TECHNICAL SPECIFICATIONS

1. WATER CHILLING MACHINE - SCREW TYPE

a. Scope

The scope of this section comprises the supply, installation, testing and commissioning of water cooled screw chillers conforming to these specifications and in accordance with the requirement of drawings and of schedule of quantities.

b. Type

The chiller package shall be consisting of screw compressor/s, squirrel cage induction motor, starter, water cooled condenser, chiller, refrigerant piping, wiring and automatic controls all mounted on a steel frame, refrigerant piping and controls, full charge of refrigerant gas and oil, vibration isolation pads and other accessories factory assembled and tested. As an option, chiller shall be equipped with multiple compressors and economizer, to optimize the operating conditions, and enhance the COPof the system.

c. Capacity

The refrigeration capacity Screw Chillers shall be as shown in the “Schedule of Quantities”.

d. Screw Compressor

The compressor/s shall be field serviceable helical rotary, twin rotor semi hermetic type using Ozone compatible R-134a refrigerant. The compressor casing shall be horizontal / vertically split so that servicing can be carried out without disturbing the connections and shall be fully field serviceable. Each compressor shall be complete with internal muffler, check valve and discharge shut off-valve.

e. Bearings

The compressor shall incorporate the necessary design features which eliminate both the axial and radial thrusts. The bearing shall be pressure lubricated during operation and shall be completely sequenced and interlocked with the start-up of the machine in such a way that the oil pump should automatically start after some time, provided the oil temperature and pressure is maintained during the start-up period.

f. Lubrication System

The lubrication system should form one integral part of the compressor assembly and shall enforce complete force feed lubrication (at a pressure and controlled

temperature) to all bearing surfaces under any speed conditions at start-up, at shut downand during operation at various loads.

An automatic oil return system shall return any oil that has migrated to the refrigerant. Full lubrication must be available to the machine during acceleration and deceleration periods through an oil pump. Further it should include thefollowing:

i. High efficiency oil filters.
ii. Low oil pressure cut-out.
iii. Oil coolers and oil heaters.
iv. Oil level indicator.
v. Oil pressure control with pressure gauges and thermometer.
vi. Lubrication failure safety controls.
vii. Factory installedand tested oil piping.
viii. Oil Separator
ix. Any other accessory required

Capacity Controls

The compressor shall be equipped with an automatic hydraulically activated stepless slide valve/ pilot-operated solenoid valve regulating its capacity from 100% to 20%. The positioning of the valve shall be done by means of thermostatically, actuated electronic temperature controller differential type. The valve will maintain constant temperature of chilled water.

h. Compressor Control Panel

The chiller package shall be provided with a factory installed and wired microprocessor control center. The control panel shall be provided with necessary TPN isolator for termination of incoming power cable (power cable shall be provided by other agencies).

All controls shall be mounted in an attractively styled panel, the control system shall automatically control the operation of the unit from the time the unit is started, through the operating period, until the unit is stopped. The internal components shall be arranged for easy access.

The control center should include safety devices to protect the unit from mal functions. These controls should shut down the unit and signal the operator with their respective red neon lights. The protective controls are :

a. High condenser pressure cutouts
b. Low oil pressure cutout

c. High oil temperature cutout
d. High discharge temperature cutout
e. Solid state motor over current cutout
f. Solid state low evaporator temperature control.

The operating controls and circuit shall have neon lights that signal the operator, of certain unit operating conditions. These controlsare asfollows:

a. Compressor "start-stop" switch with"system run" light.
b. A low chilledwater temperature cutout with an automatic reset.
c. Other controls as required.
d. The chiller shall be BMS compatible. The control panel shall incorporate hardware cards/ control units for complete integration of chillers to building automation system. Chillerwill incorporate Bacnet/Mod-bus interface card and Plant Manager.

ControlConsole:

The water chilling machine shall be complete with microprocessor based interactive control console mounted directly on the unit and pre- wired with all operating &safety controls.

The control panel shall have all features as mentioned above but not restricted to control/console the following:

- Display of main information such as pressure, temperatures, running current, ser points etc.
- Automatic operation of heating and cooling control
- Set point adjustment
- Set point drift based on outdoor temperature (in cooling or heating mode)
- Switch able double set point
- High pressure safety
- Operating time balancing
- Water flow fault, frost fault, low pressure, high pressure fault-display.
- Inclusion of pump start up within the unit stat up cycle.

i. Electric Motor

Electric motor shall be suitable for 415+10% volts, 3 phase, 50 cycles AC supply. Motor shall be squirrel cage induction motor, designed and guaranteed for continuous operation at name plate rating for open type and motors to be suitable for the refrigerant in case of semi-hermetic type. Temperature sensor shall be provided in motor winding to protect the motor for high temperature rise.

The motor shall be provided with a combination of ball and roller bearings. The roller bearings shall be fitted at the driving end while the ball bearing shall be fitted at the

free end and shall have ample capacity to deal with any axial thrust. Limit type lubricators shall be provided to enable the bearings to be correctly greased. Motor cooling shall be provided by direct liquid injection and protected by internal overload thermostat.The tender should also indicate IKW/TR for part load conditions of 25%, 50%, 75%, and 90% besides for 100% under operating conditions. The drive losses should be included in the IKW/TR figures indicated by the bidders for open type compressor.

j. Motor Starter

The motor starter shall be star delta type, sheet steel clad, fully automatic, suitable for operation on 415 volts, 3 phase, 50Hz. The panel shall be complete with starter suitably rated triple pole contactors, triple pole CT operated magnetic overload relay, timer and ammeter with CT and indication lamps. Provision shall also be made in the starters for inter locking arrangements.

k. Evaporator(Cooler)

Evaporator shall be shell and tube and even pass type as specified in the Schedule of Equipment. Tubes shall be of 19mm O.D or 10mm O.D. . In either cases, tubes shall be removable without affecting the strength and durability of the support and tube sheets or causing any leakage in the adjacent tube. Tubes shall be adequately supported at a distance not exceeding one meter to prevent vibration. Chillers shall be manufactured to ASME Codes for unfired pressure vessels and designed for refrigerant side working pressure of 16 Kg/Sq.cm. However, chillers shall be Hydraulically tested for pressure of 30 Kg/Sq.cm on refrigerant side and 21 Kg/Sq.cm on water side. Chillers shall either be flooded type or DX type. Chiller shall be factory insulated with multilayer 25mm/19mm thick classs ‘O’ closed cell elastomeric insulation material and care should be taken to avoid damage of insulation during transit.

Chillers shall be complete with the following accessories:

a. Thermostatic expansion valves for DX Coolers. Or

Orifice type expansion device for flooded Coolers.

b. Pilot solenoid valves and filter drier.

c. Necessary drain valves and vent.

d. Any other standard accessories, necessary for the equipment supplied.

I. Condenser

Condenser shall be shell and tube, cleanable type, fitted with integral finned copper tubes of 19mm O.D. . These shall be designed for the duty specified in the Schedule of Equipment. Condenser shall be manufactured to ASME codes for unfired pressure vessels and designed for refrigerant side working pressure of 21 Kg/Sqcm and water side working pressure of 12 Kg/Sqcm.

However, condenser shall be hydraulically tested for pressure of 30 Kg/Sqcm on refrigerant side and 21 Kg/Sqcm on water side.

Condensers shall be complete with the following accessories:

i. Hot gas inlet connection, liquid outlet connection, relief valve, purge valve.

ii. Water inlet and outlet connections with valves complete with descaling connections.

iii. Any other standard accessories, necessary for the equipment supplied.

accessories

Following accessories and safety and control devices should be included with offered chillers:

- Dryer filter
- Thermostatic expansion valve
- Solenoid Valves
- Compressor delivery stop valves.
- Compressor capacity control
- Evaporator freeze up protection system
- High pressure, low pressure cut out
- Low Oil pressure cut out.
- Discharge temperature measurement system.
- Winding overheating protection system.
- Checking of starting number and start timing.
- Free auxiliary contacts for field wiring signals report.

m. Miscellaneous

Water chilling unit shallinclude:

i. Rubber vibration pads or spring type of 90% efficiency in preventing transmission of vibrations.

ii. Full charge of refrigerant gas as required to obtain and maintain the design conditions and the required quantity of suitable grade lubrication oil.

iii. Each unit shall include, but not be limited to, all the items listed in the schedule of quantities.

n. Installation

Chiller housing comprising of compressor, cooler and condenser shall be mounted on a common foundation which will be prepared by the Owner. The Contractor shall supply foundation bolts, nuts, washers, leveling screws, mounting frame or base plate, vibration isolation pads etc. and it shall be his responsibility to see that all the above items are properly and accurately placed in position while the foundation is cast. The contractor shall supply the required quantity of refrigerant, lubricant and other consumables for testing and commissioning the equipment.

