3.1 A minimum of Class 20 I^2t electronic motor overload protection for single motor applications shall be provided. Overload protection shall automatically compensate for changes in motor speed.

7.3.2 Protection against input transients, loss of AC line phase, output short circuit, output ground fault, over voltage, under voltage, VFD over temperature and motor over temperature. The VFD shall display all faults in plain language. Codes are not acceptable.

7.3.3 Protect VFD from input phase loss. The VFD should be able to protect itself from damage and indicate the phase loss condition. During an input phase loss condition, the VFD shall be able to be programmed to either trip off while displaying an alarm, issue a warning while running at reduced output capacity, or issue a warning while running at full commanded speed. This function is independent of which input power phase is lost.

7.3.4 Protect from under voltage. The VFD shall provide full rated output with an input voltage as low as 90% of the nominal. The VFD will continue to operate with reduced output, without faulting, with an input voltage as low as 70% of the nominal voltage.

7.3.5 VFD shall include current sensors on all three output phases to accurately measure motor current, protect the VFD from output short circuits, output ground faults, and act as a motor overload. If an output phase loss is detected, the VFD will trip off and identify which of the output phases is low or lost.

7.3.6 If the temperature of the Veda's heat sink rises to 80°C, the VFD shall automatically reduce its carrier frequency to reduce the heat sink temperature. It shall also be possible to program the VFD so that it reduces its output current limit value if the VFD's temperature becomes too high.

- 7.3.7 In order to ensure operation during periods of overload, it must be possible to program the VFD to automatically reduce its output current to a programmed value during periods of excessive load. This allows the VFD to continue to run the load without tripping.
- 7.3.8 The VFD shall have temperature controlled cooling fan(s) for quiet operation, minimized losses, and increased fan life. At low loads or low ambient temperatures, the fan(s) may be off even when the VFD is running.
- 7.3.9 Protect from output switching : The VFD shall be fully protected from switching a contactor / isolator at the output with out causing tripping e.g.: for switching on/off the isolators of the AHU / ventilation fans.
- 7.3.10 The VFD shall store in memory the last 10 alarms. A description of the alarm, and the date and time of the alarm shall be recorded.
- 7.3.11 When used with a pumping system, the VFD shall be able to detect no-flow situations, dry pump conditions, and operation off the end of the pump curve. It shall be programmable to take appropriate protective action when one of the above situations is detected.

7.4 **INTERFACE FEATURES**

- 7.4.1 Hand, Off and Auto keys shall be provided on the control panel to start and stop the VFD and determine the source of the speed reference. It shall be possible to either disable these keys or password protect them from undesired operation.
- 7.4.2 There shall be an “Info” key on the keypad. The Info key shall include “on-line” context sensitive assistance for programming and troubleshooting.
- 7.4.3 The VFD shall be programmable to provide a digital output signal to indicate whether the VFD is in Hand or Auto mode. This is to alert the Building Automation System whether the VFD is being controlled locally or by the Building Automation System.
- 7.4.4 Password protected keypad with alphanumeric, graphical, backlit display can be remotely mounted. Two levels of password protection shall be provided to guard against unauthorized parameter changes.
- 7.4.5 All VFDs shall have the same customer interface. The keypad and display shall be identical and interchangeable for all sizes of VFDs.

- 7.4.6 To set up multiple VFDs, it shall be possible to upload all setup parameters to the VFD's keypad, place that keypad on all other VFDs in turn and download the setup parameters to each VFD. To facilitate setting up VFDs of various sizes, it shall be possible to download from the keypad only size independent parameters. Keypad shall provide visual indication of copy status.
- 7.4.7 Display shall be programmable to communicate in multiple languages including English, Chinese, Korean, Japanese, Thai and Indonesian.
- 7.4.8 A red FAULT light, a yellow WARNING light and a green POWER-ON light shall be provided. These indications shall be visible both on the keypad and on the VFD when the keypad is removed.
- 7.4.9 A quick setup menu with factory preset typical HVAC parameters shall be provided on the VFD. The VFD shall also have individual Fan, Pump, and Compressor menus specifically designed to facilitate start-up of these applications.
- 7.4.10 A three-feedback PID controller to control the speed of the VFD shall be standard.
- 7.4.11 This controller shall accept up to three feedback signals. It shall be programmable to compare the feedback signals to a common set point or to individual set points and to automatically select either the maximum or minimum deviating signal as the controlling signal. It shall also be possible to calculate the controlling feedback signal as the average of all feedback signals or the difference between a pair of feedback signals.
- 7.4.12 The VFD shall be able to apply individual scaling to each feedback signal.
- 7.4.13 For fan flow tracking applications, the VFD shall be able to calculate the square root of any or all individual feedback signals so that a pressure sensor can be used to measure air flow.
- 7.4.14 The VFD's PID controller shall be able to actively adjust its setpoint based on flow. This allows the VFD to compensate for a pressure feedback sensor which is located near the output of the pump rather than out in the controlled system.
- 7.4.15 The VFD shall have three additional PID controllers which can be used to control damper and valve positioners in the system and to provide setpoint reset.
- 7.4.16 Floating point control interface shall be provided to increase/decrease speed in response to contact closures.

- 7.4.17 Five simultaneous meter displays shall be available. They shall be selectable from (at a minimum), frequency, motor current, motor voltage, VFD output power, VFD output energy, VFD temperature in degrees, feedback signals in their own units, among others.
- 7.4.18 Programmable Sleep Mode shall be able to stop the VFD. When its output frequency drops below set “sleep” level for a specified time, when an external contact commands that the VFD go into Sleep Mode, or when the VFD detects a no-flow situation, the VFD may be programmed to stop. When the VFD’s speed is being controlled by its PID controller, it shall be possible to program a “wake-up” feedback value that will cause the VFD to start. To avoid excessive starting and stopping of the driven equipment, it shall be possible to program a minimum run time before sleep mode can be initiated and a minimum sleep time for the VFD.
- 7.4.19 A run permissive circuit shall be provided to accept a “system ready” signal to ensure that the VFD does not start until dampers or other auxiliary equipment are in the proper state for VFD operation. The run permissive circuit shall also be capable of initiating an output “run request” signal to indicate to the external equipment that the VFD has received a request to run.
- 7.4.20 VFD shall be programmable to display feedback signals in appropriate units, such as inches of water column (in-wg), pressure per square inch (psi) or temperature (°F). Examples can be room temperature in °C , return air temperature in °C , supply air temperature in °C, CO₂ concentration in ppm, pressure in bar, differential pressure in PSI etc.
- 7.4.21 VFD shall be programmable to sense the loss of load. The VFD shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communications bus. To ensure against nuisance indications, this feature must be based on motor torque, not current, and must include a proof timer to keep brief periods of no load from falsely triggering this indication.
- 7.4.22 Standard Control and Monitoring Inputs and Outputs
- 7.4.22.1 Four dedicated, programmable digital inputs shall be provided for interfacing with the systems control and safety interlock circuitry.
- 7.4.22.2 Two terminals shall be programmable to act as either as digital outputs or additional digital inputs.
- 7.4.22.3 Two programmable relay outputs, Form C 240 V AC, 2 A, shall be provided for remote indication of VFD status.
- 7.4.22.4 Each relay shall have an adjustable on delay / off delay time.
- 7.4.22.5 Two programmable analog inputs shall be provided that can be either direct-or-reverse acting.

7.4.22.6 Each shall be independently selectable to be used with either an analog voltage or current signal.

7.4.22.7 The maximum and minimum range of each shall be able to be independently scalable from 0 to 10 V dc and 0 to 20 mA.

7.4.22.8 A programmable low-pass filter for either or both of the analog inputs must be included to compensate for noise.

7.4.22.9 The VFD shall provide front panel meter displays programmable to show the value of each analog input signal for system set-up and troubleshooting,

7.4.22.10 One programmable analog current output (0/4 to 20 mA) shall be provided for indication of VFD status. This output shall be programmable to show the reference or feedback signal supplied to the VFD and for VFD output frequency, current and power. It shall be possible to scale the minimum and maximum values of this output.

7.4.22.11 It shall be possible to read the status of all analog and digital inputs of the VFD through serial bus communications.

7.4.22.12 It shall be possible to command all digital and analog output through the serial communication bus.

7.4.23 Optional Control and Monitoring Inputs and Outputs

7.4.23.1 It shall be possible to add optional modules to the VFD in the field to expand its analog and digital inputs and outputs.

7.4.23.2 These modules shall use rigid connectors to plug into the VFD's control card.

7.4.23.3 The VFD shall automatically recognize the option module after it is powered up. There shall be no need to manually configure the module.

7.4.23.4 Modules may include such items as:

7.4.23.5 Additional digital outputs, including relay outputs

7.4.23.6 Additional digital inputs

7.4.23.7 Additional analog outputs

7.4.23.8 Additional analog inputs, including Ni or Pt temperature sensor inputs

7.4.23.9 It shall be possible through serial bus communications to control the status of all optional analog and digital outputs of the VFD.

7.4.24 Standard programmable firefighter's override mode allows a digital input to control the VFD and override all other local or remote commands. It shall be possible to program the VFD so that it will ignore most normal VFD safety circuits including motor overload. The VFD shall display FIREMODE whenever in firefighter's override mode. Firemode shall allow selection of forward or reverse operation and the selection of a speed source or preset speed, as required to accommodate local fire codes, standards and conditions.

7.4.25 A real-time clock shall be an integral part of the VFD.

7.4.25.1 It shall be possible to use this to display the current date and time on the VFD's display.

7.4.25.2 Ten programmable time periods, with individually selectable ON and OFF functions shall be available. The clock shall also be programmable to control start/stop functions, constant speeds, PID parameter setpoints and output relays. It shall be possible to program unique events that occur only during normal work days, others that occur only on non-work days, and others that occur on specific days or dates. The manufacturer shall provide free PC-based software to set up the calendar for this schedule.

7.4.25.3 All VFD faults shall be time stamped to aid troubleshooting.

7.4.25.4 It shall be possible to program maintenance reminders based on date and time, VFD running hours, or VFD operating hours.

7.4.25.5 The real-time clock shall be able to time and date stamp all faults recorded in the VFD fault log.

7.4.25.6 The VFD shall be able to store load profile data to assist in analyzing the system demand and energy consumption over time.

7.4.25.7 The VFD shall include a sequential logic controller to provide advanced control interface capabilities. This shall include:

7.4.25.8 Comparators for comparing VFD analog values to programmed trigger values

7.4.25.9 Logic operators to combine up to three logic expressions using Boolean algebra

7.4.25.10 Delay timers

7.4.26 The VFD shall include a Cascade Controller which allows the VFD to operate in closed loop set point (PID) control mode one motor at a controlled speed and control the operation of 3 additional constant speed motor starters.

7.5 **SERIAL COMMUNICATIONS**

7.5.1 The VFD shall include a standard EIA-485 communications port and capabilities to be connected to the following serial communication protocols at no additional cost and without a need to install any additional hardware or software in the VFD:

Metasys N2

Modbus RTU

7.5.2 VFD shall have standard USB port for direct connection of Personal Computer (PC) to the VFD. The manufacturer shall provide no-charge PC software to allow complete setup and access of the VFD and logs of VFD operation through the USB port. It shall be possible to communicate to the VFD through this USB port without interrupting VFD communications to the building management system.

7.5.3 The VFD shall have provisions for an optional 24 V DC back-up power interface to power the VFD's control card. This is to allow the VFD to continue to communicate to the building automation system even if power to the VFD is lost.

7.6 **ADJUSTMENTS**

7.6.1 The VFD shall have a manually adjustable carrier frequency that can be adjusted in 0.5 kHz increments to allow the user to select the desired operating characteristics. The VFD shall also be programmable to automatically reduce its carrier frequency to avoid tripping due to thermal loading.

7.6.2 Four independent setups shall be provided.

7.6.3 Four preset speeds per setup shall be provided for a total of 16.

7.6.4 Each setup shall have two programmable ramp up and ramp down times. Acceleration and deceleration ramp times shall be adjustable over the range from 1 to 3,600 seconds.

Each setup shall be programmable for a unique current limit value. If the output current from the VFD reaches this value, any further attempt to increase the current produced by the VFD will cause the VFD to reduce its output frequency to reduce the load on the VFD. If desired, it shall be possible to program a timer which will cause the VFD to trip off after a programmed time period.

If the VFD trips on one of the following conditions, the VFD shall be programmable for automatic or manual reset: external interlock, under-voltage, over-voltage, current limit, over temperature, and VFD overload.

The number of restart attempts shall be selectable from 0 through 20 or infinitely and the time between attempts shall be adjustable from 0 through 600 seconds.

An automatic “start delay” may be selected from 0 to 120 seconds. During this delay time, the VFD shall be programmable to either apply no voltage to the motor or apply a DC braking current if desired. Four programmable critical frequency lockout ranges to prevent the VFD from operating the load at a speed that causes vibration in the driven equipment shall be provided. Semi-automatic setting of lockout ranges shall simplify the set-up.

7.7 **OPTIONAL FEATURES**

7.7.1 All optional features shall be built and mounted by VFD manufacturer as an inbuilt factory solution. All optional features shall be UL listed by the VFD manufacturer as a complete assembly and carry a UL label.

7.8 **SERVICE CONDITIONS**

7.8.1 Ambient temperature at full speed, full load operation with continuous drive rated output current:

7.8.2 -10 to 45°C for ratings upto 90 kW without derating

7.8.2 -10 to 40°C for ratings 110 kW and higher without derating

7.8.3 Relative Humidity : 0 to 95%, non-condensing.

7.8.4 Elevation : Up to 3,300 feet without derating.

7.8.5 AC line voltage variation : \pm 10% of nominal with full output.

7.8.6 VFD Enclosure protection : IP 55, integral, with no additional cabinets.

7.8.7 Side Clearances : No side clearance shall be required for cooling.

7.8.8 All power and control wiring shall be done from the bottom.

7.8.9 All VFDs shall be plenum rated.

7.9 **QUALITY ASSURANCE**

7.9.1 To ensure quality, the complete VFD shall be tested by the manufacturer. The VFD shall drive a motor connected to a dynamometer at full load and speed and shall be cycled during the automated test procedure.

7.9.2 All optional features shall be functionally tested at the factory for proper operation.

8. **QUALITY ASSURANCE, INSPECTION, TESTING AND COMMISSIONING**

8.1 **SCOPE**

The following quality assurance, inspection, testing and commissioning procedures shall be required to be carried out upon award of work.

- i. Provide quality assurance program (QAP), works quality assurance program (WQAP), field quality assurance program (FQAP) and quality plan.
- ii. Tests at manufacturer's works.
- iii. Perform site tests and commissioning.

8.2 **SUBMITTALS**

- i. After award of work following information shall be submitted.
 - a. Quality Assurance Program (QAP)
 - b. Works Quality Assurance programme (WQAP)
 - c. Field Quality Assurance Programme (FQAP)
- ii. For inspection and testing, submit inspection and testing procedures, programme, record sheets applicable at each hold point.

- iii. After completion of testing, submit test records, packaging, transportation and storage instructions and methods.
- iv. For site installation and commissioning, submit installation methods or procedures, notification and procedures for precommission and commissioning.
- v. After commissioning, submit site test records, as-built drawings, manufacturer's operation maintenance manuals and list of recommended spares and tools.

8.3 **QUALITY ASSURANCE CONCEPT AND CONTROL**

- i. Minimum requirements for establishing and implementing a quality assurance programme shall be applied to all aspects of the work necessary for carrying out the contract. Quality assurance shall extend to material parts, components, systems, and services as a means of obtaining and sustaining the reliability of critical items, operating performance, maintenance, and safety.
- ii. Acceptance of the Contractor's quality assurance programme does not relieve the Contractor's obligation to comply with the requirement of the contract document. If the programme is found to be ineffective, then the Owner's site representative reserves the right to request for necessary revisions of the programme.
- iii. The Contractor is required to produce readily identifiable documentary evidence covering the extent and details of both his own and his sub contractor's quality assurances system as follows :
 - a. Quality Assurance Program (QAP)
 - b. Works Quality Assurance programme (WQAP)
 - c. Field Quality Assurance Programme (FQAP)
 - d. Quality Plan.
- iv. These documents shall be prepared separately and submitted to the Owner's site representative at the time of starting the work.
- v. Quality Plan and Manual shall be prepared by the Contractor for all items and services to be supplied, after the contract has been placed, but before commencement of fabrication, and shall be subject to evaluation and acceptance by the Owner's site representative before start of work.

8.4 **QUALITY ASSURANCE MANUAL (QAM)**

- I. The QAM shall be a general comprehensive document outlining the Contractor's basic organization, policies, and procedures. The information to be given in the QAM shall include but not limited to:
- a. Quality Policy.
 - b. Quality Assurance Programmed
 - c. Organization Structure showing inters relationships.
 - d. Functional responsibilities and levels of authority.
 - e. Lines of communication.
 - f. Customer relations.
 - g. Laboratory Facilities.

8.5 **WORKS QUALITY ASSURANCE PROGRAMME (WOAP)**

- I. The WQAP shall identify the Contractor's Quality Assurance Programmed at works applicable throughout all phases of Contract performance, including design, procurement, manufacture, inspection and testing. It shall identify each of the programmed elements to be designed, developed, executed, and maintained by the Contractor for the purpose of ensuring that all supplies and services comply with this specifications.
- II. The information to be given under this programme shall include but not limited to :
- a. Organization and Responsibility.
 - b. Contract Review.
 - c. Design and Document Control.
 - d. Procurement Control.
 - e. Production Control.
 - f. Control on Sub-contractors.

- g. In-process Quality Control and Traceability.
- h. Inspection and Testing.
- i. Control of Non-conformances.
- j. Corrective Action.
- k. Control of Inspection, Measuring and Test Equipment.
- l. Handling, Storage, Packaging, and Delivery.
- m. Records.
- n. Quality Audits.
- o. After - Sales Servicing.

8.6 **FIELD QUALITY ASSURANCE PROGRAMME (FOAP)**

- I. This programmed shall identify the Contractor's Quality Assurance Programmed at site applicable throughout site construction, erection, and commissioning. It is the underlying philosophy that the quality built into the product at works shall be maintained throughout the construction and commissioning stages.
- II. While, in principle, the FQAP shall include the items discussed in WQAP, it shall, however, be approached differently to take into account site conditions.
- III. The FQAP shall include, but not limited to the following information:
 - a. Organization and responsibility.
 - b. Control of Drawings and Documentation.
 - c. Product Checklist.
 - d. Control and Traceability of Purchased materials and services.
 - e. Receipt Inspection of materials at site.
 - f. Material Storage Control.
 - g. Inspection and Examination Procedures.
 - h. Control of Painting and Insulation Works.
 - i. Pre-commissioning.
 - j. Commissioning.
 - k. Control of Non-conformances.

- l. Corrective Action.
- m. Control of Inspection, Measuring and Test Equipment.
- n. Records.
- o. Complétion Documents.
- p. List of recommended spares and tools.
- q. Personal Training.
- r. Servicing during Defects Liability Period.

8.7 **QUALITY PLAN**

- I. The contractor shall be required to prepare manufacturing and construction/erection quality plans for all equipment items and services. The quality plan shall also define the involvement of Owner's site representative in the inspection and test programmers.
- II. The Quality Plan shall incorporate as appropriate:
 - a. Charts indicating flow of materials, parts and components through manufacturing quality control inspection and test to delivery and erection.
 - b. The charts shall indicate the location of hold points for quality control, inspection and test beyond which manufacture shall not continue until the action required by the hold point is met, and the documentation required is generated.
 - c. The control documents associated with each hold point, i.e. drawings, material, specification, Works Process Schedule (WPS), Process Quality Records (PQR), quality control methods and procedures and acceptance standards.

8.8 **SITE QUALITY CONTROL SECTION**

- I. The Contractor's Quality Control (Q.C.) section shall be headed by an experienced Quality Control Engineer. He shall be assisted by other supervisors. The section shall be an independent one, reporting to the contractor's Site Manager only on administrative matters, but otherwise under full control by the Contractor's Corporate Quality System Management.
- II. The Contractor's Q.C. Section shall liasise closely with the Owner's site representative in charge of Quality Assurance/Quality Control, and to whom it shall give fullest cooperation. It is the underlying principle of this contract document that while the Contractor's Q.C. Engineer

implements the Contractor's Quality Programme, the adequacy and effectiveness of that implementation shall be audited by the Owner's site representative whose recommendations on improving or maintaining quality shall be acted upon promptly by the Contractor's Q.C. Section.

8.9 **INSPECTION AND TESTING**

- I. All equipment and components supplied may be subjected to inspection and tests by the Consultant/ Owner's site representative during manufacture, erection/installation and after completion. The inspection and tests shall include but not be limited by the requirements of this contract document. Prior to inspection and testing, the equipment shall undergo pre-service cleaning and protection.
- II. Tenderers shall state and guarantee the technical particulars listed in the Schedule of Technical Data. These guarantees and particulars shall be binding and shall not be varied without the written permission of the Owner's site representative.
- III. No tolerances shall be allowed other than the tolerances specified or permitted in the relevant approved Standards, unless otherwise stated.
- IV. If the guaranteed performance of any item of equipment is not met and / or if any item fails to comply with the specification requirement in any respect whatsoever at any stage of manufacture, test or erection, the Owner's site representative may reject the item, or defective component thereof, whichever he considers necessary; and after adjustment or modification as directed by the Owner's site representative, the contractor shall submit the item for further inspection and /or test.
- V. The approval of the Owner's site representative of inspection and/or test results shall not prejudice the right of the Owner's site representative to reject an item of equipment if it does not comply with the contract document when erected, does not, or prove completely satisfactory in service.
- VI. The Contractor shall be responsible for the timely transmission of the relevant and appropriate sections of the contract document to manufacturers and sub-contractors for the proper execution of all tests at their works as per contract specifications.

8.10 **TESTS AT MANUFACTURER'S WORKS**

- I. All tests to be performed during manufacture, fabrication, and inspection shall be agreed with the Consultant/ Owner's site representative prior to commencement of the work. The Contractor shall prepare the details of the schedule and submit these to the Consultant/ Owner's site representative for approval. It must be ensured that adequate relevant information on the design code/standard employed, the manufacture /fabrication/assembly procedure and the attendant quality control steps proposed are made available to the Consultant/Owner's site representative who will mark in the appropriate spaces his intention to attend or waive the invited tests, or inspections.
- II. I a minimum of twenty-one days' notice of the readiness of equipment for test or inspection shall be provided to the Owner's site representative by the Contractor (whether the tests are held at the Contractor's or Sub-contractor's works). The subject items should remain available for Owner's site representative inspection and test up to a minimum 8 days beyond the agreed date of witnessing the test. Every facility in respect of access, drawings, instruments, and manpower shall be provided by the Contractor and sub-contractor to enable the Owner's site representative to carry out the necessary inspection and testing of the Plant.
- III. No plant shall be packed, prepared for shipment, or dismantled for the purpose of packing for shipment, unless it has been satisfactorily inspected, all tests called for have been successfully carried out in the presence of the Owner's site representative or approved for shipment, or alternatively inspection has been waived.
- IV. Functional electrical, mechanical, and hydraulic tests shall be carried out on completed assemblies in the works. The extent of these tests and method of recording the results shall be submitted to, and agreed by, the Owner's site representative in sufficient time to enable the tests to be satisfactorily witnessed, or if necessary for any changes required to the proposed programmed of tests to be agreed.
- V. The Consultant/Owner's site representative reserves the right to visit the Manufacturer's works at any reasonable time during fabrication of equipment and to familiarize him with the progress made and the quantity of the work to date.
- VI. Within 30 days of completion of any tests, triplicate sets of all principal test records, test certificates, and correction and performance curves shall be supplied to the Owner's site representative.
- VII. These test records, certificates and performance curves shall be supplied for all tests, whether or not they have been witnessed by the Owner's site representative or not. The information given on such test certificates and curves shall be sufficient to identify the material or equipment to which the certificate refers and should also bear the Contract reference title.

- VIII. When all equipment has been tested, the test certificates from all works and site tests shall be compiled by the Contractor into volumes and bound in an approved form complete with index and four copies of each volume shall be supplied to Consultant/ Owner's site representative.
- IX. Stage wise inspection of equipment in factory is waived.

8.11 **PERFORMANCE TESTS AT MANUFACTURER'S WORKS**

- I. All equipment may be subjected to routine performance tests at the Manufacturer's Works in accordance with the relevant ANSI, ASME, ASTM, BIS standard including operating tests of complete assemblies to ensure correct operation of apparatus and components.
- II. Fans, compressor, and other rotating equipment shall be given full load tests, and run to 15% overspeed for 5 minutes to check vibration. Main and auxiliary gear boxes shall be subjected to shock load tests and a six-hour endurance run at rated speed and maximum torque.
- III. The Contractor shall submit single line diagrams including the layout of the Plant together with the location of test instrumentation and the principal dimensions of the layout. All calculations to derive performance data shall be made strictly in accordance with format given in the approved standards. Any alterations or deviations from the approved standard test layout or formulae shall be subjected to the prior approval of the Owner's Site Representative.
- IV. The performance test shall be conducted over the full operating range of the pump to a closed valve condition and a minimum of five measurement points covering the full range shall be taken. Curves indicating Quantity vs. Head, Quantity vs. Power absorbed, and Quantity vs. Pump efficiency shall be provided. In addition a curve of the NPSH required vs. Quantity shall be provided except when the suction conditions do not require this test. Any proposal for the omission of this test shall be to the approval of the Consultant/ Owner's site representative.
- V. On completion of the tests the Contractor shall submit a report showing the test results obtained together with the curves corrected to the site operating conditions.

9. **TESTING, ADJUSTING AND BALANCING**

9.1 **SCOPE**

- a. Testing, adjusting, and balancing of ventilating and air-conditioning systems at site.
- b. Testing, adjusting, and balancing of HVAC Hydroid system at site.

- c. Testing, adjusting, and balancing of exhaust system at site.

Comply with current editions of all applicable practices, codes, methods of standards prepared by technical societies and associations including:

ASHRAE : 1995 HVAC Application.

SMACNA : Manual for the Balancing and Adjustment of air distribution System.

9.2 **PERFORMANCE**

- a. Verify design conformity.
- b. Establish fluid flow rates, volumes and operating pressures.
- c. Take electrical power readings for each motor.
- d. Establish operating sound and vibration levels.
- e. Adjust and balance to design parameters.
- f. Record and report results as per the formats specified.

9.3 **DEFINITIONS**

- a. Test : To determine quantitative performance of equipment.
- b. Adjust : To regulate for specified fluid flow rates and air patterns at terminal equipment (e.g. reduce fan speed, throttling etc.)
- c. Balance : To proportion within distribution system (submains, branches and terminals) in accordance with design quantities.

9.4 **TESTING, ADJUSTING AND BALANCING (TAB) PROCEDURES**

The following procedures shall be directly followed in TAB of the total system.

Before commencement of each one of the TAB procedure explained hereunder, the contractor shall intimate the PMC about his readiness to conduct the TAB procedures in the format given in these specifications.

9.5 **DESCRIPTION OF SYSTEM AND REQUIREMENTS**

Adjust and balance the following system to provide most energy efficient operation compatible with selected operating conditions.

- a. All supply, return and outside air systems.

- b. All exhaust air systems.
- c. Emergency purge systems.

9.6 **AIR SYSTEMS**

I. Air Handlers Performance

The TAB procedure shall establish the right selection and performance of the AHUs with the following results:

- a. Air-IN DB and WB temperature.
- b. Air-OUT DB and WB temperature.
- c. Dew point air leaving.
- d. Sensible heat flow.
- e. Latent heat flow.
- f. Sensible heat factor.
- g. Fan air volume.
- h. Fan air outlet velocity.
- i. Fan static pressure.
- j. Fan power consumption.
- k. Fan speed.

II. Air distribution

Both supply and return air distribution for each AHU and for areas served by the AHU shall be determined and adjusted as necessary to provide design air quantities. It shall cover balancing of air through main and branch ducts utilizing telescoping probes of Electronic Rotating Vane Anemometers and Accubalance for grilles and diffusers.

III. The Preparatory Work

To conduct the above test, following preparatory works are required to be carried out including the availability of approved for construction shop drawings and submittals :

- a. All outside air intake, return air and exhaust air dampers are in proper position.
- b. All system volume dampers and fire dampers are in full open position.
- c. All access doors are installed & are air tight.
- d. Grilles are installed & dampers are fully open.
- e. Provision and accessibility of usage of TAB instruments for traverse measurements are available.
- f. All windows, doors are in position.
- g. Duct system are of proper construction and are equipped with turning vanes and joints are sealed.
- h. Test holes and plugs for ducting.

9.7 **READINESS FOR COMMENCEMENT OF TAB**

Before starting of any of the tests, the readiness to do so should be recorded as per the prescribed check list.

9.8 **TAB INSTRUMENTS**

I. Air Measuring Instruments

- a. For measuring DB and WB temperature, RH and dew point, microprocessor based TSI USA make VelociCalc Plus Meter, Model 8386, or equivalent shall be used. This instrument shall be capable of calculating the sensible, latent total heat flows, sensible heat factor and give printouts at site and have data logging/downloading facility.
- b. For measuring Air velocity, DB temperature and Air volume, TSI USA make VelociCalc meter model 8386/ 8345 or equivalent shall be used. It shall be able to provide instant print out of recorded Air volume readings.
- c. Pitot tube.
- d. Electronic Rotary Vane Anemometer TSI make or equivalent.
- e. Accubalance Flow Measuring Hood TSI make or equivalent.

All above instruments shall have a valid certification from a reputed testing institution.

II. Hydronic Measuring Instruments

- a. For measurement of water flow across balancing valves, instruments as provided by the manufacturer of the valves specific to the type of valves shall be need. This shall include but not be limited to differential pressure manometers. Temperature shall be

measured using electric thermometers from thermowells provided at strategic location by the HVAC contractor.

The water balancing shall be carried out being computer simulation program provided / certified by the balancing valve manufacturer.

III. Rotation Measuring Instrument

- a. Electronic Digital Tachometer.

IV. Temperature & RH Measuring Instrument

- a. TSI VelociCalc model 8386 / VelociCalc model 8345 or equivalent.

V. Electrical Measuring Devices

- a. Clamp on Volt ammeter.
- b. Continuity Meter.