After erection, the unit shall be properly leveled before grouting the foundation bolts and the levels should be shown to the Consultants. All the equipment shall be thoroughly tested and checked for leaks. The refrigeration system shall be vacuumized to 7.6mm Hg absolute and maintained for four hours. At the end of this period the pumps shall be stopped and vacuum maintained for twenty four hours without exceeding a vacuum drop of 2.5mm Hg absolute. The Contractor shall certify that the vacuum was maintained as specified above.

All safety controls, low and high refrigerant pressure controls, starter, overload trips shall be suitably set and record of all the setting shall be furnished to the Consultants.

o. Testing

Equipment capacity in tons of refrigeration shall be computed from the temperature readings and water flow measurements. Flow measurements shall be preferably through flow meters. Computed results should tally with the specified capacities and the power consumption should tally with the figures furnished with the tender.

All instruments, services needed for the tests required for computation of capacity and power consumption shall be furnished by the contractor themselves.

p. Operational analysis

Control panel shall receive, diagnose and correct/control following parameters

Temperature Control

Shall check the water temperature and compare it with set values so as to calculate the number of output stages to run or trip.

Frost Limit

Shall check the evaporator water leaving temperature against frosting limit and shall switch off the unit if temperature reaches to the limit and shall also simultaneously start the heater to restart the compressors.

Anti Short Cycle

Shall Control the number of starts of a compressor in an hour

Water flow fault

The control panel shall stop the machine in case the water flow is disrupted due to any reason. The unit shall be capable of restarting automatically if flow is resumed.

Low Pressure Safety

Each refrigerant circuit shall have independent low pressure safety. It shall stop the unit if suction pressureis lower than set valve and shall reset automatically.

High Pressure Safety

Control Panel shall shut off the individual circuit if high pressure exceeds the set points. It shall start only after manual resetting.

Oil Pressure Safety

The control panel shall check the oil pressure of semi-hermatic compressor and shall switch off the compressor in case the oil pressure falls below required level. It shall start the unit only on manual resetting. Each compressor shall have independent oil pressure safety control.

Motor Protection

The control panel shall protect compressor against overload by a thermal relay contact. After the fault clearing the start shall be by reset button. Each compressor shall have independent overload protection.

Starting Priority And Stage Operation

The control panel shall provide choice for starting any individual compressor and its capacity staging with respect to other compressor. If any unit is operating near to frosting limit it shall trip the stage when temperature is at 2 ^{0} C above freezing set point and shall restart the stage when temperature is 3.5^{0} C above the set point.

Water Pump Control

The pump shall start 10 seconds before the start up of compressor and shall stop with shut down on last control stage or fault.

Differential Temperature Control

The control panel shall provide setting of differential temperature for stage operation and cut off limits.

INSTALLATION

The chilling machine shall be installed over a platform and shall be adequately isolated as per manufacturers recommendations against transmission of vibrations to the building structure.

PAINTING

Screw water chilling machine shall be finished with durable enamel paint. Shop coats of paint that have become marred during shipment or erection, shall be cleaned off with mineral spirits, wire brushed and spot primed over the affected areas, then coated with enamel paint to match the finish over the adjoining shop-painted surfaces.

PERFORMANCE RATING :

The unit shall be selected for the lowest operating noise level Capacity ratings, and power consumption with operating points clearly indicated, shall be submitted and verified at the time of testing and commissioning of the installation. Capacity shall be ascertained by measurements of chilled water flow rate and temperature of chilled water in and out of the chilling unit.

Power consumption shall be computed from measurements of incoming voltage & input current to the chilling machine.

WITNESS TEST

Prior to shipment, chilling machines shall be subjected to inspection and witness of performance tests to verify various performance parameters as confirmed by vendor earlier at the time of award of contract. Performance test shall be carried out as per procedure laid down by ARI / EUROVENT.

In case of equipment being supplied by the contractor from a place outside India for which department may or may not be able to send its representative, the manufacturers test certificates (for all acceptance test) for inspection of material and witnessing. The various tests at the factory as carried out by the manufacturer have to be submitted alongwith the supply of equipments. This must be witnessed by the representative of the contractor at their own cost.

2. PUMPS

2.1 SCOPE

The scope of this section comprises the supply, erection, testing and commissioning of water pumps conforming to these Specifications and in accordance with requirements of Schedule of Quantities.

2.2 TYPE

The type and size of all chilled water, condensing water, cold water and condensate drain pumps for air conditioning applications shall be in accordance with requirement of Drawings and Schedule of Quantities.

2.3 CAPACITY

Water flow rates and head of the pumps shall be in accordance with the requirements of Schedule of Quantities.

2.4 SPLIT CASING PUMPS

a. Pump casing shall be close-grained cast iron of heavy section, horizontally/vertically split, making possible complete servicing of rotating parts without breaking piping or motor connections. Motor to pump connection shall be of the flexible coupling type. Suction passages shall be volute in form, promoting smooth entry to impeller and increased efficiency. Impeller shall be bronze or gun metal, double suction, enclosed type, hydraulically balanced and passages smooth-finished for minimum friction and maximum efficiency. Impeller rings shall be secured from relative movement by tongue and groove fittings. Shaft shall be steel, protected by gunmetal sleeves extending through stuffing boxes. Stuffing boxes shall be extra deep, water sealed with renewable bushes. Shaft shall be supported in ball /journal bearings, grease lubricated, contained in easily removable housing. Pumps shall be fitted with mechanical seals, an air valve, two grease lubricators, drain plug and water seal drain connections.

b. Motor shall be energy efficient, totally enclosed, fan-cooled, class-F insulation. Motor shall be specially designed for quiet operation and its speed shall not exceed 1440 rpm. The motor rating shall be such as to ensure non overloading of the motor throughout its capacity range. Motor shall be suitable for 415±10% volts, 3 phase, 50 cycles AC, power supply with efficiency as EFF-1.

c. Base shall be of a size suitable for the pump, motor and shaft and shall be constructed of cast iron or welded steel. Flexible coupling shall be protected by a guard mounted on the common base.

d. Installation : The pump shall be installed on a concrete foundation with vibration isolators as per Approved-for-Construction shop drawings/Schedule of Quantities.

2.5 MONOBLOC PUMPS

a. Pump shall be monobloc end-suction design directly connected to motor. The pump casing shall be of cast iron. Impeller shall be cast iron, hydraulically balanced and keyed to shaft. Stuffing boxes shall be integral with casing and water sealed. Shaft sleeve shall be of gun metal extending through stuffing boxes.

b. Motor shall be drip and splash proof, designed as integral part of pump. Motor shall be suitable for 415±10% volts, 3 phase, 50 cycles AC power supply.

c. Installation : The pump base shall be mounted on a concrete foundation as per on Approved-for-Construction shop drawings.

2.6 LUBRICATION

Upon installation of the complete system and before testing, the pump shall be lubricated in strict accordance with the manufacturer's instructions.

2.7 PUMP ALIGNMENT

Split casing pumps, prior to testing, shall be aligned with a dial indicator within 0.05 mm.

2.8 PAINTING

All pumps, motors and bases shall be supplied with approved finish. Shop coat of paint that have become marred during shipment or erection shall be cleaned off with mineral spirits, wire brushed and spot primed over the affected areas, then coated with enamel paint to match the adjoining areas.

2.9 PERFORMANCE DATA

Pump performance curves and power consumption with operating points clearly indicated shall be submitted and verified at the time of testing and commissioning of the installation.

2.10 TESTING

Pump performance shall be computed from the pump curves provided by manufacturer. All pumps shall be tested at factory as per relevant BIS codes.

3. VARIABLE SPEED PUMPING SYSTEM

3.1 SCOPE

The scope of this section comprise the supply, erection, testing and commissioning of variable speed pumping package consisting of following :

a. Individual Components

b. Pump Control Panel

c. Adjustable Frequency Drive

d. Different pressure transmitted

e. Logic Programming for sequence of Operation

f. Power wiring and control wiring shall be carried out by installation contractor as shown on the field connection drawings and wiring diagrams supplied with the pumping package.

3.2 REFERENCES

a. ANSI - American National Standards Institute

b. NEMA - National Electrical Manufacturers Association

c. UL - Underwriters Laboratories Inc.

d. ETL - Electrical Testing Laboratories

e. CSA - Canadian Standards Association

f. NEC - National Electrical Code

g. ISO - International Standards Organization

h. IEC - International Electrochemical Commission

3.3 SUBMITTALS

Submittals shall include the following and shall be specific to this project. General Submittals shall not be accepted.

a. System summary sheet.

b. Sequence of operation

c. Shop drawing indicating dimensions, required clearances and location and size of each field connection.

d. Power and control wiring diagrams.

e. System profile analysis including variable speed pump curves and system curve. The analysis shall also include pump, motor and Adjustable Frequency Drive (AFD) efficiencies, job specific load profile, staging points, horse power and kilowatt/hour consumption.

f. Pump data sheets.