VI. Vibration and Noise Levels

Vibration and alignment field measurements shall be taken for each circulating water pump, air handling unit and fan driven by a motor over 8 HP. Readings shall include shaft alignment, equipment vibration, bearing housing vibration, and other test as directed by the PMC.

Sound level readings shall be taken at ten (8) locations in the building as selected by the PMC. The readings shall be taken on an Octave Band analyzer in a manner acceptable to him. The contractor shall submit test equipment data and reporting forms for review. In order to reduce the ambient noise level the readings shall be taken at night. All tests shall be performed in the presence of PMC/Consultant.

(ii) **Technical Specifications for Plumbing & Firefighting SYSTEMS**

SPECIAL CONDITIONS

1. GENERAL

These special conditions are intended to amplify the General Conditions of Contract, and shall be read in conjunction with the same. For any discrepancies between the General Conditions and these Special Conditions, the more stringent shall apply.

2. SCOPE OF WORK

The general character and the scope of work to be carried out under this contract is illustrated in Drawings, Specifications and Schedule of Quantities. The Tenderer shall carry out and complete the said work under this contract in every respect in conformity with the contract documents and with the direction of and to the satisfaction of the OWNER's site representative. The tenderer shall furnish all labour, materials and equipment (except those to be supplied by the OWNER) as listed under Schedule of Quantities and specified otherwise, transportation and incidental necessary for supply, installation, testing and commissioning of the complete Plumbing / Sanitary & Fire Fighting system as described in the Specifications and as shown on the drawings. This also includes any material, equipment, appliances and incidental work not specifically mentioned herein or noted on the Drawings / Documents as being furnished or installed, but which are necessary and customary to be performed under this contract. The Plumbing / Sanitary & Fire Fighting System shall comprise of following:

- a. Sanitary Fixtures and Fittings.
- b. Internal Water Supply.
- c. Internal Drainage
- e. Sprinkler System
- f. Hand Held Fire extinguishing System
- g. Approval from Local Authorities

- h. 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.
- i. Balancing, testing & commissioning of the entire plumbing & fire fighting system.
- j. Test reports, list of recommended spares, as-installed drawings, operation & maintenance manual for the entire plumbing & fire fighting system.
- k. Training of Owner's staff.

3. ASSOCIATED CIVIL WORKS

Following civil works associated with Plumbing / Sanitary & Fire Fighting installation are excluded from the scope of this contract. These shall be executed by other agencies in accordance with approved shop drawings and under direct supervision of the Plumbing / Sanitary & Fire Fighting tenderer.

- a. Water proofing of floors.
- b. Urinals division plates

4. ASSOCIATED SERVICES WORKS

4.1 All **ELECTRICAL WORKS** are excluded from the scope of this contract. However, the plumbing contractor for connections to be provided for motors.

- a. The plumbing contractor within 10 days of issue of LOI shall furnish an electrical load diagram showing the position of the loads.

5. BUILDING AUTOMATION SYSTEM

(No additional cost shall be paid for providing the interfacing).

The scope of Plumbing / Sanitary & Fire Fighting Tenderer shall include the following for the interface to Building Automation System.

- a. Sockets /Nipples including shut-off valve for mounting sensors/transmitters on pipe lines.

- b. It is to be clearly understood that the final responsibility for the sufficiency, adequacy and conformity to the contract requirements, of the Plumbing / Sanitary & Fire Fighting system, lies solely with the tenderer.

6. PROJECT EXECUTION AND MANAGEMENT

The Tenderer shall ensure that senior planning and erection personnel from his organisation are assigned exclusively for this project. They shall have minimum 10 years experience in this type of installation. The Tenderer shall appoint one Project Director holding senior management position in the organisation. He shall be assisted on full time basis by a minimum of two erection engineers & two senior supervisors. The entire staff shall be posted at site on full time basis.

The project management shall be through modern technique. Erection engineer and supervisors shall be provided with mobile communication system so that they can always be reached.

For quality control & monitoring of workmanship, tenderer shall assign at least one full-time engineer who would be exclusively responsible for ensuring strict quality control, adherence to specifications and ensuring top class workmanship for the installation.

The Tenderer shall arrange to have mechanised & modern facilities of transporting material to place of installation for speedy execution of work.

7. INSPECTION AND TESTING

That the equipment installed complies with specification in all respects and is of the correct rating for the duty and site conditions.

That all items operate efficiently and quietly to meet the specified requirements

The contractor shall provide all necessary instruments and labour for testing, shall make adequate records of test procedures and readings, shall repeat any tests requested by the Project Manager and shall provide test certificate signed by a properly authorized person. Such test shall be conducted on all materials and equipments and tests on completed work as called for by the Project Manager at contractor's expenses unless otherwise called for.

If it is proved that the installation or part thereof is not satisfactorily carried out, then the contractor shall be liable for the rectification and retesting of the same as called for by the Project Manager whose decision as to what constitutes a satisfactory test shall be final.

The above general requirements as to testing shall be read in conjunction with any particular requirements specified elsewhere. All tests shall be carried out by a test house approved by the Project Manager.

8. BYE-LAWS AND REGULATIONS

The installation shall be in conformity with the Bye-laws, Regulations and Standards of the local authorities concerned, in so far as these become applicable to the installation. But if these Specifications and Drawings call for a higher standard of materials and / or workmanship than those required by any of the above regulations and standards, then these Specifications and Drawings shall take precedence over the said regulations and standards. However, if the Drawings and specifications require something which violates the Bye-laws and Regulations, then the Bye-laws and Regulations shall govern the requirement of this installation.

9. FEES AND PERMITS

The tenderer shall obtain all permits/ licenses and pay for any and all fees required for the inspection, approval and commissioning of their installation. However, all receipted amount shall be reimbursed on production of proof of payment.

10. DRAWINGS

The Plumbing / Sanitary & Fire Fighting Drawings listed under Appendix-I, issued with tenders are diagrammatic only and indicate arrangement of various systems and the extent of work covered in the contract. These Drawings indicate the points of supply and of termination of services and broadly suggest the routes to be followed. Under no circumstances shall dimensions be scaled from these Drawings. The architectural/interiors drawings and details shall be examined for exact location of sprinklers, hydrants, equipments and water supply / drainage piping etc.

The tenderer shall follow the tender drawings in preparation of his shop drawings, and for subsequent installation work. He shall check the drawings of other trades to verify spaces in which his work will be installed.

Maximum headroom and space shall be maintained at all points. Where headroom appears inadequate, the tenderer shall notify the Architect/Consultant/OWNER's site representative before proceeding with the installation. In case installation is carried out without notifying, the work shall be rejected and tenderer shall rectify the same at his own cost.

The tenderer shall examine all architectural, structural, plumbing, electrical and other services drawings and check the as-built works before starting the work, report to the OWNER's site representative any discrepancies and obtain clarification. Any changes found essential to coordinate installation of his work with other services and trades, shall be made with prior approval of the Architect/Consultant/ OWNER's site representative without additional cost to the OWNER. The data given in the Drawings and Specifications is as exact as could be procured, but its accuracy is not guaranteed.

11. TECHNICAL DATA

Each tenderer shall submit alongwith his tender, the technical data for all items listed in Appendix-IV in the indicated format. Failure to furnish complete technical data with tenders may result in summary rejection of the tender.

12. SHOP DRAWINGS

All the shop drawings shall be prepared on computer through Autocad System based on Architectural Drawings, site measurements and Interior Designer's Drawings. Within two weeks of the award of the contract, tenderer shall furnish, for the approval of the Architect/Consultant, two sets of detailed shop drawings of all equipment and materials including layouts for Typical toilets drawings showing exact location of supports, flanges, bends, tee connections, reducers, detailed piping drawings showing exact location and type of supports, valves, fittings etc; external insulation details for pipe insulation etc; electrical panels inside/outside views, power and control wiring schematics, cable trays, supports and terminations.

These shop drawings shall contain all information required to complete the Project as per specifications and as required by the Architect/Consultant/OWNER's site representative. These Drawings shall contain details of construction, size, arrangement, operating clearances, performance characteristics and capacity of all items of equipment, also the details of all related items of work by other tenderers. Each shop drawing shall contain tabulation of all measurable items of equipment/materials/works and progressive cumulative totals from other related drawings to arrive at a variation-in-quantity statement at the completion of all shop drawings. Minimum 12 sets of drawings shall be submitted after final approval along with CD.

Each item of equipment/material proposed shall be a standard catalogue product of an established manufacturer strictly from the manufacturers listed in Appendix-III and quoted by the tenderer in technical data part of Appendix - IV.

When the Architect/Consultant makes any amendments in the above drawings, the tenderer shall supply two fresh sets of drawings with the amendments duly incorporated along with check prints, for approval. The tenderer shall submit further twelve sets of shop drawings to the OWNER's site representative for the exclusive use by the OWNER's site representative and all other agencies. No material or equipment may be delivered or installed at the job site until the tenderer has in his possession, the approved shop drawing for the particular material/equipment/installation.

Shop drawings shall be submitted for approval four weeks in advance of planned delivery and installation of any material to allow Architect/Consultant ample time for scrutiny. No claims for extension of time shall be entertained because of any delay in the work due to his failure to produce shop drawings at the right time, in accordance with the approved programme.

Manufacturers' drawings, catalogues, pamphlets and other documents submitted for approval shall be in four sets. Each item in each set shall be properly labelled, indicating the specific services for which material or equipment is to be used, giving reference to the governing section and clause number and clearly identifying in ink the items and the operating characteristics. Data of general nature shall not be accepted.

Samples of all materials like valves, pipes etc. shall be submitted to the OWNER's site representative prior to procurement. These will be submitted in two sets for approval and retention by OWNER's site representative and shall be kept in their site office for reference and verification till the completion of the Project. Wherever directed a mockup or sample installation shall be carried out for approval before proceeding for further installation.

Approval of shop drawings shall not be considered as a guarantee of measurements or of building dimensions. Where drawings are approved, said approval does not mean that the drawings supercede the contract requirements, nor does it in any way relieve the tenderer of the responsibility or requirement to furnish material and perform work as required by the contract.

Where the tenderer proposes to use an item of equipment, other than that specified or detailed on the drawings, which requires any redesign of the structure, partitions, foundation, piping, wiring or any other part of the mechanical, electrical or architectural layouts; all such re-design, and all new drawings and detailing required therefore, shall be prepared by the tenderer at his own expense and gotten approved by the Architect/Consultant/ OWNER's site representative. Any delay on such account shall be at the cost of and consequence of the Tenderer.

Plumbing / Sanitary & Fire Fighting Tenderer shall prepare coordinated services shop drawings based on the drawings prepared by Electrical, HVAC & Low Voltage Tenderers to ensure adequate clearances are available for installation of services for each trade.

Where the work of the tenderer has to be installed in close proximity to, or will interfere with work of other trades, he shall assist in working out space conditions to make a satisfactory adjustment. If so directed by the OWNER's site representative, the tenderer shall prepare composite working drawings and sections at a suitable scale, not less than 1:50, clearly showing how his work is to be installed in relation to the work of other trades. If the Tenderer installs his work before coordinating with other trades, or so as to cause any interference with work of other trades, he shall make all the necessary changes without extra cost to the OWNER.

Within two week of approval of all the relevant shop drawings, the tenderer shall submit four copies of a comprehensive variation in quantity statement, and itemized price list of recommended (by manufacturers') imported and local spare parts and tools, covering all equipment and materials in this contract. The Project Manager shall make recommendation to OWNER for acceptance of anticipated variation in contract amounts and also advise OWNER to initiate action for procurement of spare parts and tools at the completion of project.

13. QUIET OPERATION AND VIBRATION ISOLATION

All equipment shall operate under all conditions of load without any sound or vibration which is objectionable in the opinion of the OWNER's site representative. In case of rotating machinery sound or vibration noticeable outside the room in which it is installed, or annoyingly noticeable inside its own room, shall be considered objectionable. Such conditions shall be corrected by the Tenderer at his own expense. The tenderer shall guarantee that the equipment installed shall maintain the desired NC levels.

14. ACCESSIBILITY

The Tenderer shall verify the sufficiency of the size of the shaft openings, clearances in cavity walls and suspended ceilings for proper installation of his piping and other ancillaries. His failure to communicate insufficiency of any of the above, shall constitute his acceptance of sufficiency of the same. The Tenderer shall locate all equipment which must be serviced, operated or maintained in fully accessible positions. The exact location and size of all access panels, required for each concealed valve or other devices requiring attendance, shall be finalized and communicated in sufficient time, to be provided in the normal course of work. Failing this, the Tenderer shall make all the necessary repairs and changes at his own expense. Access panel shall be standardised for each piece of equipment / device / accessory and shall be clearly nomenclatured / marked.

15. MATERIALS AND EQUIPMENT

All materials and equipment shall conform to the relevant Indian Standards and shall be of the approved make and design. Makes shall be strictly in conformity with list of approved manufacturers as per Appendix - III.

16. MANUFACTURERS INSTRUCTIONS

Where manufacturer has furnished specific instructions, relating to the material and equipment used in this project, covering points not specifically mentioned in these documents, such instructions shall be followed in all cases.

17. ELECTRICAL INSTALLATION

The electrical work related to Plumbing / Sanitary & Fire Fighting services is excluded from the scope of the tenderer. The termination of the cable to the various motors shall be carried out by the contractor.

18. BALANCING, TESTING AND COMMISSIONING

Balancing of all water systems and all tests as called for the Specifications shall be carried out by the tenderer through a specialist group, in accordance with the Specifications and ASPE / ASHRAE Guide lines and Standards. Performance test shall consist of three days of 10 hour each operation of system for each season.

The installation shall be tested again after removal of defects and shall be commissioned only after approval by the OWNER's site representative. All tests shall be carried out in the presence of the representatives of the Architect/Consultant and OWNER's site representative.

19. COMPLETION DRAWINGS

Tenderer shall periodically submit completion drawings as and when work in all respects is completed in a particular area. These drawings shall be submitted in the form of two sets of floppies / CD's and four portfolios (300 x 450 mm) each containing complete set of drawings on approved scale indicating the work as - installed. These drawings shall clearly indicate complete plant room layouts, piping layouts, location of wiring and sequencing of automatic controls, location of all concealed piping, valves, controls, wiring and other services. Each portfolio shall also contain consolidated control

diagrams and technical literature on all controls. The tenderer shall frame under glass, in the plant room, one set of these consolidated control diagrams.

20. OPERATING INSTRUCTION & MAINTENANCE MANUAL

Upon completion and commissioning of part Plumbing / Sanitary & Fire Fighting system the tenderer shall submit a draft copy of comprehensive operating instructions, maintenance schedule and log sheets for all systems and equipment included in this contract. This shall be supplementary to manufacturer's operating and maintenance manuals. Upon approval of the draft, the tenderer shall submit four (4) complete bound sets of typewritten operating instructions and maintenance manuals; one each for retention by Consultant and OWNER's site representative and two for OWNERs Operating Personnel. These manuals shall also include basis of design, detailed technical data for each piece of equipment as installed, spare parts manual and recommended spares for 4 year period of maintenance of each equipment.

“Preventive Maintenance Schedule for each equipment / panel shall be submitted along with Operation and Maintenance Manual”.

21. ON SITE TRAINING

Upon completion of all work and all tests, the Tenderer shall provide necessary operators, labour and helpers for operating the entire installation for a period of fifteen (15) working days of ten (10) hours each, to enable the OWNER's staff to get acquainted with the operation of the system. During this period, the tenderer shall train the OWNER's personnel in the operation, adjustment and maintenance of all equipment installed.

22. MAINTENANCE DURING DEFECTS LIABILITY PERIOD

22.1 Complaints

The Tenderer shall receive calls for any and all problems experienced in the operation of the system under this contract, attend to these within 10 hours of receiving the complaints and shall take steps to immediately correct any deficiencies that may exist.

22.2 Repairs

All equipment that require repairing shall be immediately serviced and repaired. Since the period of

Mechanical Maintenance runs for one year concurrently with the defects liability period, all replacement parts and labour shall be supplied promptly free-of-charge to the OWNER.

23. UPTIME GUARANTEE

The tenderer shall guarantee for the installed system an uptime of 98%. In case of shortfall in any month during the defects liability period, the Defects Liability period shall be extended by a month for every month having shortfall. In case of shortfall beyond the defects liability period, the contract for Operation and Maintenance shall get extended by a month for every month having the shortfall and no reimbursement shall be made for the extended period.

The Tenderer shall provide log in the form of diskettes and bound printed comprehensive log book containing tables for daily record of all pressures, power consumption. Starting and stopping times for various equipment, daily services rendered for the system alarms, maintenance and record of unusual observations etc. Tenderer shall also submit preventive maintenance schedule.

Each tenderer shall submit along with the tender, a detailed operation assistance proposal for the OWNER's site representatives/Consultant's review. This shall include the type of service planned to be offered during Defects Liability Period and beyond. The operation assistance proposal shall give the details of the proposed monthly reports to the Management.

The tenderer shall include a list of other projects where such an Operation Assistance has been provided.

24. OPERATION AND MAINTENANCE

Tenderer may be required to carry out the operation of the PLUMBING / SANITARY & FIRE FIGHTING installation for a period of one year from the date of commissioning and handing over of the entire system. Further, he may also be required to carry out operation and all inclusive maintenance of the entire system for a period of four years beyond the defects liability period.

24.1 Operation contract (Plumbing / Sanitary & Fire Fighting)

- i. 16 hours a day, year round.
- ii. All stand-by equipment to be operated as per mutually agreed programme.
- iii. Proper entry and unkeep of relevant log books.

- iv. Maintain complaints register. Submit weekly report.
- v. Proper housekeeping of all areas under the contract.
- vi. Prepare daily consumption report and summary of operation.

24.2 Terms of payment

- i. Monthly at the end of each month on pro-rata basis.

24.3 All Inclusive Maintenance Contract

- a. Routine Preventive Maintenance Schedule to be submitted
 - i. Schedule to cover manufacturer's recommendation and/or common engineering practice (for all plant and machinery under contract).
 - ii. Plant and machinery history card giving full details of equipment and frequency of checks and overhaul.
 - iii. Monthly status report.
 - iv. Entire Plumbing / Sanitary & Fire Fighting installation to be painted in fourth year (from end of defects and liability period) before the expiry of operation and maintenance contract.
- b. Uptime during maintenance contract
 - i. 98% uptime of all systems under contract.
 - ii. Up time shall be assessed every month and in case of shortfall during any month the contract shall be extended by a month.
 - iii. There shall be no reimbursement for the extended period.
 - iv. Break-downs shall be attended to within ten hours of reporting.

- v. Spare compressor/motor assembly to be made available within seven calendar days in case of total breakdown/burnout.

- c. Manpower
 - i. Adequate number of persons to the satisfaction of the OWNER's site representative shall be provided including relievers.
 - ii. Statutory requirements of EPF, ESIC and other applicable labour legislations to be complied with; and monthly certification to that effect to be submitted.
 - iii. Duty allocation and Roaster control shall be tenderer's responsibility.

- d. Shut Downs
 - i. Routine shut downs shall be permitted only during winter season.
 - ii. Tenderer shall be at liberty to carry out routine maintenance as and when required but with prior permission of the OWNER.

- e. Payment Terms
 - i. Monthly payment at the end of each month on pro-rata basis.

25. PARTIAL ORDERING

OWNER through the Architect/Consultant/ OWNER's site representative reserves the right to order equipment and material from any and all alternates, and /or to order high side and /or low side equipment and materials or parts thereof from one or more tenderers.

APPENDIX-I

LIST OF DRAWINGS

Sr. No.	DRAWING NO.	DRAWING TITLE
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APPENDIX – II

GUARANTEE PROFORMA

GUARANTEE FOR PLUMBING, SANITARY & FIRE FIGHTING SYSTEM INSTALLATION

We hereby guarantee the year round Plumbing, Sanitary & Drainage Which We Have Installed In The Complex Described Below :

Building : **COMMERCIAL BUILDING (BEC BUILDING)**

Location : **DHOLERA**

For a period of one year from the date of acceptance of the total installation, WE AGREE TO repair or replace to the satisfaction of the Owner, any or all such work that may prove defective in workmanship, equipment or materials within that period, ordinary wear and tear and unusual abuse or neglect excluded, together with any other work, which may be damaged or displaced in so doing. In the event of our failure to comply with the above mentioned conditions within a reasonable time, after being notified in writing, we collectively and separately, do hereby authorise the Owner to proceed to have the defects repaired and made good at our expense, and we shall pay the cost and charges thereof, immediately upon demand.

WE ALSO HEREBY UNDERTAKE to test the entire installation in first SUMMER, WINTER AND MONSOON on following the completion of the installation, to check and do everything necessary to ensure that the specified design conditions and functional requirement are met, that all water, sewage, air pollution control systems are properly balanced, that all controls are calibrated accurately, and that all units are functioning satisfactorily.

**SIGNATURE OF TENDERE *or* PLUMBING,
SANITARY & FIRE FIGHTING SYSTEM**

DATE :

SEAL

APPENDIX – III

LIST OF APPROVED MAKES FOR EQUIPMENT & MATERIALS

Details of Materials / Equipment	Manufacturer's Name
C.P. Grating for Floor Trap	Chilly GMGR Neer
Drip Seal	ACQUA Bond Vinod Cement Co. Chandigarh Megaseal
Cast Iron Pipes & Fittings Manhole covers & frames	
a. As per IS:3989 (Pipes & Fittings)	NECO Kapilansh SKF
GI / MS Pipes (IS : 1239 and IS : 3589)	Tata Steel Jindal (Hissar)
GI pipes fittings	Zoloto M Unik
GI pipe sealent	Henkel - LOCTITE 55
Pipe clamp & supports	Chilly Euroclamp Kanwal
UPVC Pipe	Finolex Prince Supreme Jain Irrigation

CPVC pipes	Ajay Ashirwad Astral
GM / Forged Brass Ball Valves	Danfoss Honeywell Zoloto
Paints	Asian Paints Berger ICI Shalimar Paints
Insulation for Hot Water Pipes	Armacell – Armaflex K-Flex Thermaflex
Welding Rods	ADOR Esab
Fastner	Fisher Hilti
U.V. Sterlizer	ALFA Pentair Eureka Forbes

APPENDIX – III (B)

LIST OF APPROVED MAKES FOR EQUIPMENT & MATERIALS FIRE FIGHTING SYSTEM

Details of Materials / Equipment	Manufacturer's Name
G.I. / M.S. Pipes (IS : 1239 / IS : 3589)	Tata Steel Jindal (Hissar)
Standard M.S. Fittings	Seamless Fittings Pipeline Products
DI / CI / Forged Steel Fittings	Jainsons Industries VS BM Fittings Bharat Forge
Paints	Asian Paints Berger ICI Shalimar Paints
Double / Single Headed Landing Valve	Safeguard New Age New Tech Minimax
Fire Hose	Safeguard CRC Jayashree New Age Padmini
First Aid Hose Reel (LPCB Approved)	Safeguard New Age Padmini Minimax

Branch Pipe	Safeguard New Age Minimax
Fireman Axe	Safeguard New Age Eversafe Minimax
Sprinkler Heads	Victaulic Tyco Viking Reliable
Flexible Drop Connection (UL Listed)	Victaulic Newage Tyco Easyflex Viking
Electrical Panel Detection & Supperssion System	Avec India Fire Trace

	Details of Materials / Equipment	Manufacturer's Name
13.	Fire Extinguishers	Safeguard Minimax New tech Safefire
14.	Water Flow Switch	Honeywell Potter System Sensor Spray Safe
15.	Pipe clamp & supports	Chilly Euroclamp Kanwal
16.	GM / Forged Brass Valves	Danfoss Zoloto Honeywell
17.	Hose Reel Drum (ISI marked)	Safeguard Eversafe Newage
18.	Inspector's test assembly	Victaulic Eversafe (Giacomini) Viking
19.	Welding Rods	ADOR Esab
20.	Fastner	Fisher Hilti

APPENDIX – IV

SCHEDULE OF TECHNICAL DATA

1. FIRE PROTECTION SYSTEM

PIPING

15 NB TO 50 NB

15 TO 50 NB Fittings

65 NB TO 150 NB Pipes

65 NB TO 150 NB Fittings

200 NB ONWARDS Pipes

200 NB ONWARDS Fittings

Flanges

Gaskets

HYDRANT VALVES

Technical Specifications :

Item

Working Pressure

Code for Design Mft.

Construction Features

Type of Stem

Type of Inlet

Type of Outlet

Flange Drilling

Material of Construction

Body and Bonnet

Stop Valve, Valve Seat

Check nut & gland nut

PRESSURE GAUGE

Technical Specifications :

Working Pressure

Code for Design Mft.

Scale range

Construction Features

Case

Pointer

Dial Size

Dial Lettering

Process Connection

Material of Construction

Case

Movement

Block

PRESSURE SWITCHES

Technical Specifications :

Item

Working Pressure

Scale range

Construction Features

Protection

Cable Entry

Process Connection

Repeatability

Switch

Type

No. of contacts

Contact Rating

Material of Construction

Enclosure

Pressure element

Wetted Parts

VI APPENDIX – V

LIST OF BUREAU OF INDIAN STANDARDS CODES

All equipment, supply, erection, testing and commissioning shall comply with the requirements of Indian Standards and code of practices given below as amended upto date. All equipment and material being supplied by the tenderer shall meet the requirements of IS. Tarrif advisory committee's regulation (fire insurance), electrical inspectorate and Indian Electricity rules and other Codes / Publications as given below:

General

SP : 6 (1)	Structural Steel Sections
IS : 27	Pig Lead
IS : 325	Three Phase Induction Motors
IS : 554	Dimensions for pipe threads where pressure tight joints are required on the threads.
IS : 694	PVC insulated cables for working voltages upto & including 1100 V.
IS : 779	Specification for water meters (domestic type).
IS : 782	Specification for caulking load.
IS : 800	Code of practice for general construction in steel
IS : 1068	Electroplated coatings of nickel plus chromium and copper plus nickel plus chromium.
IS : 1172	Code of Basic requirements for water supply drainage and sanitation.
IS : 1367 (Part 1)	Technical supply conditions for threaded steel fasteners: Part 1 introduction and general information.
IS : 1367	Technical supply conditions for threaded steel fasteners: Part 2

(Part 2)	product grades and tolerances.
IS : 1554 (Part 1)	PVC insulated (heavy duty) electric cables: Part 1 for working voltages upto and including 1100 V.
IS : 1554 (Part 2)	PVC insulated (heavy duty) electric cables: Part 2 for working voltages from 3.3 KV upto and including 11 KV.
IS : 1726	Specification for cast iron manhole covers and frames.
IS : 1742	Code of practice for building drainage.
IS : 2064	Selection, installation and maintenance of sanitary appliance code of practice.
IS : 2065	Code of practice for water supply in buildings.
IS : 2104	Specification for water meter for boxes (domestic type)
IS : 2373	Specification for water meter (bulk type)
IS : 2379	Colour code for identification of pipe lines.
IS : 2629	Recommended practice for hot dip galvanizing on iron and Steel.
IS : 3114	Code of practice for laying of cast iron pipes
IS : 4111 (Part 1)	Code of practice for ancillary structures in sewerage system : Part 1 manholes.
IS : 4127	Code of practice for laying glazed stoneware pipes.

IS : 4853	Recommended practice for radiographic inspection of fusion welded butt joints in steel pipes.
IS : 5329	Code of practice for sanitary pipe work above ground for buildings.
IS : 5455	Cast iron steps for manholes.
IS : 6159	Recommended practice for design and fabrication of material, prior to galvanizing.
IS : 7558	Code of practice for domestic hot water installations.
IS : 8321	Glossary of terms applicable to plumbing work.
IS : 8419 (Part 1)	Requirements for water filtration equipment: Part 1 Filtration medium sand and gravel.
IS : 8419 (Part 2)	Requirements for water filtration equipment: Part 2 under drainage system.
IS : 9668	Code of practice for provision and maintenance of water supplies and fire fighting.
IS : 9842	Preformed fibrous pipe insulation.
IS : 9912	Coal tar based coating materials and suitable primers for protecting iron and steel pipe lines.
IS : 10221	Code of practice for coating and wrapping of underground mild steel pipelines.
IS : 10446	Glossary of terms relating to water supply and sanitation.
IS : 11149	Rubber Gaskets
IS : 11790	Code of practice for preparation of butt-welding ends for pipes, valves, flanges and fittings.

IS : 12183 (Part 1)	Code of practice for plumbing in multistoried buildings : Part 1 water supply.
IS : 12251	Code of practice for drainage of building basements.
IS : 5572	Code of practice for sanitary pipe work.
BS : 6700	Specification for design, installation, testing and maintenance of services supplying water for domestic use within buildings and their cartilages.
BS : 8301	Code of practice for building drainage.
BSEN : 274	Sanitary tap were, waste fittings for basins, bidets and baths. General technical specifications.

**Pipes and
Fittings**

IS : 458	Specification for precast concrete pipes (with and without reinforcement)
IS : 651	Salat glazed stone ware pipes and fittings.
IS : 1239 (Part 1)	Mild steel, tubes, tubulars and other wrought steel fittings : Part 1 Mild Steel tubes.
IS : 1239 (Part 2)	Mild Steel tubes, tubulars and other wrought steel fittings : Part 2 Mild Steel tubulars and other wrought steel pipe fittings.
IS : 1536	Centrifugally cast (spun) iron pressure pipes for water, gas and sewage.
IS : 1537	Vertically cast iron pressure pipes for water, gas and sewage.
IS : 1538	Cast Iron fittings for pressure pipes for water, gas and sewage.
IS : 1729	Sand Cast iron spigot and socket soil, waste and ventilating pipes, fittings and accessories.

IS : 1879	Malleable cast iron pipe fittings.
IS : 1978	Line pipe
IS : 1979	High test line pipe.
IS : 2501	Copper tubes for general engineering purposes
IS : 2643 (Part 1)	Dimensions for pipe threads for fastening purposes : Part 1 Basic profile and dimensions.
IS : 2643 (Part 2)	Dimensions for pipe threads for fastening purposes : Part 2 Tolerances.
IS : 2643 (Part 3)	Dimensions for pipe threads for fastening purposes : Part 3 Limits of sizes.
IS : 3468	Pipe nuts.
IS : 3589	Seamless or electrically welded steel pipes for water, gas and sewage (168.3 mm to 2032 mm outside diameter).
IS : 3989	Centrifugally cast (sun) iron spigot and socket soil, waste and ventilating pipes, fittings and accessories.
IS : 4346	Specifications for washers for use with fittings for water services.
IS : 4711	Methods for sampling steel pipes, tubes and fittings.
IS : 6392	Steel pipe flanges
IS : 6418	Cast iron and malleable cast iron flanges for general engineering purposes.
IS : 7181	Specification for horizontally cast iron double flanged pipe for water, gas and sewage.