3.4 QUALITY ASSURANCE

a. The pumping package shall be assembled by the pump manufacturer. An assembler of pumping systems not actively engaged in the design and construction of centrifugal pumps shall not be considered a pump manufacturer. The manufacturer shall assume "Unit Responsibility" for the complete pumping package. Unit responsibility shall be defined as responsibility for interface and successful operation of all system components supplied by the pumping system manufacturer.

b. The local supplier of Chilled Water Variable Speed Pumping System (VSPS) shall have relevant expertise in all aspects of design, application engineering, installation, programming, interfacing, commissioning and after sales service.

c. All functions of the variable speed pump control system shall be tested at the factory prior to shipment. This test shall be conducted with motors connected to AFD output and it shall test all inputs, outputs and program execution specific to this application.

d. Tenderer shall comply with all sections of this specification relating to packaged pumping systems. Any deviations from this specifications shall be clearly defined in writing at time of bid. If no exceptions are taken at time of bid, the supplier shall be bound by these specifications.

3.5 MANUFACTURED UNITS

a. Furnish and install as shown on the plans a Variable Speed Pumping System as per approved manufacturers.

b. The control system shall include as, a minimum, the programmable logic pump controller, adjustable frequency drive(s) and remote sensor / transmitters as indicated in the drawings and schedule of quantities on the plans. Additional items shall be included as specified or as required to properly execute the sequence of operation.

c. The variable speed pump logic controller, adjustable frequency drives, AFD bypass if indicated in schedule of quantities, and remote sensor / transmitters shall be shipped as individual components to the job site.

d. Pump logic controller, adjustable frequency drives, sensor / transmitters and related equipment shall be installed by the mechanical contractor as shown on the plans.

e. Power wiring shall be installed by the mechanical contractor as shown on the field connection drawings and wiring diagrams supplied with the pumping package.

f. Low voltage wiring shall be installed by the mechanical controls contractor as shown on the field connection drawings and wiring diagrams supplied with the pumping package.

3.6 PUMP LOGIC CONTROLLER

a. The pump logic controller assembly shall be listed by and bear the label of Underwriter's Laboratory INC. (UL). The controller shall meet Part 15 of FCC regulations pertaining to class A computing devices. The controller shall specifically designed for variable speed pumping applications.

b. The controller shall function to a proven program that safeguards against hydraulic conditions including :

   i. Pump flow surges
   ii. Hunting
   iii. End of curve
   iv. System over pressure.
   v. NPSHR above NPSHA
   vi. Motor overload

c. The pump logic controller shall be capable of receiving up to two discrete analog inputs from zone sensor / transmitter as indicated on the plans. It will then select the analogue signal that has deviated the greatest amount from its setpoint. This selected signal shall be used as the command feedback input for a hydraulic stabilization function to minimize hunting. Each input signal shall be capable of maintaining a different set point value. Controller shall be capable of controlling upto three pumps in parallel.

d. The pump logic controller shall have an additional analog input for a flow sensor. This input shall serve as the criteria for the end of curve protection algorithm.

e. The hydraulic stabilization program shall utilize a proportional-integral-derivative control function. The proportional, integral and derivative values shall be user adjustable over an infinite range.

f. The pump logic controller shall be self prompting. All messages shall be displayed in plain English. The operator interface shall have the following features :

   i. Multi-fault memory and recall last 10 faults and related operational data
   ii. Red fault light, Yellow warning light and Green power on light.
   iii. Soft-touch membrane keypad switches.

g. The display shall have four lines, with 20 characters on three lines and eight large characters on one line. Actual pump information shall be displayed indicating pump status.

h. Controller shall be capable performing the following pressure booster function :

   i. Low suction pressure cut-out to protect the pumps against operating with insufficient suction pressure.
   ii. High system pressure cut-out to protect the piping system against high pressure conditions.
   iii. No flow shut down to turn the pumps off automatically when system demand is low enough to be supplied by hydropneumatic tank. No flow shutdown shall require any external flow meters, flow switches, nor pressure switches to determine when a No Flow condition exists.

j. The following communication features shall be provided to BAS :

   i. Remote system start / stop non-powered digital input.
   ii. Failure of any system component. Output closes to indicate alarm condition.
   iii. One 4-20 mA output with selectable output of :

      - Frequency
      - Process Variable
      - Output Current
      - Output power.

k. The following communication features shall be provided to the building automation system via an RS-485 port utilizing Johnson Controls Metasys N2 protocol or equivalent protocol.

   i. Individual Analog Input
   ii. Individual Zone Set Points.
   iii. Individual Pump / AFD on/off status.
   iv. System percent speed.
   v. System Start / Stop command
   vi. System operation mode.
   vii. Individual KW signals.
   viii. System flow, when optional flow sensor is provided.

l. The pump logic controller shall be a ITT industries technologic 500 or approved equal housed in a NEMA 1 Enclosure.

3.7 ADJUSTABLE FREQUENCY DRIVE

a. The adjustable frequency drives shall be Pulse Width Modulation (PWM) type, microprocessor controlled design.

b. The Adjustable Frequency Drive (AFD), including all factory installed option, be tested to UL standard 508. The AFD shall also meet C-UL and be CE marked and built to ISO 9001 standards.

c. The AFD shall be housed in a NEMA 1 enclosure. AFF with plastic enclosure shall not be acceptable.

d. The AFD shall employ and advanced sine wave approximation and voltage vector control to allow operation at rated motor shaft output speed with no derating. This voltage vector control shall minimize harmonics to the motor to increase motor efficiency and lift. Power factor shall be near unity regardless of speed or load.

e. The AFD shall have balanced DC link reactors to minimize power line harmonics AFDs without a DC link reactor shall provide a 3% impedance line reactor.

f. Input and output power circuit switching can be done without interlocks or damage to the AFD.

g. The following customer modifiable adjustments shall be provided :

   i. Accel time.
   ii. Decel time.
   iii. Minimum Frequency.
   iv. Maximum Frequency.

h. RS-485 communication for Johnson Controls N2 shall be available and provided as an option.

i. An automatic energy optimization selection feature shall be provided. This feature shall reduce voltage when lightly loaded and provide a 3% to 10% additional energy savings.

j. The AFD shall be suitable for upto 3300 feet elevation above sea level without derating. Maximum operating ambient temperature shall not less than 104 degrees F. AFD shall be suitable for operation in environments upto to 955 non-condensing humidity.

k. The AFD shall be capable of displaying the following information in plain English via an alphanumeric display :

   i. Frequency.
   ii. Voltage
   iii. Current
   iv. Kilowatts per hour
   v. Fault Identification.
   vi. Percent Torque.
   vii. Percent Power
   viii. RPM

3.8 AUTOMATIC AFD BYPASS

a. Variable speed pumping system shall be equipped with an automatic bypass in accordance with requirement of Schedule of Quantities.

b. Bypass shall consist of a main power disconnect with ground fault protection, a pair of interlocked contractors and a motor overload relay. All are to be mounted in a NEMA 1 enclosure.

c. Automatic bypass shall operate as shown in schematic drawings described in the sequence of operation.

3.9 SENSOR / TRANSMITTERS

a. Provide field mounted differential pressure sensor transmitters as indicated in BOQ or on the plans. Unit shall transmit an isolated 4-20mA dc signal indicative of process variable to the pump logic controller via standard two wire 24 DC system. Unit shall have a corrosion resistant steel body with 1/8" NPT process connection. It shall have a NEMA 1 electrical enclosure capable of withstanding 450 PSI static pressure. Accuracy shall be within 0.5% of full span. The installation contractor shall ensure that these differential pressure sensor are enclosed within pilfer proof housing such MS plate housing with lockable access panel.