Valves

IS : 778	Specification for copper alloy gate, globe and check valves for water
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works purposes.

IS : 780	Specification for sluice valves for water works purposes (50 mm to 300 mm size).
IS : 1703	Specification copper alloy float valves (horizontal plunger type) for water supply fittings.
IS : 2906	Specification for sluice valves for water works purposes (350 mm to 1200 mm size)
IS : 3950	Specification for surface boxes for sluice valves.
IS : 5312 (Part 1)	Specification for swing check type reflux (non return) valves : part 2 Multi door pattern.
IS : 5312 (Part 2)	Specification for swing check type reflux (non return) valves : part 2 Multi door pattern.
IS : 12992 (Part 1)	Safety relief valves, spring loaded : Design
IS : 13095	Butterfly valves for general purposes.

Sanitary

Fittings

IS : 771 (Part 1 to 3)	Specification for glazed fire clay sanitary appliances.
IS : 774	Specification for flushing cistern for water closets and urinals (other than plastic cistern)
IS : 775	Specification for cast iron brackets and supports for wash basins and sinks
IS : 781	Specification for cast copper alloy screw down bib taps and stop valves for water services.

IS : 1700	Specification for drinking fountains.
IS : 2548 (Part 2)	Specification for plastic seats and covers for water closets: Part 1 Thermoset seats and covers.
IS : 2556 (Part 1)	Specification for vitreous sanitary appliances (Vitreous china) : Part 1 General requirement.
IS : 2556 (Part 2)	Specification for vitreous sanitary appliances (vitreous china): Part 2 Specific requirements of wash-down water closets.
IS : 2556 (Part 3)	Specification for vitreous sanitary appliances (vitreous china): Part 3 Specific requirements of squatting pans.
IS : 2556 (Part 4)	Specification for vitreous sanitary appliances (vitreous china): part 4 specific requirements of wash basins.
IS : 2556 (Part 6 Sec 2)	Specification for vitreous sanitary appliances (vitreous china): part 6 Specific requirements of urinals, section 2 half stall urinals.
IS : 2556 (Part 6 Sec 4)	Specification for vitreous sanitary appliances (vitreous china): Part 6 specific requirements of urinals, section 4 partition slabs.
IS : 2556 (Part 6 Sec 5)	Specification for vitreous sanitary appliances (vitreous china): Part 6 Specific requirements of urinals, section 5 waste fittings.
IS : 2556 (Part 6 Sec 6)	Specification for vitreous sanitary appliances (vitreous china) : Part 6 Specific requirements of urinals, section 6 water spreaders for half stall urinals.
IS : 2556 (Part 7)	Specification for vitreous sanitary appliances (vitreous china) : Part 7 Specific requirements of half round channels.
IS : 2556 (Part 8)	Specification for vitreous sanitary appliances (vitreous china): Part 8 Specific requirements of siphoning wash down water closets.

IS : 2556 (Part 11)	Specification for vitreous sanitary appliances (vitreous china): Part 11 Specific requirements for shower rose.
IS : 2556 (Part 12)	Specification for vitreous sanitary appliances (vitreous china): Part 12 Specific requirements of floor traps.
IS : 2556 (Part 15)	Specification for vitreous sanitary appliances (vitreous china): Part 15 Specific requirements of universal water closets.
IS : 2692	Specification for ferrule for water services
IS : 2717	Glossary of terms relating to vitreous enamelware and ceramic metal systems
IS : 2963	Specifications for waste plug and its accessories for sinks and wash basins.
IS : 3311	Specification for waste plug and its accessories for sinks and wash basins.
IS : 5961	Specification for cast iron gratings for drainage purposes.
IS : 6249	Specification for gel-coated glass fibre reinforced polyester resin bath tubs.
IS : 6411	Specification for gel-coated glass fibre reinforced polyester resin bath tubes.
IS : 8931	Specification for copper alloy fancy single taps, combination tap assembly and stop valves for water services.
IS : 9758	Specification for flush valves and fitting for water closets and urinals.

Technical Specifications

1. BASIS OF DESIGN

The Plumbing, Sanitary & Drainage System for the project is designed keeping in view the following:

- 1.1 Requirement of adequate and equal pressure availability of hot and cold water lines in Toilets and Pantries.
- 1.2 Provision of firefighting appurtenance such as sprinklers, fire hydrants, hose reel, and portable extinguishers.

The execution of works and materials used shall be as per the latest relevant I.S. specifications.

Wherever reference has been made to Indian Standard or any other specifications, the same shall mean to refer to the latest specification irrespective of any particular edition of such specification being mentioned in the specifications below or Schedule of Quantities.

2. CONCEPT OF THE SYSTEM

The following services are envisaged for the complex

- 2.1 Domestic water supply through gravity feed System.
- 2.2 Firefighting system for the Complex comprising of Hydrant, Hose Reels, Sprinklers and portable fire extinguishers.

3. WATER STORAGE & DISTRIBUTION SYSTEM

3.1 Water Requirement

The water requirement for the project is proposed to be based on the provisions of IS: 1172 and prevalent practice. The estimated requirement of water per day for the Complex based on the number of users and other services.

3.2 Source of Water

It is expected that part of the daily domestic water requirement for the Building shall be through municipal mains supply. Since it is unlikely that municipality would be able to meet the entire daily requirement, supply will have to be supplemented by having provision of existing of tub well. Provision of tanker water fill feasibility shall also be made.

3.3 **Water Quality**

Domestic Water Requirement: The total domestic water shall be passed through basic water treatment plant and further specialized treatment shall be done based on the water analysis report and requirement. The basic water treatment plant shall comprise of MG filter, iron removal filter, Softener and Hypo dosing.

3.4 **Water Distribution**

The water distribution for hot and cold water supply for the Building shall be designed to ensure availability of adequate residual head at user outlet. Provision of pressure reducing station and non-return valve shall be made for effective and efficient water distribution in the Building. Design is such that the hot and cold water pressure and flow shall be fairly equal to avoid reversal of flow from one service to another

3.5 **Appurtenant**

Following components shall be included in the water supply system for efficient functioning:

- i. Automatic air vent at each of the high point (Air Valve)
- ii. Drain valve at each of the low point (Scour Valve)
- iii. Pressure Release valve where abnormally high pressure is to be reduced.
- iv. Flow meter.
- v. Pressure Gauge.
- vi. Anchor block / thrust block.

4. **SEWAGE, SULLAGE AND STORM WATER**

The soil and waste shall be carried down in separate independently vented pipes. Two pipe drainage systems shall be adopted as per NBC (Part-IX). Provision of ASP vertical vent shall also be made for hygiene, safety consideration and to avoid foul smell entering through trapped gully in WC.

4.1 **Design Limitations**

The system is designed considering the following:

- a. High thrust developed at soil & water pipe connections.

- b. Termination of vent cowl at terrace level.
- c. Provision of adequate slope for horizontal header pipes for achieving self-cleaning velocity in the pipes.
- d. Provision of cleanout plug.

5. WORKMANSHIP

The workmanship shall be best of its kind and shall conform to the specifications, as below or Indian Standard Specifications in every respect or latest trade practices and shall be subject to approval of the Owner's Site Representative. All materials and/or Workmanship which in the opinion of the Owner's Site Representative / Architect / Consultant is defective or unsuitable shall be removed immediately from the site and shall be substituted with proper materials and/or workmanship forthwith.

6. MATERIALS

All materials shall be best of their kind and shall conform to the latest Indian Standards.

All materials shall be of approved quality as per samples and approved by the Owner's Site Representative / Architect / Consultants.

As and when required by the Owner's Site Representative / Consultant, the contractor shall arrange to test the materials and/or portions of works at his own cost to prove their soundness and efficiency. If after tests any materials, work or portions or work are found defective or unsound by the Owner's Site Representative / Consultant, the contractor shall remove the defective material from the site, pull down and re-execute the works at his own cost to the satisfaction of the Owner's Site Representative / Consultant. To prove that the materials used are as specified the contractor shall furnish the Owner's Site Representative with original vouchers on demand.

SANITARY FIXTURES & FITTINGS

1. SCOPE

The scope of this section consists of but is not necessarily limited to supply, installation, testing and commissioning of following items:

- a. Sanitary appliances and fixtures for toilets.
- b. Chromium plated brass fittings
- c. Stainless steel sinks

- d. Accessories e.g. towel rods, toilet paper holders, soap dish, liquid soap dispensers, towel rails, coat hooks etc.
- e. Hand driers, drinking water fountains etc.

Whether specifically mentioned or not the Contractor shall provide for all appliances and fixtures all fixing devices, nuts, bolts, screws, hangers as required.

All exposed pipes within toilets and near appliances/fixtures shall be of chromium plated brass or copper unless otherwise specified.

GENERAL REQUIREMENT

Sanitary appliances and fixtures for toilets, chromium plated brass fittings, stainless steel sinks, bathroom accessories like towel rods, toilet paper holders, soap dish, liquid soap dispensers, towel rails coat hooks etc and mirrors, hand driers, drinking water fountains etc as listed in the relevant items in the Schedule of Quantities shall be supplied free of cost by the Owner's Site Representative. The rates shall be inclusive of accessories (in such case) required for installation. All sanitary fixtures and fittings shall receive from the Owner's Site Representative and thereafter be stored under covered roof and handled carefully to prevent any damage by the Contractor.

All appliances, fixtures and fittings shall be provided with all such accessories as are required to complete the item in working condition whether specifically mentioned or not in the Schedule of Quantities, specifications, drawings. Accessories shall include proper fixing arrangements, brackets, nuts, bolts, washers, screws and required connection pieces.

The sanitary fixtures and fittings shall be installed at the correct assigned position as shown on the drawings and as directed by the Architect / Owner's Site Representative and shall fully meet with the aesthetic and symmetrical requirements as demanded by the Architect / Interior Designer

All fixtures and accessories shall be fixed in accordance with a set pattern matching the tiles or interior finish as per Architect requirements. Wherever necessary, the fittings shall be centered to dimensions and pattern as called for.

Fixing screws shall be half round head chromium plated (CP) brass screws, with CP brass washers unless otherwise specified.

Fixtures shall be installed by skilled workman with appropriate tools according to the best trade practice.

All appliances, fittings and fixtures shall be fixed in a neat workmanlike manner true to level and to heights shown on the drawings and in accordance with the manufacturer's recommendations. Care shall be taken to fix all inlet and outlet pipes at correct positions. Faulty locations shall be made good and any damage to the finished floor, tiling, plaster, paint, insulation or terrace shall be made good by the Contractor at his own cost. Fixtures shall be mounted rigid, plumb and true to alignment.

All materials shall be rust proofed; materials in direct or indirect contact shall be compatible to prevent electrolytic or chemical (bimetallic) corrosion.

Wall flanges shall be provided on all walls, floors, columns etc. wherever supply and disposal pipes pierce through them. These wall caps shall be of chromium plated brass fittings and the receiving pipes and shall be large enough to cover the punctures properly. Sanitary appliances, subject to the type of appliance and specific requirements, shall be fixed in accordance with the relevant standards and the following :

- i. Contractor shall, during the entire period of installation and afterwards protect the appliances by providing suitable cover or any other protection so as to absolutely prevent any damage to the appliances until handing over (The original protective wrapping shall be left in position for as long as possible)
- ii. The appliances shall be placed in correct position or marked out in order that pipe work can be fixed or partially fixed first.
- iii. The appliance shall be fixed in a manner such that it will facilitate subsequent removal if necessary.
- iv. The appliance shall be securely fixed. Manufacturer's brackets and fixing methods shall be used wherever possible. Compatible rust-proofed fixings shall be used. Fixing shall be done in a manner that minimize noise transmission.
- v. Appliances shall not be bedded (e.g. WC pans, pedestal units) in thick strong mortar that could crack the unit (e.g. ceramic unit)
- vi. Pipe connections shall be made with demountable unions. Pipe work shall not be fixed in a manner that it supports or partially supports and appliance.
- vii. Appliances shall be fixed true to level firmly fixed to anchor or supports provided by the manufacturer and additional anchors or supports where necessary.

Sizes of sanitary fixtures given in the Specifications or in the Schedule of Quantities are for identification with reference to the catalogues of make considered. Dimensions of similar models of other makes may vary within $\pm 10\%$ and the same shall be provided and no claim for extra payment shall be entertained NOR shall any payment be deducted on this account.

The contractor shall fix all plumbing fittings such as water faucets, shower fittings, mixing valves etc. in accordance with manufacturer's instructions and connect to piping system. The contractor shall supply all fixing materials such as screws, rawl plugs, unions, collars, compression fittings etc., as required.

Joints / gaps between all sanitary appliances / fixtures and the floor / walls shall be caulked with an approved mildew resistant sealant, having antifungal properties, of colour and shade to match that of the appliances / fixture and the floor / wall to the extent possible.

2.1 Water Closet

Water Closet shall be wash down or symphonic wash down type floor or wall mounted set, as shown in the drawings, designed for low volume flushing from 3-6 litres of water, flushed by means of a porcelain flushing cistern or an exposed or concealed type (as detailed in the drawings or as directed by the Owner's Site Representative) 32 mm size CP brass flush valve with regulator valve. Flush pipe / bend shall be connected to the WC by means of a suitable rubber adaptor. Wall hung WC shall be supported by CI floor mounted chair which shall be fixed in a manner as approved by the Owners Site Representative.

Each WC set shall be provided with approved quality of seat, rubber buffers and chromium plated hinges. Seat shall be so fixed that it remains absolutely stationary in vertical position without falling down on the WC.

Each WC shall be provided with 110 mm dia (OD) PVC Pan connector connecting the ceramic outlet of WC to CI pipe.

2.2 Urinals

Urinals shall be lipped type half stall with glazed vitreous China of size as called for in the Bill of Quantities.

Half stall urinals shall be provided with 15mm dia CP spreader, 32mm dia CP domical waste and CP cast brass bottle trap with pipe and wall flange and shall be fixed to wall by CI brackets, CI wall clips

and CP brass screws as recommended by manufacturer complete as directed by the Owner's Site Representative.

Flushing for urinals shall be by means of no hand operation, infrared electric flush valve with complete kit of plumbing, electrical and electronic items, infrared photo cells, solenoid valve transformer and electrical connection. The automatic flush sensor plate shall be flush and press fitted and be of high quality mirror polish finish. Each urinal shall be provided with one flush valve unit.

Flush pipes shall be GI pipes concealed in wall chase but with chromium plated bends at inlet and outlet.

Urinal Partitions

Urinal partitions shall be white glazed vitreous china of size specified in the Schedule of Quantities.

Porcelain partitions shall be fixed at proper heights with CP brass bolts, anchor fasteners and MS clips as recommended by the manufacturer and directed by the Owner's Site Representative.

2.3 Cisterns / Flush Valve

Low level flushing cistern (exposed or concealed) shall be provided for WC in specified toilets. Contractor shall install cistern in accordance to the manufacturer's specification to the satisfaction of the Owner Site Representative. Provision of flush valve shall be made for Public / Staff toilets.

2.4 Wash Basin

Wash basins shall be white glazed vitreous china of size, shape and type specified in the Schedule of Quantities.

Each basin shall be provided with painted MS angle or CI brackets and clips and the basin securely fixed to wall/counter slab. Placing of basins over the brackets without secure fixing shall not be accepted. The MS angle shall be provided with two coats of red oxide primer and two coats of synthetic enamel paint of make , brand and colour as approved by the Owner's Site Representative. The cost of fixing the basin shall be inclusive of supply and installation of brackets as described above.

Each basin shall be provided with 32mm dia CP waste with overflow, pop-up waste or rubber plug and CP brass chain as specified in the Schedule of Quantities.

Each basin shall be provided with hot and cold water mixing fitting or as specified in the Schedule of Quantities.

2.5 Sinks

Sinks shall be stainless steel or any other material as specified in the Schedule of Quantities.

Each sink shall be provided with painted MS or CI brackets and clips and securely fixed. Counter top sinks shall be fixed with suitable painted angle iron brackets or clips as recommended by the manufacturer. Each sink shall be provided with 40mm dia CP waste and rubber plug with CP brass chain as given in the Schedule of Quantities. The MS angle shall be provided with two coats of red oxide primer and two coats of synthetic enamel paint of make, brand and colour as approved by the Owner's site representative.

Sanitary fittings for sinks shall be deck mounted or wall mounted CP swivel faucets with or without hot and cold water mixing fittings as specified in the Schedule of Quantities. Installation of fittings shall be measured and paid for separately.

2.6 Flow Control Device

Approved / rated flow control fitment in brass body, chrome outer cover, rated for flow / discharge of the fixture.

2.7 Toilet Paper Holder

Toilet paper holder shall be white glazed vitreous china or chrome plated of size, shape and type specified in the Schedule of Quantities.

Porcelain toilet paper holder shall be fixed in walls and set in cement mortar 1:2 (1 cement : 2 coarse sand) and fixed in relation to the tiling work.

The latter (chrome) shall be fixed by means of screws/capping having finish similar to the toilet paper holder in wall/temper partitions with raw l plugs or nylon sleeves. When fixed on timber partition, it shall be fixed on a solid wooden base member provided by the Owner's Site Representative.

2.8 Towel Rail

Towel rail shall be chromium plated brass or of stainless steel or powder coated brass of size, shape and type specified in the Schedule of Quantities.

Towel rail shall be fixed with screws/capping having finish similar to the towel rail in wall with rawl plugs or nylon sleeves and shall include cutting and making good as required or directed by the Owner's Site Representative.

2.9 Janitor's Sink

Janitor's sink shall be stainless steel, single bowl type of size as called for in the Schedule of Quantities , provided with painted R.S. or CI brackets and clips and securely fixed. Each sink shall be provided with 40mm dia CP waste. Fixing shall be as directed by the Owner's Site Representative.

The supply fittings for Janitor's sink shall be wall mounted type of size as mentioned in Schedule of Quantities.

a. Drinking Water Fountain

Drinking water fountain shall be well mounting type made of vitreous china, stainless steel or any other material as given in the Schedule of Quantities.

The drinking water fountain shall be with anti-squirt bubble less, self closing valve type with automatic volume regulator.

The drinking water fountain shall be provided with an anti-splash back and integral strainer with 32mm or 40mm cast brass trap.

2.11 Liquid Soap Dispenser

Liquid Soap Dispenser shall be wall/counter mounted suitable for dispensing liquid soaps, lotions, detergents. The cover shall lock to body with concealed locking arrangement, opened only by key provided.

Liquid soap dispenser body and shank shall be of high impact resistance material. The piston and spout shall be stainless steel with 1 litre capacity polyethylene container.

The valve shall operate with less than 2.27 Kg (5 lbs) of force.

2.12 Hand Drier

The hand drier shall be no touch operating type with solid state time delay to allow user to keep hand in any position.

The hand drier shall be fully hygienic, rated for continuous repeat use (CRU).

The rating of hand drier shall be such that time required to dry a pair of hands up to wrists is approximately 30 seconds.

The hand drier shall be of wall mounting type suitable for 230 V, single phase, 50 Hz, AC power supply.

3. TOILETS FOR THE DISABLED

Where specified, in washroom facilities designed to accommodate physically disabled, accessories shall be provided as directed by the Owner's Site Representative.

Stainless steel garb brass of required size suitable for concealed or exposed mounting and opened non-slip gripping surface shall be provided in all washroom. The flushing cistern/valve shall be provided with chromium plated long handles.

4. MOCKUP AND TRIAL ASSEMBLY

The installation of the Sanitary fixtures and fittings shall be as per the shop drawings approved by the Architect/Consultant.

The contractor shall have to assemble at least one set of each type of sanitary fixtures and fittings in order to determine precisely the required supply and disposal connections. Relevant instructions from manufacturers shall be followed as applicable. This trial assembly shall be developed to determine the location of puncture holes, holding devices etc. which will be required for final installation of all sanitary fixtures and fittings. The above assembly shall be subject to final approval by the Architect / Interior Designer.

The fixtures in the trial assembly can be re-used for final installation without any additional payments for fixing or dismantling of the fixtures.

5. SUPPORTING AND FIXING DEVICES

The contractor shall provide all the necessary supporting and fixing devices to install the sanitary fixtures and fittings securely in position. The fixing devices shall be rigidly anchored into the building structure. The devices shall be rust resistant and shall be so fixed that they do not present an unsightly appearance in the final assembly. Where the location demands, the Architect may instruct the contractor to provide chromium plated or other similarly finished fixing devices. In such circumstances

the contractor shall arrange to supply the fixing devices and shall be installed complete with appropriate vibration isolating pads, washers and gaskets.

6. FINAL INSTALLATION

The contractor shall install all sanitary fixtures and fittings in their final position in accordance with approved trial assemblies and as shown on drawings. The installation shall be complete with all supply and waste connections. The connection between building and piping system and the sanitary fixtures shall be through proper unions and flanges to facilitate removal/replacement of sanitary fixtures without disturbing the built in piping system. All unions and flanges shall match in appearance with other exposed fittings.

Fixtures shall be mounted rigid, plumb and to alignment. The outlets of water closet pans and similar appliances shall be examined to ensure that outlet ends are butting on the receiving pipes before making the joints. It shall be ensured that the receiving pipes are clear of obstruction. When fixtures are being mounted, attention shall be paid to the possibility of movement and settlement by other causes. Overflows shall be made to ensure that necessary anchoring devices have been provided for supporting water closets, wash basins, sinks and other appliances.

7. PROTECTION AGAINST DAMAGE

The contractor shall take every precaution to protect all sanitary fixtures against damage, misuse, cracking, staining, breakage and pilferage by providing proper wrapping and locking arrangement till the completion of the installation. At the time of handing over, the contractor shall clean, disinfect and polish all the fixtures and fittings. Any fixtures and fittings found damaged, cracked chipped stained or scratched shall be removed and new fixtures and fittings free from defects shall be installed at his own cost to complete the work.

8. MEASUREMENT

- 8.1 Rate for fixing only of sanitary fixtures accessories, CP fittings shall etc. include all items, and operations stated in the respective specifications and bill of quantities and nothing extra is payable.
- 8.2 Rates for all items under specifications para above shall be inclusive of cutting holes and chases and making good the same, CP screws, nuts, bolts and any fixing arrangements required and recommended by manufacturers, testing and commissioning and making good to the satisfaction of the Owner's Site Representative.

9. TESTING

All appliances, fixtures and fittings shall be tested before and after installation. Water seals of all appliances shall be tested. The contractor shall block the ends of waste and ventilation pipes and shall conduct an air test.

WATER SUPPLY (COLD & HOT)

1. SCOPE

The scope of this section comprises the supply, installation, testing and commissioning of piping network for water supply for internal & external services as follows:

- a. Drinking Water Supply.
- b. Flushing Water Supply

The Contractor shall make all necessary application and arrangements for his work to be inspected by the Local Authorities.

The Contractor shall be solely responsible for obtaining the Authorities approval of his works prior to the handing over of the complete water supply / distribution installation to the Owner.

2. PIPING MATERIALS

The piping system shall consist of heavy class galvanized iron pipes and fittings conforming to IS:1239. The sizes and makes is specified in the Schedule of Quantities.

The piping system shall also consist of CPVC pipes as per CT's SDRM for domestic plumbing.

For any internal works, the galvanized iron pipes and fittings shall be embedded in the wall chase or run on the floor/ceiling unless otherwise specified. No unsightly exposed runs shall be permitted. Outside the building the piping shall be installed at least 1.0 m below the finished grade level.

2.1 Galvanised Iron Pipes & Fittings

The pipes shall be galvanised mild steel welded (ERW) or (HFW) screwed and socketed conforming to the requirements of IS:1239. The Galvanising shall conform to IS:4736, the zinc coating shall be uniform, adherent reasonably smooth and free from such imperfections as flux, ash and drop inclusions, bare patches, black spots, pimples, lumpiness, runs, rust strains, bulky white deposits and

blisters. The pipes and sockets shall be cleanly finished, well galvanised in and out and free from cracks, surface flaws laminations and other defects. All screw threads shall be clean and well cut. The ends shall be cut cleanly and square with the axis of the pipe.

The fittings shall be malleable iron and comply with all the requirements of the pipes. The sizes of pipes and fitting are specified in the schedule of quantities.

2.2.1 **Laying And Jointing Of GI Pipes**

The galvanised pipes and fittings shall run in wall chase or ceiling or as 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 where to be laid on surface. Where it is specified to conceal the pipes, chasing may be adopted for pipes fixed in the shafts, ducts etc. there should be sufficient space to work on the pipes with the usual tools. As far as possible, pipes may be buried for short distances provided adequate protection is given against damage and where so required special care to be taken at joints. Where directed by the Owner's Site Representative, pipe sleeves shall be fixed at a place the pipe is passing through a wall or floor for reception of the pipe and allow freedom for expansion and contraction and other movements. In case of pipe is embedded in walls or floors it shall be painted with anticorrosive bitumastic paints of approved quality. Under the floors the pipes shall be laid in layer of sand filling.

Galvanised iron pipes shall be jointed with threaded and socket joints, using threaded fittings. Care shall be taken to remove any burr from the end of the pipes after threading. Teflon tape, White lead or an equivalent jointing compound of proprietary make shall be used, according to the manufacturer's instructions, with a grommet of a few strands of fine yarn while tightening. Compounds containing red lead shall not be used because of the danger of contamination of water. Any threads exposed after jointing shall be painted with bituminous paint to prevent corrosion.

CPVC Pipes & Fittings

The pipes shall be CPVC (Chlorinated Poly Vinyl Chloride) material for hot & cold water supply piping system with pipes as per CTs SDR -11 at a working pressure of 320 PSI at 23 deg C and 80 PSI at 82 deg.C, using solvent welded CPVC fittings i.e. Tees, Elbows, Couplees, Unions, Reducers, Brushing etc. including transition fittings (connection between CPVC & Metal pipes / GI) i.e. Brass adapters (both Male & Female threaded and all conforming to ASTM D-2846 with only CPVC solvent cement conforming to ASTM F-493, with clamps / structural metal supports as required /directed at site including cutting chases & fitting the same with cement concrete / cement mortar as required, including painting of the exposed pipes with one coat of desired shade of enamel paint. All termination points for installation of faucets shall have brass termination fittings. Installation shall be to the

satisfaction of manufacturer & Project Manager. The material shall have to be gotten approved from Chief Fire Officer.

i. **Joining Pipes & Fittings**

a. **Cutting:**

Pipes shall be cut either with a wheel type plastic pipe cutting or hacksaw blade and care shall be taken to make a square cut which provides optimal bonding area within a joint.

b. **Deburring / Beveling:**

Burrs and fittings should be removed from the outside and inside of pipe with a pocket knife or file otherwise burrs and fittings may prevent proper contact between pipe and fittings during assembly.

c. **Fitting preparation:**

A clean dry rag/cloth should be used to wipe dirt and moisture from the fitting sockets and tubing end. The tubing should make contact with the socket wall 1/3 or 2/3 of the way into the fitting socket.

d. **Solvent Cement Application:**

Only CPVC solvent cement conforming to ASTM-F493 should be used for joining pipe with fittings. An even coat of solvent cement should be applied on the pipe end and a thin coat inside the fitting socket, otherwise too much of cement solvent can cause clogged water ways.

e. **Assembly**

After applying the solvent cement on both pipe and fitting socket, pipe should be inserted into the fitting socket within 30 seconds, and rotating the pipe ¼ to ½ turn while inserting so as to ensure even distribution of solvent cement with the joint. The assembled system should be held for 10 seconds (approximately) in order to allow the joint to set up.

An even bead of cement should be evident around the joint and if this bead is not continues remake the joint to avoid potential leaks.

Set & Cure times:

Solvent cement set and cure times shall be strictly adhered to as per the below mentioned table.

Minimum Core prior to pressure testing at 150 PSI

Ambient Temperature during Core period	Pipe Size	
	½" - 1"	1¼" - 2"
Above 15 deg. C	1 Hr	2 Hrs
4-15 deg.C	2 Hrs	4 Hrs
Below 4 deg C	4 Hrs	8 Hrs

Special care shall be exercised when assembling flow guard systems in extremely low temperature (below 4°C) or extremely high temperature (above 45°C) In extremely hot temperatures, make sure that both surfaces to be joined are till wet with cement solvent when putting them together.

f. **Testing**

Once an installation is completed and cored as per above mentioned recommendations, the system should be hydrostatically pressure tested at 150 psi(10 Bar) for one hour. During pressure testing, the system should be fitted with water and if a leak is found, the joint should be cut out and replacing the same with new one by using couplers.

ii. **Transition of Flow guard CPVC to Metals**

When making a transition connection to metal threads, special Brass / plastic transition fitting (Male and female adapters) should be used. Plastic threaded connections should not be over torqued Hard tight pluts one half turn should be adequate.

iii. **Threaded Sealants**

Teflon tape shall be used to make threaded connections leak proof.

iv. **Solvent Cement**

Only CPVC solvent cement conforming to ASTM F 493 should be used for joining pipe with fittings and valves. Flow guard CPVC cement solvent have a minimum shelf life of 1 year.

Aged cement solvent will often change colour or being to thicken and become gelatinous or jelly like and when this happens, the cement should not be used. The cement solvent should be used within 30 days after opening the company's seal and tightly close the seal after using in order to avoid its freezing. The freezed cement solvent should be discarded immediately and fresh one should be used. The CPVC solvent cement usage should be adhered to as given in table below

Diameter of pipe in inch (flowguard)	½"	¾"	1"	¼"	1½"	2"
Approx. nos. of joints which can be mode per litre of solvent cement.	200 Nos	180 Nos	150 Nos	130 Nos	100 Nos	70 Nos

v. **Hangers and supports**

For Horizontal runs, support should be given at 3 foot (90 cm) intervals for diameters of one inch and below and at 4 foot (1.2m) intervals for larger sizes.

Hangers should not have rough or sharp edges which come in contact with the tubing.