3.10 SECONDARY PUMPS

a. SCOPE

The scope of this section comprise the supply, erection, testing and commissioning of water pumps conforming to these specifications and in accordance with requirements of Schedule of Quantities.

b. TYPE

The type and size of secondary chilled/hot water, and pumps for air conditioning applications shall be in accordance with requirement of Drawings and Schedule of Quantities.

c. CAPACITY

Water flow rates and head of the pumps shall be in accordance with the requirements of Schedule of Quantities.

d. SPLIT CASING PUMPS

i. Pump casing shall be close-grained cast iron of heavy section, horizontally/vertically split, making possible complete servicing of rotating parts without breaking piping or motor connections. Motor to pump connection shall be of the flexible coupling type. Suction passages shall be volute in form, promoting smooth entry to impeller and increased efficiency. Impeller shall be bronze or gun metal, double suction, enclosed type, hydraulically balanced and passages smooth-finished for minimum friction and maximum efficiency. Impeller rings shall be secured from relative movement by tongue and groove fittings. Shaft shall be steel, protected by gunmetal sleeves extending through stuffing boxes. Stuffing boxes shall be extra deep, water sealed with renewable bushes. Shaft shall be supported in ball /journal bearings, grease lubricated, contained in easily removable housing. Pumps shall be fitted with mechanical seals, an air valve, two grease lubricators, drain plug and water seal connections.

ii. Motor shall be energy efficient, totally enclosed, fan-cooled, class-F insulation and suitable for operation on Adjustable Frequency Drive (AFD). Motor shall be specially designed for quiet operation and its speed shall not exceed 1440

rpm. The motor rating shall be such as to ensure non overloading of the motor throughout its capacity range. Motor shall be suitable for 415 ± 10% volts, 3 phase, 50 cycles AC, power supply.

iii. Base shall be of a size suitable for the pump, motor and shaft and shall be constructed of cast iron or welded steel. Flexible coupling shall be protected by a guard mounted on the common base.

iv. Installation : The pump shall be installed on a concrete foundation as shown in Approved-for-Construction shop drawings.

v. Each pumps shall be provided with certified performance curves showing power absorbed and corresponding flow rates by varying the speed. Tests shall be done at factory and may be witnessed by department site representative.

e. PUMP ALIGNMENT

Split casing pumps, prior to testing shall be aligned with a dial indicator within 0.05 mm. Monobloc pumps shall be factory aligned with motor on common base, and need not be realigned at site.

f. PERFORMANCE DATA

Pump performance curves and power consumption with operating points clearly indicated shall be submitted and verified at the time of testing and commissioning of the installation.

g. TESTING

Pump performance at site shall be computed from the pump curves provided by manufacturer.

3.11 PAINTING

All variable pumping system, pumps, motors and bases shall be supplied with approved finish. Shop coat of paint that have become marred during shipment or erection shall be cleaned off with mineral spirits, wire brushed and spot primed over the affected areas, then coated with enamel paint to match the adjoining areas.

3.12 SEQUENCE OF OPERATION

a. The system shall consist of a pump logic controller, multiple pump / AFD sets, with manual and automatic alternation and pump staging.

b. The pumping system shall start upon the closure of customer's contact when the pump logic controller Mode of Operation selector switch is in the REMOTE position.

c. When the pump logic controller selector switch is in the LOCAL position, and start command on Tech 500 is given via operator interface, the pumping system shall operate automatically.

d. Sensor / transmitters shall be provided as indicated on the plans.

e. Each sensor / transmitter shall send a 4-20 mA signal to the pump logic controller, indicative of process variable condition.

f. The pump logic controller shall compare each signal to the independent, engineer / user determined set points.

g. When all set points are satisfied by the process variable, the pump speed shall remain Constant at the optimum energy consumption level.

h. The pump logic controller shall continuously scan and compare each process variable to its individual set point and control to the least satisfied zone.

i. If the set point can not be satisfied by the designated lead pump, the pump logic controller shall initiate a timed sequence of operation to stage a lag pump.

j. The lag pump shall accelerate resulting in the lead pump(s) decelerating until they equalize in speed.

k. Further change in process variable shall cause the pumps to change speed together.

l. When the set point criteria can be safely satisfied with fewer pumps, the Technologic pump logic controller shall initiate a timed destage sequence and continue variable speed operation.

m. As the worst case zone deviates from set point, the pump logic controller shall send the appropriate analog signal to the AFD to speed up or slow down the pump / motor.

n. In the event of a AFD fault, the pump logic controller automatically initiates a times sequence of events to start the redundant pump / AFD set in the variable speed mode. The redundant variable speed system shall be started through the pump logic controller.

o. Upon AFD fault(s), the pump controller shall display an alarm condition through a plain english message.

p. AFD fault indication shall be continuously displayed on the operator interface of the pump until the fault has been corrected and the controller has been manually reset.

q. In the event of the failure of a zone sensor / transmitter, its process variable signal shall be removed from the scan / compare program. Alternative zone sensor / transmitters, if available, shall remain in the scan / compare program for control.

r. Upon sensor failure a plain english warning message shall be displayed on the operator interface of the pump logic controller.

s. In the event of failure to receive all zone process variable signals, a user selectable number of AFDs shall maintain a user adjustable speed, reset shall be automatic upon correction of the zone failure.

4. COOLING TOWERS

4.1 SCOPE

The scope of this section comprises the supply, erection, testing and commissioning of cooling towers in accordance with requirements of Drawings and of the Schedule of Quantities.

4.2 TYPE

Cooling Towers shall be induced draft in accordance with requirement of Drawings and of the Schedule of Quantities.

4.3 INDUCED DRAFT COOLING TOWER

Cooling Towers shall be suitable for outdoor use. Tower shall be vertical, induced draft, counter/cross flow type. FRP construction, in rectangular/ square /octagonal profile, complete with fan, motor, diffusion deck spray section, eliminators, steel supports, and sound attenuation equipment where called for in Schedule of Quantities.

a. Capacity

The cooling tower capacities shall be as per the Drawings and Schedule of Quantities.

b. Side Casing

This shall be made out of FRP construction of minimum 5mm thick and UV stabilized with smooth surface on both sides for minimum resistance to air flow. It shall have sufficient structural strength to adequately withstand high wind velocities and vibration. The casing may be installed in the reinforced cement concrete basin if so identified in drawings, or in Schedule of Quantities. The tower supporting structure shall be made out of hot dipped galvanized tubular frame. Air intake shall be all along the sides so that tower can be installed quite independent of prevailing wind direction. Anodized aluminium or PVC louvers integrated with fill UV stabilized PVC fill and backed up by galvanized bird screen / FRP Louvers shall be provided at air intake. Sufficient clearance between casing and adjoining structures shall be provided to enable servicing and periodic cleaning.

c. Cold Water Basin

Cold water basin shall be 600mm deep sump and made out of 5mm thick FRP construction and UV stabilized on which cooling tower super structure shall be supported. RCC suction tank with easily removable double brass strainers may be provided with this basin, if separately identified in drawings or in Schedule of Quantities.

Basin fittings shall include the following :

i. Bottom outlet.
ii. Screened suction assembly.
iii. Drain connected to the side / underside of basin.
iv. Overflow connected to the side of basin.
v. Built-in bleed off attached to inlet header discharging through polyethylene tube into overflow pipe.
vi. Ball type automatic make up water valve.
vii. Quick fill connected to the side of basin.
viii. Equalizing connection and balancing valve for multiple CTs.

d. Distribution System

Hot water distribution system shall comprise of header and branch arms system or open pan gravity flow system.

e. Filling

Fillings shall be made of corrosion proof and rigid PVC film in honey comb design and arranged in square / rectangular form. Fill sheets shall be suspended from H.D.G steel structural tubing supported from the lower structure & shall be elevated above the floor of the cold water basin to facilitate cleaning and easy replacement. They shall be arranged in such a manner to ensure negligible resistance to air flow and to eliminate back water spots and prevent fouling through scales that may form. In order to reduce carry-over losses through entrainment of moisture drops in air stream, PVC drift eliminator shall be installed.

f. Mechanical Equipment

The tower shall be provided with low speed fan running at less that 360 RPM through gear reducer. Direct driven fan speed shall not exceed 700 RPM. Fan shall be of the propeller type light-weight rotor fitted with multiple aerofoil blades. The entire fan assembly shall be statically and dynamically balanced. Fan shall be driven by 415±8% volts, 3 phase, 50 cycles, AC supply, energy efficient motor totally-enclosed, fan-cooled, weather-proof construction, designed and selected to operate in humid air stream. Fan shall be protected by a fan guard and bird screen of galvanized steel construction to prevent birds from nesting during idling period & shall be easily accessible for inspection and maintenance. A service ladder (Aluminium construction) shall also be provided for greater convenience. The mechanical equipment assembly shall be adequately supported on a rugged steel base welded to tubular support assuring vibration-free support. Fan guard and bird screen (of galvanized steel construction) shall be provided to prevent birds from nesting during idling periods. Gear-reducer shall be of spiral bevel type. G.S.S canopy shall be provided over the fan motor for protection against rain water. Care shall be taken that fan air is not restricted. Motor terminal box shall be made water tight

e. Variable Frequency Drive

VFD designed for HVAC applications for supply air fan with built-in PID controller, control panel (keypad & display) , IP-55 enclosure for use on standard centrifugal fans. The VFDs should not cause any deration of the connected motors and must ensure that class B temperature levels of the connected motors are never exceeded. The display should be in alpha-numeric characters and programming facility should be in user-friendly HVAC terminology. VFD's shall have builtin harmonic filters.

Each VFD panel to be provided with digital display showing electrical parameters like voltage, current and power consumption.

Each VFD shall be installed in a dedicated external IP-55 enclosure and the inter connecting wires between driver and MCC shall be included.

4.4 PERFORMANCE DATA

Complete performance ratings and power consumption at varying loads and outdoor wet bulb temperatures, shall be submitted and verified at the time of testing and commissioning of the installation.