Supports should be as per the below mentioned table:

Size of Pipe	21° C	49° C	71° C	82° C
Inch	Ft.	Ft.	Ft.	Ft.
½"	5.5	4.5	3.0	2.5
¾"	5.5	5.0	3.0	2.5
1"	6.0	5.5	3.5	3.0
1¼"	6.5	6.0	3.5	3.5
1½"	7.0	6.0	3.5	3.5
2"	7.0	6.5	4.0	3.5

3. PIPING INSTALLATION SUPPORT

Tender drawings indicate schematically the size and location of pipes. The Contractor, on the award of the work, shall prepare detailed working drawings, showing the cross-sections, longitudinal sections,

details of fittings, locations of isolating and control valves, drain and air valves, and all pipe supports. He must keep in view the specific openings in buildings and other structure through which pipes are designed to pass.

Piping shall be properly supported on, or suspended from, on stands, clamps, hangers as specified and as required. The Contractor shall adequately design all the brackets, saddles, anchor, clamps and hangers, and be responsible for their structural stability.

Pipe work and fittings shall be supported by hangers or brackets so as to permit free expansion and contraction. All accessories and ancillaries of support system such as brackets, saddles, clamps, hangers etc. shall be hot dip galvanized after fabrication. Further to permit free movement of common piping, support shall be from a common hanger bar, fabricated from galvanised steel sections.

Pipe hangers shall be provided at the following maximum spacing:

Pipe Dia (mm)	Hanger Rod Dia (m)	Spacing between Supports (m)
Up to 25	6	2
32 to 50	10	2.7
80 to 100	12	2.7
125 to 150	16	3.6
200 to 300	19	5.3

Insulated piping shall be supported in such a manner as not to put undue pressure on the insulation. 14 gauge metal sheets shall be provided between the insulation and the clamp, saddle or roller, extending atleast 15 cm. on both sides of the clamps, saddles or roller.

All pipe work shall be carried out in a proper workman like manner, causing minimum disturbance to the existing services, buildings, roads and structure. The entire piping work shall be organized in consultation with other agencies work, so that area can be carried out in one stretch.

Cut-outs in the floor slab for installing the various pipes area are indicated in the drawings. Contractor shall carefully examine the cut-outs provided and clearly point out wherever the cut-outs shown in the drawings, do not meet with the requirements.

Pipe sleeves, larger diameter than pipes, shall be provided wherever pipes pass through walls and slab and annular space filled with fibreglass and finished with retainer rings.

The contractor shall make sure that the clamps, brackets, saddles and hangers provided for pipe supports are adequate or as specified / approved by Consultants. Piping layout shall take due care for expansion and contraction in pipes and include expansion joints where required.

All pipes shall be accurately cut to the required sizes in accordance with relevant BIS codes and burrs removed before laying. Open ends of the piping shall be closed as the pipe is installed to avoid entrance of foreign matter. Where reducers are to be made in horizontal runs, eccentric reduces shall be used for the piping to drain freely. In other locations, concentric reduces may be used.

All buried pipes for CWS shall be cleaned and coated with two coats of bitumen and then wrapped with two layers of 400 microne polythene sheet coating.

Automatic air valves shall be provided at all high points in the piping system for venting. All valves shall be of 15mm pipe size and shall be associated with an equal size isolation ball valve. Automatic air valves shall also be provided on hot water risers.

Discharge from the air valves shall be piped through a galvanized steel pipe to the nearest drain or sump. All pipes shall be pitched towards drain points.

Pressure gauges shall be provided as shown on the approved drawings and include in Bill of Quantities. Care shall be taken to protect pressure gauges during pressure testing.

Temperature gauge as specified shall be provided at the hot water supply and return and as shown on drawings and included in Bill of Quantities.

4. FERRULES

The ferrules for connection with main shall generally conform to IS:2692. It shall be of non-ferrous materials with a bell mouth cover and shall be of nominal bore as specified. The ferrule shall be fitted with a screw and plug or valve capable of completely shutting of the water supply to the communication pipe, as and when required.

4.1 **Fixing Ferrules**

For fixing ferrule in cast iron mains, the empty main shall be drilled and tapped at 45 deg to the vertical and the ferrule screwed in. The ferrule must be so fitted that no portion of the shank shall be left projecting within the main into which it is fitted.

5. **WATER METERS**

Water meters of approved make and design shall be supplied for installation at locations as shown. The water meters shall meet with the approval of local supply authorities. Suitable valves and chambers or wall meter box to house the meters shall also be provided along with the meters.

The meters shall conform to Indian Standard IS:779 and IS:2373.

Provision shall also be made to lock the water meter. The provision shall be such that the lock is conveniently operated from the top. Where the provision is designed for use in conjunction with padlocks, the hole provided for padlocks shall be a diameter not less than 4mm.

5.1 **Installation of Water Meter and Stop Cock**

The G.I. lines shall be cut to the required lengths at the position where the meter and stop cock are required to be fixed. Suitable fittings shall be attached to the pipes. The meter and stop cock shall be fixed in a position by means of connecting pipes, jam nut and socket etc. The stop cock shall be fixed near the inlet of the water meter. The paper disc inserted in the ripples of the meter shall be removed. And 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 pipe line, the pipe line shall have to be completely washed before fitting the meter.

6. **TESTING**

The Contractor shall notify the Architect three days in advance of any test so that the Architect can witness the tests if he so wishes.

All water supply system shall be tested to hydrostatic pressure test of atleast one and a half (1.5) times the maximum pressure but not less than 10Kg/Sq.cm for a period of not less than 8 hours. All leaks and defects in joints revealed during the testing shall be rectified and got approved at site by retest. Piping required subsequent to the above pressure test shall be retested in the same manner.

System may be tested in sections and such sections shall be entirely retested on completion.

The Contractor shall make sure that proper noiseless circulation of fluid is achieved through the entire piping network of the system concerned. In case of improper circulation, the contractor shall rectify the defective connections. He shall bear all expenses for carrying out the above rectifications including the tearing up and refinishing of floors and walls as required.

In addition to the sectional testing carried out during the construction, contractor shall test the entire installation after connections to the overhead tanks or pumping system or mains. He shall rectify all leakages and shall replace all defective materials in the system. Any damage done due to carelessness, open or burst pipes or failure of fittings, to the building, furniture and fixtures shall be made good by the contractor during the defects liability period without any cost.

After commissioning of the water supply system, contractor shall test each valve by closing and opening it a number of times to observe if it is working efficiently. Valves which do not effectively operate shall be replaced by new ones at no extra cost and the same shall be tested as above.

A test register shall be maintained and all entries shall be signed and dated by Contractor(s) and Owner's site representative.

7. DISINFECTION OF PIPING SYSTEM AND STORAGE TANKS

Before commissioning the water supply system, the contractor shall arrange to disinfect the entire system as described in the succeeding paragraph.

The water storage tanks and pipes shall first be filled with water and thoroughly flushed out. The storage tanks shall then be filled with water again and disinfecting chemical containing chlorine added gradually while tanks are being filled to ensure thorough mixing. Sufficient chemical shall be used to give water a dose of 50 parts of chlorine to one million parts of water. If ordinary bleaching powder is used, the proportions will be 150 gm of power to 1000 liters of water. The power shall be mixed with water in the storage tank. If a proprietary brand of chemical is used, the proportions shall be specified by the manufacturer. When the storage tanks is full, the supply shall be stopped and all the taps on the distributing pipes are opened successively working progressively away from the storage tank. Each tap shall be closed when the water discharged begins to smell of chlorine. The storage tank shall then be filled up with water from supply pipe and added with more disinfecting chemical in the recommended proportions. The storage tank and pipe shall then remain charged at least for three hours. Finally the tank and pipes shall be thoroughly flushed out before any water is used for domestic purpose.

The pipework shall be thoroughly flushed before supply is restored.

8. STERILIZATION OF MAIN

After the pipework has been tested and approved, but before it is coupled, it shall be sterilized with a solution of chloride of lime.

9. CUTTING CHASES IN MASONARY WALLS

Cold water distribution pipes to fixtures and equipment exposed to view in the bathrooms, kitchens, and sanitary compartments shall be chased into walls or floors or placed in wall cavities. The Contractor shall be responsible for cutting all notches, chases, and recesses in walls and floors and only a diamond cutter shall be used. The maximum size of conduit or pipe permitted to be concealed in floor slabs shall be 32 mm diameter unless otherwise approved by the Architect.

The chases upto 7.5 x 7.5 cm shall be made in the walls for housing GI pipes etc. These shall be provided in correct positions as shown in the drawings or directed by the Architects. Chases shall be made by chiseling out the masonry to proper line and depth. After the pipes etc are fixed in chases, the chases shall be filled with cement mortar 1:2:4 or as may be specified, and made flush with the masonry surface. The concrete surface shall be roughened with wire brush to provide a key for plastering.

Where pipes pass through beams or structural walls, subject to the approval of the Structural Consulting Engineer, the Contractor shall ensure that sizes and locations of openings required are formed in when the relevant beams or walls are cast.

10. VALVES

All valves (gate, globe, check, safety) shall be of gun metal suitable for the particular service as specified. All valves shall be of the particular duty and design as specified. Valves shall either be of screwed type or flanged type, as specified, with suitable flanges and non-corrosive bolts and gaskets. Tail pieces as required shall be supplied along with valves. Gate, globe and check valves shall conform to Indian Standard IS:776 and non-return valves and swing check type reflux to IS:5312.

Sluice valves, where specified shall be flanged sluice valves of cast iron body. The spindle, valve seat and wedge nuts shall be gunmetal. They shall generally have non-rising spindle and shall be of the particular duty and design as specified. The valves shall be supplied with suitable flanges, non-corrosive bolts and asbestos fibre gaskets. Sluice valves shall conform to Indian standard IS:780 and IS:2906.

Ball valves with floats to be fixed in storage tanks shall consist of cast brass lever arm having copper balls (26 SWG) screwed to the arm integrally. The copper ball shall have bronze welded seams. The closing/opening mechanism incorporating the piston and cylinder shall be non-corrosive metal and include washers. The size and construction of ball valves and float shall be suitable for desired working pressure operating the supply system. Where called for brass valves shall be supplied with brass hexagonal back nuts to secure them to the tanks and a socket to connect to supply pipe.

Globe valves on Hot-water line shall be union bonnet with stem/disc and body seat ring of SS. Suitable for temperature upto 80° C.

S.No	Type of Valve	Size	Construction	Ends
a.	Isolating Valve	15 mm to 50 mm 65 mm and above	Gun Metal Gun Metal	Screwed Flanged
b.	Sluice Valve & Butterfly Valve	65 mm and above	Cast Iron	Flanged
c.	G.M. non return valve	15 mm to 50 mm 65 mm above	Gun Metal Gun Metal	Screwed Flanged
d.	Flap Type – Non return valve	65 mm and above	Cast Iron	Flanged

All valves shall be suitable for the working pressure involved.

10.1 Pressure Relief Valves

Each pressure relief valve shall be of the fully enclosed type and fitted with hand easing gear.

Each pressure relief valve in a pressure reducing station shall have a flow capacity equal to that of the pressure reducing valve.

Pressure relief valves in locations other than reducing stations shall have flow capacities equal to that of the associated equipment.

10.2 Pressure Gauge

The pressure gauge shall be constructed of die cast aluminium and stove enamelled. It shall be weather proof with an IP 55 enclosure. It shall be a stainless steel Bourden tube type pressure gauge with a scale range from 0 to 16 Kg / cm square and shall be constructed as per IS:3524. Each pressure gauge shall have a siphon tube connection. The shut off arrangement shall be by Ball Valve.

11. WATER FITTINGS

Unless otherwise specified all Gunmetal fittings such as gate, globe, check & safety valves shall be fitted in pipe line in workman like manner. Necessary unions shall be provided on both ends of the valves for easy replacement. The joints between fittings and pipes shall be leak-proof when tested to desired pressure rating. The defective fittings and joints shall be replaced or redone.

12. CONNECTIONS TO VARIOUS MECHANICAL EQUIPMENT SUPPLIED BY OTHER AGENCIES

All inlets, outlets, valves, piping and other incidental work connected with installation of mechanical equipment supplied by other agencies all be carried out by the contractor in accordance with the drawings, requirements for proper performance of equipment, manufacturer's instructions and the directions of the Owner's site representative / Architect. The equipments to be supplied by the other agencies consist mainly for Kitchen, Back-of-the-House area and other similar areas. The work of connections to the various equipments shall be effected through proper unions and isolating valves. The work of effecting connections shall be executed in consultation with and according to the requirement of equipment suppliers, under the directions of the Owner's site representative / Architect. The various aspects of connection work shall be executed in a similar way to the work of respective trade mentioned elsewhere in these specifications.

13. CONNECTIONS TO RCC WATER TANKS

The contractor shall provide all inlets, outlets, washouts, vents, ball cocks, overflows control valves and all such other piping connections including level indicator to water storage tanks as called for. All pipes crossing through RCC work shall have puddle flanges fabricated from MS/GI pipes of required size and length and welded to 6/8 mm thick MS plate. All puddle flanges must be fixed in true alignment and level to ensure further connection in proper order.

Full way gate valves of a approved make shall be provided as near the tank as practicable on every outlet pipe from the storage tank except the overflow pipe. Overflow and vent pipes shall terminate with mosquito proof grating.

The overflow pipe shall be so placed to allow the discharge of water being readily seen. The overflow pipe shall be of size as indicated. A stop valve shall also be provided in the inlet water connection to the tank. The outlet pipes shall be fixed approximately 75mm above the bottom of the tank towards which the floor of the tank is sloping to enable the tank to be emptied for cleaning.

14. MEASUREMENTS

The length above ground shall be measured in running meter correct to a cm for the finished work, which shall include pipe and fittings such as coupling, bends, tees, elbows, reducers, crosses, plugs, sockets, nipples and nuts, unions. Deductions for length of valves shall be made. Rate quoted shall be inclusive of all fittings, clamps, cutting holes chased and making good the same and all items mentioned in the specifications and Bill of Quantities.

All pipes below ground shall be measured per linear meters (to the nearest cm) and shall be inclusive of all fittings e.g. coupling, tees, bends, elbows, unions, deduction for valves shall be made rate quoted shall be inclusive of all fittings, excavation, back filling and disposal of surplus earth, cutting holes and chase and making good all item mentioned in Bill of Quantities.

15. HOT WATER PIPING INSULATION

Material

Insulation material for Pipe insulation shall be Closed Cell Elastomeric Nitrile Rubber or closed cell cross linked polyethylene foam. Thermal conductivity of elastomeric nitrile rubber shall not exceed 0.038 W/moK or 0.0313 Kcal / Mhr oC or 0.212 BTU / (Hr-ft²-oF/inch) at an average temperature of 30oC. The product shall have temperature range of -40 oC to 105oC. Density of material shall not be less than 0.06 gm/cm³. The insulation shall have fire performance such that it passes minimum CLASS 1 as per BS476 part 7 for surface spread of flame. Water vapour permeability shall not exceed 0.024 perm inch (3 x 10⁻¹⁴ Kgs / m.sec.Pa). The material shall have approval from the Chief Fire Officer.

Thickness of the insulation shall be as specified for the individual application. Each lot of insulation material delivered at site shall be accompanied with manufacturer test certificate for thermal conductivity values. Samples of insulation material from each lot delivered at site may be selected by client's site representative and gotten tested for thermal conductivity and density at Tenderer's cost All joints shall be sealed properly with adhesive, which shall provide similar vapour barrier as the original insulating material.