4.5 TESTING

Capacity of the cooling tower shall be computed from the measurements of water flow, incoming/outgoing water temperatures and ambient air wet bulb temperature using accurately calibrated mercury-in-glass thermometers. Computed ratings shall conform to the specified

capacities and quoted ratings. Power consumption for cooling towers shall be computed from measurements of incoming voltage and input current.

5. FANS

5.1 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.

5.2 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.

5.3 CAPACITY

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

5.4 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 800 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±8% 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 8%. Motor shall be designed specially for quiet operation and motor speed shall not exceed 1440 rpm. The fan and motor combination selected for the particular required performance shall be of the most efficient (smallest horse power), so that sound level is lowest.

f. Drive to fan shall be provided through belt with adjustable motor sheave and a standard belt guard. Belts shall be of the oil-resistant type.

g. Vibration Isolation : MS base shall be provided for both fan and motor, built as an integral part, and shall be mounted on a concrete foundation through resistoflex vibration isolators. The concrete foundation shall be atleast 15 cm above the finished floor level, or as shown in approved-for-construction shop drawings.

5.5 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 aluminium or cast steel construction. Blades shall be die-formed aerofoil shaped for maximum efficiency and shall vary in twist and width from hub to tip to effect equal air distribution along the blade length. Fan blades mounting on the hub shall be statically and dynamically balanced. Extended grease leads for external lubrication shall be provided. The fan pitch control may be manually readjusted at site upon installation, for obtaining actual air flow values, as specified and quoted.

c. Motor: shall be energy efficient squirrel-cage, totally-enclosed, fan cooled, standard frame, constant speed, continuous duty, single winding, suitable for 415±8% 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 800 RPM for fans with impeller diameter above 450 mm, and 1440 RPM for fans with impeller diameter 450 mm and less. For lowest sound level, fan shall be selected for maximum efficiency or minimum horsepower. Motor conduit box shall be mounted on exterior of fan casing, and lead wires from the motor to the conduit box shall be protected from the air stream by enclosing in a flexible metal conduit.

d. Drive : to fan shall be provided through belt drive with adjustable motor sheave and standard sheet steel belt guard with vented front for heat dissipation. Belts shall be of oil-resistant type.

e. Vibration Isolation : The assembly of fan and motor shall be suspended from the slab by vibration isolation suspension of rubber-in-shear 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.

5.6 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 9 to 16 gauge sheet steel depending upon the

fan size. Orifice ring shall be correctly formed by spinning or stamping to provide easy passage of air without turbulence and to direct the air stream.

b. Fan Blades shall be constructed of aluminium or steel. Fan hub shall be of heavy welded steel construction with blades bolted to the hub. Fan blades and hub assembly shall be statically and dynamically balanced at the manufacturer's works.

c. Shaft shall be of steel, accurately ground and shall be of ample size for the load transmitted and shall not pass through first critical speed thru the full range of specified fan speeds.

d. Motor shall be standard (easily replaceable) permanent split capacitor or shaded pole for small sizes, totally enclosed with prelubricated sleeve or ball bearings, designed for quiet operation with a maximum speed of 800 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±6% volts, 50 cycles 3 phase power supply, and for smaller fans shall be suitable for 220 ± 6% volts, 50 cycles single phase power supply. Motors shall be suitable for either horizontal or vertical service as indicated on Drawings and in Schedule of Quantities.

e. Accessories : The following accessories shall be provided with propeller fans :

   i. Wire guard on inlet side and birdscreen at the outlet.

   ii. Fixed or gravity louvers built into a steel frame at the outlet.

   iii. Regulator for controlling fan speed for single phase fan motor.

   iv. Single phase preventors for 3 phase fans.

5.7 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.

5.8 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.

6. AIR HANDLING UNITS FOR OPERATION ROOMS

6.1 SCOPE

The scope of this section, comprises the supply, erection, testing and commissioning of double skin construction air handling units, conforming to these Specifications and in accordance with requirements of drawings and of the Schedule of Quantities.

6.2 TYPE

The air handling units shall be double skin construction, draw-thru type comprising of various sections, filter section, coil section and fan section, mixing box, (wherever the return air and fresh air are ducted) as shown on drawings and included in schedule of quantities.

6.3 CAPACITY

The air handling capacities, maximum motor horse power and static pressure shall be as shown on Drawings and in Schedule of Quantities.

6.4 CASING

Double skinned panels of AHUs shall be 23mm thick for recirculation type AHUs & 46 mm thick for 100% fresh air (TFA) AHUs & outdoor type AHUs. These shall be made of galvanized steel, pressure injected with foam insulation (density 40 kg/m^3) These panels shall be fixed to minimum 1.5 mm thick aluminium alloy structural framework with stainless steel screws. Outer sheet of double skinned panels shall be made of pre-plasticized galvanized sheet, and inner sheet of plain G.I. Sheet, both inner & out shafts shall be of 24 gauge.

The entire framework shall be mounted on an aluminium alloy or galvanized steel channel base as per manufacturer's design. Sealing of panels to the frame work shall be through heavy duty `O' ring gaskets held captive in the framed extrusion. All panels shall be detachable or hinged. Handles for panels shall be made of hard nylon and shall be operational from both inside and outside of the unit. Units supplied with various sections shall be suitable for on site assembly gaskets shall be continuous & concealed.

AHU shall have hinged, access door in the fan section and also in filter section where filters are not accessible from outside. Access doors shall be part of double skinned panels.

Condensate drain pan shall be fabricated from 18 gage stainless steel sheet with all corners welded. It shall be isolated from bottom floor panel with elastomeric nitrile rubber or crosslinked polyethylene insulation.

6.5 MIXING BOX

AHU's shall be with mixing boxes & shall be complete with thermal break profile, fresh and return air dampers. Dampers shall be opposed blade types. Blades shall be made of 16 G double skinned aerofoil aluminum extruded aluminum alloy frame. All linkages and supporting spindles shall be made of aluminum or nylon, turning in teflon bushes. Manual dampers shall be provided with a bakelite knob for locking the damper blades in position. Linkages shall be extended wherever specified for motorised operation. Damper frames shall be sectionalised to minimise blade warping. Air leakage through dampers when in the closed position shall not exceed 1.5% of the maximum design air volume flow rate at the maximum design air total pressure.

6.6 DAMPER

Dampers shall be opposed blade type. Blades shall be made of 16 G double skinned aerofoil aluminum sections with integral gasket and assembled within a rigid extruded aluminum alloy frame. All linkages and supporting spindles shall be made of aluminum or nylon, turning in teflon bushes. Manual dampers shall be provided with a bakelite knob for locking the damper blades in position. Linkages shall be extended wherever specified for motorised operation. Damper frames shall be sectionalised to minimise blade warping. Air leakage through dampers when in the closed position shall not exceed 1.5% of the maximum design air volume flow rate at the

maximum design air total pressure. Damper construction shall be such a that there is no rattling noise, when damper is partially (close to 50%) closed & AHU is ON.

6.7 MOTOR AND DRIVE

Fan motors shall be energy efficient EFF-1 and shall be 415±10% volts, 50 cycles, three phases, totally enclosed fan-cooled class F, with IP-55 protection. Motors shall be especially designed for quiet operation. Direct driven plug fans shall be used for SA and RA and belt drives are not acceptable. Provision for cable entry to the motor shall be made at the factory itself. Drilling of holes at site shall not be acceptable. Limit switch arrangement along with wiring shall be provided, so that when access doors opens, fan stops. Fan body, impeller and motor shall be epoxy painted.

6.8 FAN

Fans shall be centrifugal airfoil backward inclined blades. Fan casing shall be made of galvanised steel sheet. Fan wheels shall be made of galvanised steel. Fan casing and impeller shall be epoxy coated. Fan shaft shall be grounded C45 carbon steel and supported in self-aligning plummer block operating less than 75% of first critical speed, grease lubricated bearings. Fan wheels and pulleys shall be individually tested and precision balanced dynamically. Complete AHU assembly shall be dynamically balanced to grade G 6.3 as per ANSI / AMCA 204 - 96 in the factory. Fan blades shall be epoxy painted.

Motors shall be mounted inside the AHU casing on slide rails for easy belt tensioning, and be totally enclosed, fan cooled, to be class `F' insulation. Motors shall drive heavy duty V-belt, constant pitch, drive selected at 110% of motor horsepower.

Both fan and motors assemblies shall be mounted on a deep section aluminum alloy or galvanised steel (depending on size) base frame. Isolation shall be provided from the unit casing by combination spring and rubber anti vibration mounts and flame retardant, waterproof neoprene impregnated flexible connection on the fan discharge.

6.9 COOLING COILS

Refrigerant piping and fittings interconnecting compressor condenser shall be all copper and valves shall be brass / gunmetal construction.

6.10 FILTERS

Each unit shall be provided with a factory assembled filter section containing pre-filter & fine filter. Filter banks shall be easily accessible and designed for easy withdrawal and renewal of filter cells. Filter frame shall be fully sealed and constructed from aluminum alloy. Frame work for filter mounting arrangement shall be of SS material. Mico-vee filters shall be placed after supply air fan.

6.11 ACCESSORIES

Each air handling unit shall be provided with manual air vent at high point in the cooling coil and drain plug in the bottom of the coil.

6.12 ISOLATORS

Vibration isolators shall be provided with all air handling units. Vibration isolators shall be cushyfoot mounting type.

6.13 FRESH AIR INTAKES

Fresh air dampers shall be of the interlocking, opposed-blade louver type. Blades shall be made of extruded aluminium construction and shall be rattle-free. Dampers shall be similar to

those specified in “DAMPERS”. Fresh air intakes shall be as per the requirements of Schedule of Quantities.

6.14 PAINTING

Shop coats of paint that have become marred during shipment or erection shall be cleaned off with mineral spirits, wire brushed and spot primed over the affected areas, then coated with paint to match the finish over the adjoining shop painted surface.

6.15 PERFORMANCE DATA

Air handling unit shall be selected for the lowest operating noise level of the equipment. Fan performance rating and power consumption data, with operating points clearly indicated shall be submitted and verified at the time of testing and commissioning of the installation.

7. AIR DISTRIBUTION

7.1 SCOPE

The scope of this section comprises supply fabrication, installation and testing of all aluminum ducts(for clean rooms and OTs), 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.

7.2 DUCT MATERIALS

a RAW MATERIALS

Galvanizing shall be Class VIII –coating of zinc, nominal 120gm/sq.mt 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.

b GAUGES, BRACING BY SIZE OF DUCTS

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

For Ducts with External SP upto 500 Pa (50mmWg) (For Clean rooms)

Rectangular Ducts G. S.	**External Pressure 500 Pa**		
	Duct Section Length 1.2 m (4 ft)		
Maximum Duct Size	**Gauge**	**Joint Type**	**Bracing Spacing**
1–400 mm	26	C&S Connector	Nil
401-700 mm	24	C&S Connector	Nil
701-900 mm	24	TDF Flange	Nil
901-1000 mm	22	TDF Flange	Nil
1001-1200 mm	22	TDF Flange	JTR or ZEE BAR
1201-2100 mm	20	TDF Flange	JTR or ZEE BAR
2101-above	18	TDF Flange	JTR or ZEE BAR

For ALUMINIUM Ducts with External SP upto 500 to 750 Pa (OTs areas with 3 stage filtration)

Maximum Duct Size	**Gauge**	**Joint Type**	**Bracing Spacing**
1 - 750 mm	22	(4 Bolt TDC (E))	Nil
751- 1000 mm	20	(4 Bolt TDC (H))	Nil
Plenum	(min) 16		

Note:- For aluminum ducts material shall be one commercial gauge higher with 22 g as minimum

All GI ducts shall be fabricated with minimum 24 gauge sheet
Ducts shall be fabricated as per SMACNA / BIS standards.

7.3. 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.

a) 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.

b) All edges to be machine treated using lock formers, flangers and rollers for turning up edges.

7.4. DUCT CONSTRUCTION

All ducts shall be fabricated and installed in workman like 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 slip and drive (C & S/SS) joints. The internal ends of slip joints shall be in the direction of airflow. Care should be taken to ensure that S/SS 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.

7.5. 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. All vertical ductwork shall be supported by structural members on each floor slab

d) 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.

e) 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.

f) 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.

g) Duct shall not rest on false ceiling and shall be in level from bottom. Taper pieces shall taper from top.

7.6. DAMPERS

a) Dampers: All duct dampers shall be opposed blade louver dampers of robust aluminum 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.

7.7 FIRE & SMOKE DAMPERS

a) All supply and return air ducts at AHU room crossings and at all floor crossings shall be provided with Motor operated Fire & smoke damper of atleast 90 minutes rating as per UL555/1995 tested by CBRI. These shall be of multi-leaf type and provided with Spring Return electrical actuator having its own thermal trip for ambient air temperature outside the duct and air temperature inside the duct. Actuator shall have Form fit type of mounting, metal enclosure and guaranteed long life span.

b) Fire damper blades and outer frames shall be of 16G galvanised steel construction fitted with 18 guage extended sleeves on both sides. The damper blade shall be pivoted on both ends using chrome plated spindles in self lubricated bronze bushes. Stop seals shall be provided on top and bottom of the damper housing made of 16G galvanised sheet steel. For preventing smoke leakage metallic compression seals will be provided.

c) The electric actuator shall be energized either upon receiving a signal from smoke detector installed in AHU room supply air duct / return air duct or temperature sensor. The fire damper shall also close upon sensing temperature rise in supply air ducts thru the electronic temperature sensor.

d) Each damper shall be provided with its own control panel, mounted on the wall and suitable for 240 VAC supply. This control panel shall be suitable for spring return actuator and shall have atleast the following features:

- Potential free contacts for AHU fan ON/ Off and remote alarm indication.
- Accept signal from external smoke / fire detection system for tripping the electrical actuator.
- Test and reset facility.
- Indicating lights / contacts to indicate the following status:
- Power Supply On
- Alarm
- Damper open and close position.

e) Actuators shall be mounted on the sleeve by the damper supplier in his shop and shall furnish test certificate for satisfactory operation of each Motor Operated Damper in conjunction with 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 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.

7.8 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.

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.

7.9 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 colour shall be provided in supply air duct collars. For fan coil units horizontal fixed bar grilles as described above shall be provided with flanges on four sides, and the core shall be & suitable for clip fixing, permitting its removal without disturbing the flanges.

a) All registers shall be selected in consultation with the Architect. Different spaces shall require horizontal or vertical face bars, and different width of margin frames. These shall be procured only after obtaining written approval from Architect for each type of register.

b) All registers shall have a soft continuous rubber/foam gasket between the periphery of the register and the surface on which it has to be mounted. The effective area of the registers for air flow shall not be less than 66 percent of gross face area.

c) Registers specified with individually adjustable bars shall have adjustable pattern as each grille bar shall be pivotable to provide pattern with 0 to +45 degree horizontal arc and upto 30 degree deflection downwards. Bars shall hold deflection settings under all conditions of velocity and pressure.

d) Bar longer than 45 cm shall be reinforced by set-back vertical members of approved thickness.

e) All volume control dampers shall be anodised aluminium in mat black shade.

7.10 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 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 aluminium construction anodised 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.

7.11 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 centerline 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.

7.12 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.

8. PRESSURE INDEPENDENT BALANCING CUM CONTROL VALVES

Each Air Handling Unit / Fan Coil Unit shall be provided with 2/3Way Pressure Independent Balancing Cum Control Valve with Integrated in a single Body with Globe Type in Construction.

Control - Valve should be equipped with electronic modulating actuator which can accept either 4(0)-20 mA / 2(0)-10 V DC signals. Operating voltage for actuator shall be 24V AC. Delta p controller should ensure 100% valve authority at all loads (part load Actuator shall be able to work against maximum closing pressure of 6 Bar at full load). With feedback signal to Control system. 230/24V transformer shall be included.

Balancing – Each Valve should have steeples adjustable maximum flow limitation as per the designed flow rate of coils. Balancing should be done only in Valve not in actuator so that at any given condition of failure balancing is not lost and easily accessible.

All Valve actuator shall be microprocessor based with self calibrating feature. Valve should be of inear control characteristics with stepless characteristics.

8.1 Valve Specifications

Discription	For 15 to 32 mm	For 40 to 150 mm
Diff Pressure (P1-P3)	16 To 400 kPa	20 To 400 kPa
Media Temperature	5 ° to 120 °C	5 ° to 120 °C
Ambient Temperature	10 ° to 54 °C	10 ° to 54 °C
Body Material	Brass (CuZn40Pb2 - CW 617N)	Grey iron EN-GJL-250(GG25)
Internal Components	316 Stainless Steel	316 Stainless Steel
Test Ports	Needle measuring nipple	Needle measuring nipple
Leakage acc. to standard IEC 534	max.0,01 - 0.05% of kv at 650N	max.0,01 - 0.05% of kv at 650N
Stem Seals	EPDM - CuZn40Pb2 - CW 617N	EPDM -NBR
Maximum Close Off Pr	600 kPaD	600 kPaD
Maximum Operational Pr	400 kPaD	400 kPaD
Control Range	Standard IEC 534 Since CV Characteristic is Linear Control Range is Infinity	
Control Valve Character	Linear Characteristic with the help of Actuator in equal Ratio Percentage	

8.2 Actuator Specifications for All Sizes

Supply Voltage **:** 24V AC (230/24 Transformer shall be included)
Power Consumption **:** 10V AC Max.
Frequency **:** 50 HZ
Control Input **:** 2-10V DC, 4-20mA, 3-point Selection.
Position Output **:** 2-10V DC 4-20mA
Body Housing Insulation **:** Non Corrosive **-** IP 42 Till DN 40 & IP 54 Till DN 50 To 150.