All hot water piping shall be insulated in the manner specified herein. Before applying insulation, all pipe shall be brushed and cleaned. Thermal insulation shall be applied as follows or as specified in drawings or schedule of quantity:

Pipe size (mm)	Thickness of Nitrile rubber insulation
15 mm to 25 mm	9 mm
32 mm to 50 mm	13 mm
65 mm and above	19 mm

Insulation for pipes in wall chase and for pipes in shaft / plant room.

Insulating material in tube form shall be sleeved on the pipes. On existing piping, slit opened tube from insulating material shall be placed over the pipe and adhesive (as recommended by the manufacturer) shall be applied as suggested by the manufacturer. Adhesive must be allowed to tack dry and then press surface firmly together starting from butt end and working towards centre.

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. The insulation shall be continuous over the entire run of piping, fittings and valves. All valves, fittings, joints, strainers etc. in hot 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.

All insulation work shall be carried out by skilled workmen specially trained in this kind of work. All insulated pipes shall be labeled (HWS / HWR / HWRR) and provided with 300 mm wide band of paint along circumference at every 1200 mm for colour coding. Direction of fluid shall also be marked. All painting shall be as per relevant BIS codes.

Protective Coating Over Insulation

To provide mechanical strength and protection from damage & UV rays all exposed pipe insulated with nitrile rubber as indicated in BOQ shall be covered with fibreglass fabric. The fibreglass fabric shall be applied with one coat of fire proof epoxy or acrylic compound. The coat shall be allowed to cure to non-stick state. Subsequently second coat of compound shall be applied to give a tough and smooth finish to the insulated surface.

Measurement Of Insulation

Unless otherwise specified measurement for pipe insulation for the project shall be on the basis of centre line measurements described herewith

Pipe Insulation shall be measured in units of length along the centre line of the installed pipe, strictly on the same basis as the piping measurements. The linear measurements shall be taken before the

application of the insulation. It may be noted that for piping measurement, all valves, orifice plates and strainers shall not be separately measurable by their number and size. It is to be clearly understood that for the insulation measurements, all these accessories including valves, orifice plates and strainers etc. shall be considered strictly by linear measurements along the centre line of pipes and no special rate shall be applicable for insulation of any accessories, fixtures or fittings whatsoever.

INTERNAL DRAINAGE (SOIL, WASTE, VENT & RAIN WATER PIPES)

1. SCOPE

The scope of this section comprises the supply, installation, testing and commissioning of internal drainage services.

Work under this section shall consist of furnishing all labour, materials, equipments and appliances necessary and required to completely install all soil, waste, vent and rainwater pipes and fittings as required by the drawings, and given in the schedule of quantities.

2. BASIC PIPING SYSTEM

Soil, waste and vent pipes in shafts, ducts and in concealed areas i.e. false ceilings etc. shall consist of cast iron pipes & fittings as called for. In general wastes and vents smaller than and upto 50mm dia shall be of heavy class GI.

The soil pipes shall be circular with a minimum diameter of 100mm. Pipes shall be fixed by means of stout GI clamps in two sections, bolted together, built into the walls, wedged and neatly jointed as directed and approved by the Owner's site representative / Architect. All bends, branches, swan neck and other parts shall conform to the requirement and standards as described for the pipes. Pipes shall be rested against the walls on suitable wooden cradles. Local authority regulations applicable to the installations shall be strictly followed.

Where indicated, the soil pipes shall be continued upwards without any diminution in its diameter, without any bend or angle to the height shown in the drawings. Joints throughout shall be made with molten lead as described under jointing of cast iron pipes. Soil pipes shall be painted as provided under 'painting'. The soil pipes shall be covered on top with cast iron terminal outlets as directed and approved. All vertical soil pipes shall be firmly fixed to the walls with properly fixed clamps, and shall as far as possible be kept 50mm clear of wall. Waste pipes and fittings shall be of cast iron or galvanised mild steel pipes. Pipes shall be fixed, jointed and painted as described in installation of soil, waste & vent pipes.

Every waste pipe shall discharge above the grating of properly trapped gully. The contractor will ensure that this requirement is adequately met with. Wherever floor traps are provided, it shall be

ensured that atleast one wash is connected to such floor traps to avoid drying of water seal in the trap. Ventilating pipes shall be of cast iron or galvanised mild steel pipes, conforming to the requirements laid down earlier. Anti-syphon vent pipes/relief vent pipes where called for on the drawings shall be of cast iron or galvanised mild steel pipes as specified. The pipes shall be of the diameter shown on the drawings.

All traps on branch soil and waste pipes shall also be ventilated at a point not less than 75mm or more than 300mm from their highest part and on the side nearest to the soil pipe or waste pipes.

Access doors for fittings and clean outs shall be so located that they are easily accessible for repair and maintenance. Any access panel required in the civil structure, false ceiling or marble cladding etc. shall be clearly reported to the Owner in the form of shop drawings so that other agencies are instructed to provide the same.

All the fittings used for connections between soil, waste and ventilation pipes and branch pipes shall be made by using pipe fittings with inspection doors for cleaning. The doors shall be provided with 3mm thick rubber insertion packing and when closed and bolted shall be air and water tight.

Where soil, waste and ventilating pipes are accommodated in shafts ducts, adequate access to cleaning eyes shall be provided.

Head (starting point) of drains and sewage / waste water sumps (as and where applicable) having a length of greater than 4 m upto it connection to the main drain or manhole shall be provided with a 80 / 100 mm vent pipe.

3. PIPING MATERIALS

3.1 Cast Iron Pipes

Cast iron pipes and fittings shall be of good and tough quality and dark grey on fracture. The pipes and fittings shall be true to shape, smooth and cylindrical, their inner and outer surface being as nearly as practicable concentric. They shall be sound and nicely cast, shall be free from cracks, taps, pinholes and other manufacturing defects.

The pipes and fittings shall conform to IS:3989 / IS:1729 as called for. Fittings shall be of required degree with or without access door. All access doors shall be made up with 3mm thick insertion rubber gasket of white lead and tightly bolted to make the fittings air and water tight. The fittings shall be of the same manufacture as the pipes used for soil and waste.

All CI pipes and fittings shall bear the manufacturer's name and ISI specification to which it conforms.

All pipes and fittings shall be coated internally and externally with the same material at the factory, the fittings being preheated prior to total immersion in a bath containing a uniformly heated composition having a tar/other suitable base. The coating material shall have good adherence and shall not scale off. The coating shall be smooth and tenacious and hard enough not to flow when exposed to a temperature of 77 degree C but not so brittle at a temperature of '0' degree C as to chip off when scratched lightly with a pen knife.

All pipes and fittings before installation at site shall be tested hydrostatically to a pressure of 0.45 Kg/sq. cm without showing any sign of leakage, sweating or other defects of any kind. The pressure shall be applied internally and shall be maintained for not less than 15 minutes. All these tests shall be carried out in the presence of the representative of the Project Manager. Alternatively a test certificate from manufacturers be obtained before dispatch of material to site.

Cast Iron Specialities

If required, Cast iron speciality items such as deep seal floor traps, urinal traps, trap integral pieces with integral inlet/outlet connections, manhole cover with frame, chamber cover etc. shall be fabricated to suit individual location requirements. The contractor shall arrange the fabrication of these items from an approved source.

Lead Caulked joints with pig lead:

The approximate depth and weights of pig lead for various diameters of CI pipes and specials shall be as follows:

<u>Nominal size of</u> <u>Pipe (mm)</u>	<u>Lead per Joint</u> <u>(Kg)</u>	<u>Depth of Lead</u> <u>Joint (mm)</u>
50	0.77	25
80	0.88	25
100	0.99	25
150	1.5	38

Drip Seal Joints :

Drip seal PJS-43 (pipe joint sealant) shall be used for joining various diameters of C.I. pipes and specials. This sealant replaces the standard Drip seal caulked joints. The application is by Homogenously mixing the two pack system in cold condition. Drip seal PJS - 43 is the proprietary item of M/s. Vinod Cement Co., Chandigarh.

Application Procedure:

Clean the pipe joints thoroughly to ensure it is free from any traces of oil, dirt or any other foreign body. Mix two parts of Drip Seal thoroughly with an iron flat to get a homogenous compound. * Place Spun yarn in the pipe joint as a filler and then take the required quantity of the compound and push it in the joint with a caulking tool, MS flat / damp finger uniformly all over to obtain a smooth and uniform joint. Dip the fingers in water every often to ensure the compound does not stick to the hands of the workmen, but this will ensure perfect sealing and the smooth surface for the joint cement. (* The compound prepared from the two mixtures is to be used within 30 minutes) Precaution to be taken to wash hands thoroughly with soap before and after use. Preferably use disposable gloves for hand application.

3.2 Galvanised Iron Pipes

Waste pipes of 50mm dia and below and where called for shall be galvanised iron pipes screwed and socketed conforming to the requirements of IS:1239 of heavy grade. The pipes and sockets shall be cleanly finished, well galvanised in and out and free from cracks, surface flaws, laminations and other defects. All screw thread shall be clean and well cut. All pipes and fittings shall bear manufacturer's trade mark and conform to the IS as specified.

3.3 UPVC Pipes and Fittings

The pipes shall be round and shall be supplied in straight lengths with socketed ends. The internal and external surfaces of pipes shall be smooth, clean, free from groovings and other defects. The ends shall

be cleanly cut and square with the axis of the pipe. The pipes shall be designed by external diameter and shall conform to IS:4985-1981. The pipes shall be of Class-III; 6 Kg/sqm pressure rating.

Fittings

Fittings shall be of the same make as that of pipes, injection moulded and shall conform to Indian Standard.

Laying and Jointing

The pipes shall be laid and clamped to wooden plugs fixed above the surface of the wall. Alternatively plastic clamps of suitable designs shall be preferred. Provision shall be made for the effect of thermal movement by not gripping or disturbing the pipe at supports between the anchors for suspended pipes. The supports shall allow the repeated movements to take place without abrasion.

Jointing for UPVC pipes shall be made by means of solvent cement for horizontal lines and 'O' rubber ring for vertical line. The type of joint shall be used as per site conditions / direction of the Owner's site representative. Where UPVC pipes are to be used for rain water pipes, the pipe shall be finished with GI adopter for insertion in the RCC slab for a water proof joint complete as directed by Owner's site representative.

Supports

UPVC pipes require supports at close intervals. Recommended support spacing for unplasticised PVC pipes is 1400 mm for pipes 50 mm dia and above. Pipes shall be aligned properly before fixing them on the wooden plugs with clamps. Even if the wooden plugs are fixed using a plumb line, pipe shall also be checked for its alignment before clamping, piping shall be properly supported on, or suspended from clamps, hangers as specified and as required. The Contractor shall adequately design all the brackets, saddles, anchors, clamps and hangers and be responsible for their structural sufficiency. Pipe supports shall be primer coated with rust preventive paint.

Repairs

While temporary or emergency repairs may be made to the damaged pipes, permanent repairs shall be made by replacement of the damaged section. If any split or chip out occur in the wall of the pipe, a short piece of pipe of sufficient length to cover the damaged portion of the pipe is cut. The sleeve is cut longitudinally and heated sufficiently to soften it so that it may be slipped over the damaged hard pipe.

4. PIPES HANGERS, SUPPORTS, CLAMPS ETC.

All vertical pipes shall be fixed by galvanized clamps and galvanized angle brackets truly vertical. Branch pipes shall be connected to the stack at the same angle as that of the fittings. No collars shall be used on vertical stacks. Each stack shall be terminated at top with a cowl (terminal guard).

Horizontal pipes running along ceiling shall be fixed on galvanized structural adjustable clamps of special design shown on the drawings or as directed. Horizontal pipes shall be laid to uniform slope and the clamps adjusted to the proper levels so that the pipes fully rest on them.

Contractor shall provide all sleeves, openings, hangers, inserts during the construction. He shall provide all necessary information to the building contractor for making such provisions in the structure as necessary. All damages shall be made good to restore the surfaces.

All pipes clamps, supports and hangers shall be galvanized. Factory made prefabricated clamps shall be preferred. Contractor may fabricate the clamps of special nature and galvanize them after fabrication but before installation. All nuts, bolts, washers and other fasteners shall be factory galvanized.

Clamps shall be of approved design and fabricated from MS flats (which shall be galvanized after fabrication) of thickness and sizes as per drawings or contractor's shop drawings. Clamps shall be fixed in accordance to manufacturer's details/shop drawings to be submitted by the contractors.

When required to be fixed on RCC columns, walls or beam they shall be fixed with approved type of galvanized expansion anchor fasteners (Dash fasteners) of approved design and size according to load.

Structural clamps e.g.. trapeze or cluster hangers shall be fabricated by electro-welding from MS structural members e.g. rods, angles, channels flats as per contractors shop drawings shall be galvanized after fabrication. All nuts, bolts and washers shall be galvanized.

Galvanized slotted angle/channel of approved sizes supports on walls shall be provided wherever shown on shop drawings. Angles/channels shall be fixed to brick walls with bolts embedded in cement concrete blocks and to RCC walls with anchor fasteners mentioned above. The spacing of support bolts on support members fixed horizontally shall not exceed 1 m.

5. INSTALLATION OF SOIL, WASTE & VENT PIPES

Soil, waste & vent pipes in shafts under the floors / suspended below slab shall consist of cast iron pipes as described earlier. Waste pipes from bottle trap to floor/urinal traps for wash basin, urinal and sink shall be GI pipes and fittings.

All Horizontal pipes running below the slab and along the ceiling, shall be fixed on structural adjustable clamps, sturdy hangers of the design as called for in the drawings. The pipes shall be laid in uniform slope and proper levels. All vertical pipes shall be truly vertical fixed by means of stout clamps in two sections, bolted together, built into the walls, wedged and neatly jointed. The branch pipes shall be connected to the stack at the same angle as that of fittings. All connections between soil, waste and ventilating pipes and branch pipes shall be made by using pipe fittings with inspection doors for cleaning. Pipes shall be fixed in a manner as to provide easy accessibility for repair and maintenance and shall not cause obstruction in shafts. Where the horizontal run off the pipe is long or where the pipes cross over building expansion joints etc. suitable allowance shall be provided for any movements in the pipes by means of expansion joint etc. such that any such movement does not damage the installation in any way.

All cast iron pipes and fittings shall be jointed with drip seal / Best Quality pig lead free from impurities conforming to IS 27.

Before jointing, the interior of the socket and exterior of the spigots shall be thoroughly cleaned and dried. The spigot end shall be inserted into the socket right up to the back of the socket and carefully centered by two or three laps of threaded spun yarn, twisted into ropes of uniform thickness, well caulked into the back of the socket. No piece of yarn shall be shorter than the circumference of the pipe. The jointed pipe line shall be at required levels and alignment. The remainder of the socket is left for the lead caulking. Where the gasket has been tightly held, a jointing ring shall be placed round the barrel against the face of the socket. Molten Lead shall be poured to the remainder of the socket.

The depth of the lead joints for the cast iron pipes shall be 45mm for the pipes upto 100mm dia and 50mm for the pipes beyond 100mm dia respectively.

The joint shall not be covered till the pipe line has been tested under pressure. Rest of pipe line shall be covered so as to prevent the expansion and contraction due to variation in temperature.

Rainwater Pipes

All open terraces shall be drained by rain water down takes.

Rainwater down takes are separate and independent of the soil and waste system and will discharge into the underground storm water drainage system of the complex.

Rainwater in open courtyards shall be collected in catch basins and connected to the Storm Water Drains.