8.3 Valve Body and Characteristics:-

1. Pressure Controller Device should maintain the Pressure irrespective of Fluctuation with the help of Diaphragm self adjusting type and should not be in contact with each other.

2. Control valve shall accurately control the flow, with help of Modulating Actuator

3. All Valve Sizes should have a Testing Port Device for verifying accuracy of flow performance with respective of Differential Pressure.

4. Flow regulation unit shall consist of stainless steel Material 316.

8.4 Valve Actuator and Housing:-

5. The Valve + Actuator must have ability to undertake both Logarithmic Control Characteristics and Linear Control Characteristics. This shall ensures compatibility for both Water/Air and Water/Water Heat Exchange.

6. Valve Actuator housing shall made of non Corrosive (Aluminum) Material. Valve actuator housing shall be IP Protection (Weather Proof: Dust & Water Protected). Valve actuator housing shall be acceptable to IP 42 Till 40MM and above should be IP54.

7. Control/Dip Switch Setting should be easy to Manual Access to avoid Manual Contact to directly with Integrated IC Circuit of the system.

8. Actuator should not play a part in balancing process.

8.5 Valve Flow Balancing :

9. Balancing & Control : Balancing should be accomplished by the Diaphragm and Control should be taken care by Actuator receiving signals from Room Thermostats or BMS.

10. Manual Override Flow Balancing should only be done in Valve , not in actuator and should not involve opening of actuator Body.

- Flow Setting Balancing (Commissioning) for the Valves should be simple and fool proof.
- Should not involve opening of the actuator.
- Should not need compulsory involvement of high end technicians.
- Should avoid direct Manual Contact with Integrated Circuit (IC) of the actuators.

9. COLD WATER AND DRAIN PIPING

a. All pipes to be used for cold water (makeup), drain, condensate drain and fittings shall be galvanized steel class `B' (medium class) conforming to relevant BIS Codes.

b. All jointing in the pipe system shall be by screwed joints and/or by screwed flanges using 3 mm 3 ply rubber insertion gaskets. Pipe threads and flanges shall be as per relevant BIS Codes.

c. All pipes supports shall be mild steel, thoroughly cleaned and given one primary coat of red oxide paint before being installed.

d. Fittings shall be galvanized steel `medium class' malleable casting of pressure rating suitable for the piping system. Flanges shall be of approved make. Supply of flanges shall include bolts, nuts, gaskets as required. Sufficient number of flanges and unions shall be provided for future cleaning and servicing of piping. Tee-off connection shall be through equal or reducing tees. All equipment and valve connections, or connections to any other mating pipes shall be through flanges required for the mating connections. Fittings & flanges shall form part of piping and are not separately identified in Schedule of Quantities.

e. Gate valves, globe valves, check valves and strainers shall be similar to those specified for chilled, condensing and hot water piping.

f. For proper drainage of AHU Condensate, 'U' trap shall be provided in the drain piping.

f. All condensate drain piping shall be insulated and painted as per the section "Insulation" as indicated in Schedule of Quantities.

g. Automatic balancing valves shall automatically control flow rates with + 5% accuracy. Valve control mechanism shall consist of a stainless steel cartridge with a ported cup and coil / helical spring to avoid corrosion. Four operating ranges shall be available with the minimum range requiring less than 14 kPa to actuate the mechanism. Manufacturer shall provide independent laboratory tests verifying assurance of performance.

h. Pot Strainers body shall be fabricated out of MS plate IS 226. Thickness of sheet shall be as per size of the strainer chamfered pipes with flanges shall be provided at inlet /outlet connections of the strainer. The tangential entry of water shall create a centrifugal action and due to velocity shall separate sediments and deposit on the inner surface of Filter Element and at bottom of the Strainer. Butterfly valves shall be provided at inlet / outlet connections as shown in drawing and included in BOQ. The strainer body shall have two separate chambers properly sealed to avoid mixing of filtered and unfiltered water. A powerful magnet shall be provided in the body to arrest MS particles. Filter element of Pot Strainer shall be of non magnetic 18 gage SS sheet properly reinforced to avoid damage of the element. A cone with sufficiently large drain pipe with butterfly valve shall be provided at the bottom chamber to flush-out foreign particles. This arrangement shall avoid frequent opening of Pot Strainer for cleaning of filter element. Gage connection shall be provided at inlet and outlet connection.

i. Strainers shall be 'Y' type or Pot Strainer suitable for PN 16 rating as shown on drawings and included in BOQ. 'Y' Strainer shall be fabricated out of MS 'C' class pipe two sizes higher than that of Strainer pipe size. Flanges as per ANSI B16.5 (#150 class)shall be provided at inlet and outlet connectors. The body shall be hot dip galvanized. Permanent magnet shall be provided in the body of the Strainer to arrest MS particles. Filter element shall be of non magnetic 20 gage SS sheet with 3 mm perforation. Strainers shall be provided at in let of each Air Handling Unit and Pump as shown in drawings and included in BOQ.

10. INSULATION

10.1 SCOPE

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

10.2 MATERIAL

Elastomeric Nitrile Rubber

Insulation material for Duct & Pipe insulation shall be closed cell Elastomeric Nitrile Rubber. Thermal conductivity of the insulation material shall not exceed 0.036 W/m^{o}K or 0.208 BTU / (Hr-ft^2-^{o}F/inch) at an average temperature of 30°C. Density of the nitrile rubber shall be 40-60 Kg/m^3. The product shall have temperature range of –40 ^{o}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 perm inch (2.48 x 10^{-14} Kg/m.s.Pa i.e. µ>10000: Water vapour diffusion resistance). The material shall have approval from the Chief Fire Officer. Material shall also be FM global approved.

Thermal conductivity of the material shall not be affected by ageing, as per DIN 52615. The material must be tested for ageing effect in an accredited laboratory for a minimum period of five years to satisfy the ageing criteria.

The insulation shall comprise of a single layer up to 16 mm thickness.

The material shall be antimicrobial as per ASTM 2180 and ASTM G21-96. There shall be no growth of fungus and mould.

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, vapour proof adhensive strictly as per manufacturer's recommendations.

Ducting insulation thickness shall be as per table below.

Elastomeric Nitrile Rubber

Ducting position	**Thk. for non-coastal places**	**Thk. for coastal places**
SA duct in RA path	13mm	19mm
Ducted return air system	SA duct: 19mm RA duct: 13mm	SA duct: 25mm RA duct: 19mm
Both SA& RA exposed	Both 25mm	Both 25mm

10.3 DUCT ACOUSTIC LINING

Material shall be open cell anti microbial nitrile rubber with density of 140 to 180 Kg/m3.

Ducts so identified and marked on drawings and included in Schedule of Quantities shall be provided with acoustic lining of thermal insulation material for a distance of minimum 5 meters as follows:

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

It should have antimicrobial protection, and should pass Fungi Resistance as per ASTM G 21 and Bacterial Resistance as per ASTM E 2180. The insulation should pass Air Erosion Resistance Test in accordance to ASTM Standard C 1071-05 (section 12.7).

10.4 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 90^0 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 thin 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.The adhesive shall be strictly as recommended by the manufacturer.

10.5 PIPING INSULATION

All refrigerant, and condensate drain 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 mentioned schedule of quantity & as per manufacturer standard :

Insulating material on tube form shall be sleeved on the pipes. On piping, factory laminated (for Mechanical and UV protection) and factory slit opened tube shall be placed over the pipe and joint shall be made by removing the peel off paper. The lamination should be minimum 200 GSM and should not require any paint for UV/Mechanical protection. Butt joints and sealing shall be done by manufacturer recommended adhesive. Wherever flat sheets shall be used, it will again be factory laminated for UV and mechanical protection. it shall be cut out in correct dimension using correct tools. Scissors or Hacksaw-blade shall not be allowed. The adhesive shall be strictly as recommended by the manufacturer. The insulation shall be continuous over the entire run of piping, fittings and valves. All valves, fittings, joints, strainers etc

Manufacturer's installation manual shall be submitted and followed for full compliance. All insulation work shall be carried out by skilled workmen specially trained by manufacturer.

10.6 PROTECTIVE COATING OVER INSULATION

To provide mechanical strength and protection from damage all pipe / duct insulated with closed cell elastomeric nitrile rubber as indicated in BOQ shall be covered with fibreglass fabric of minimum thickness. Which will also provide UV protection.

In case of Cross Linked Polyethylene, it shall be provided with factory fitted aluminium foil, which will provide protection against mechanical damage as well as UV protection

10.7 SOUND ATTENUATORS

Material shall be engineered Nitrile Rubber open cell foam.The Random Incidence Sound Absorption Coefficient (RISAC); tested as per ISO 354, should be minimum as per enclosed chart

Freq (Hz)	125	250	500	1000	2000	4000	NRC
10 mm	0.03	0.04	0.14	0.04	0.88	1.00	0.35
15 mm	0.01	0.09	0.29	0.74	1.08	0.83	0.55
20 mm	0.04	0.13	0.4	0.9	1.04	0.90	0.60
25 mm	0.02	0.25	0.86	1.14	0.88	0.99	0.80

The material should be fibre free. The density of the same shall be within 140-180 Kg/m3. It should have Microban®*; antimicrobial product protection, and should pass Fungi Resistance as per ASTM G 21 and Bacterial Resistance as per ASTM E 2180. The material should have a thermal conductivity not exceeding 0.047 W/m.K @ 20 Deg. C .The material should withstand maximum surface temperature of +85 Deg C and minimum surface temperature of -20 Deg C. The material should conform to Class 1 rating for surface spread of Flame in accordance to BS 476 Part 7 & UL 94 (HBF, HF 1 & HF 2) in accordance to UL 94, 1996. The insulation should pass Air Erosion Resistance Test in accordance to ASTM Standard C 1071-05 (section 12.7).

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 as per manufacturer recommendation.

10.8 MEASUREMENT OF INSULATION

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

a. 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 described earlier. The linear measurements shall be taken before the application of the insulation. It may be noted that for piping measurement, all valves & fitting are separately measurable by their number and size.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 centre line of insulation thickness. Thus the surface area of externally thermally insulated or acoustically lined be based on the perimeter comprising centre line (of thickness of insulation) width and depth of the cross section of insulated or lined duct, multiplied by the centre-line length including tapered pieces, bends, tees, branches, etc. as measured for bare ducting.

11. HVAC Pipe & Duct Support

11.1 Steel Wire Rope Hangers& Supports:

Wire Hangers shall be used to suspend all static HVAC Air Distribution services.

Wire Hangers should consist of a pre-formed wire rope sling with a range of end fixings to fit various substrates and service fixings, these include a ferruled loop, permanently fixed threaded M6 (or M8, M10) stud, permanently fixed nipple end with toggle, at one end or hook or eyelet, cladding hook, barrel, wedge anchor, eyebolt anchor or any other end fixture type or size as per manufacturers recommendation and design. The end fixings and the wire must be of the same manufacturer with several options available. The system should be secured and tensioned with a Hanger self-locking grip (double channel lock)at the other end. Once the grip is locked for safety purpose unlocking should only be done by using a separate setting key and should not be an integral part of the self-locking grip.Only wire and/or supports supplied and/or approved, shall be used with the system.
c

a. Wire Hangersshould have been independently tested by Lloyds Register. APAVE, TUV, CSA, Chiltern International fire, ADCAS, Intertek, ECA, and SMACNA, approved by CSA and comply

with the requirements of DW/144 and BSRIA – wire Rope Suspension systems.Wire rope should be 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 (which incorporates a 5:1 safety factor).

The correct specification of wire hanger required is determined using the following formula.

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

Where the installed wire rope is not vertical then the working load limit shall be reduced in accordance with the recommendations give in the manufacturer's handbook.

The contractor shall select the correct length of wire rope required to support the service. Lengths from 1-10m lengths. Specials can be made, check with manufacturer. No in–line joints should be made in the rope.

Table. 1

Wire (Gripple) Hanger Safe Working Loads		
size	**minimum breaking load of Wire Rope**	**working load limit (kg/lbs)**
No. 1	80kg/176 lbs	0-10 kg / 0-22 lbs
No. 2	260kg/572 lbs	10-45 kg / 23-100 lbs
No. 3	580kg/1276 lbs	45-90 kg / 101-200 lbs
No. 4	1500kg/3300 lbs	90-225 kg / 210-495 lbs
No. 5	2160kg/4752 lbs	225-325 kg / 496-715 lbs
No. 6	2500kg/5500 lbs	325-500 kg / 715-1100 lbs

The standard range of Hanger Kits should contain galvanized high tensile steel wire rope or stainless steel wire rope as per the application, the minimum specification is as above and should be manufactured to BS 302 (1987), BSEN12385. **Comply with manufacturer's load ratings and recommended installation procedures.**Note the testing is done to the minimum breaking load of the wire thus giving a minimum safety factor of 5: 1.

11.2 DUCT Supports – Gripple Hanger Supports are suitable for: Rectangular duct, Spiral Duct, Oval Duct, Fabric Duct, Desertification fans, Air Conditioning Units, Plenum Boxes, Fan Coil Units, Diffusers.

11.2.1 Ducting Supports:

a) All ductwork shall be independently supported from building construction. All horizontal ducts shall be rigidly and securely supported, in an approved manner, with hangers formed of galvanized steel wire ropes and galvanized steel angle/channel or a pair of brackets, connected by galvanized steel wire hangers under ducts, rigid supports may be provided at certain interval if need be**.** The spacing between supports should be not greater than 2.4 meter. All vertical ductwork shall be supported by structural members on each floor slab. Duct supports may be through galvanized steel insert plates or Toggle end wire fixing left in slab at the time of slab casting. Galvanized steel cleat with a hole for passing the wire rope hanger

shall be welded to the plates. Trapeze hanger formed of galvanized steel wire rope using Gripple 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. Wire rope supports shall hang through the cleats or wire rope threaded studs can be screwed into the anchor fasteners. In case of PEB structure Loop and Catenary system can be used based on the site conditions as per approved suspension system drawings.

b) 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 (refer to typical drawings) under ducts at no greater than 3000mmcentre, for 3001mm-above appropriate size angle along with neoprene pad in between the duct & MS angleshould be used with prior approval. 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 wires shall then hang around the ducting.Rigid supports shall be used in conjunction with wire rope hangers to assist with alignment of services where recommended for by the manufacturer. Rigid support must also be used in conjunction with wire rope hangers with duct work at each change of direction or connectionor as per approved drawings. Support ducting in accordance with Schedule I at the end of this Section.Any other Gripple solution can be used based on manufacturer's recommendation on site conditions after prior approval. In cases of Spiral ducting the wire can be wrapped directly around the ducting without the need for a spiral ducting clamp for sizes above 1100 a cradle support should be provided, refer to manufacturer's recommendations.

c) 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. All supports of pipe shall be taken from structural slab/wall by means of fastener.

Catenary Supports: Refer to manufacturer's recommendations on Catenary supports with C-clip, special care should be taken with tensioning of the wire and angles at which the installation of services are made**.**

i. Stainless Steel Supports should be available for food, chemical and High Corrosion areas near coastlines.

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 - 750	26	1 or 2	1–600 mm	26	1 or 2
751-1000	26	2	601-750 mm	26	2
1001-1200	24	2 or 3	751-1000 mm	24	2 or 3
1201 - 1500	24	3	1001-1200 mm	22	3 or 4
1501 - 1800	22	3 or 4	1201-1300 mm	20	3 or 4
1801-2100	20	3 or 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 or 5
			2251-2400 mm	18	4 or 5
			2401-2700 mm	18	4 or 5

Notes:

a. **All supports are considered at 2400 mm interval in above table and may vary as per the design but should not be greater than 2400mm.**

b. **Desertification fans, Air Conditioning Units, Plenum Boxes, Fan Coil Units, Diffusers, Cassette units.**

All units shall be adequately secured and supported in an approved manner using wire hanger suspension Y fit solution as per manufacturers' recommendation with prior approval.

Rigid Supports:

Rigid supports if required in conjunction with wire hangers shall be of steel, adjustable for height and Zinc chromate primer coated and finish coated black. Where supports and clamps are of dissimilar materials, a gasket shall be provided in between. If the MS angle at the bottom if required as per design should be as per following table:

Longer size of Duct	Type of Joints
Up to 750	25x25x3 mm L angle with M8 nuts & bolts
751-1000	25x25x3 mm L angle with M8 nuts & bolts
1001-1500	40x40x5 mm L angle with M8 nuts & bolts
1501-2250	50x50x5 mm L angle with M10 nuts & bolts
2251 & above	50x50x6 mm L angle with M10 nuts & bolts

All the supporting system should be supplied from same manufacturer.

11.2 Steel Wire Rope Hangers& Supports:

Wire Hangers shall be used to suspend all static HVAC & Mechanical services.

Wire Hangers should consist of a pre-formed wire rope sling with a range of end fixings to fit various substrates and service fixings, these include a ferruled loop, permanently fixed threaded M6 (or M8, M10) stud, permanently fixed nipple end with toggle, at one end or hook or eyelet, cladding hook, barrel, wedge anchor, eyebolt anchor or any other end fixture type or size as per manufacturers recommendation and design. The end fixings and the wire must be of the same manufacturer with several options available. The system should be secured and tensioned with a Hanger self-locking grip (double channel lock) at the other end. Once the grip is locked for safety purpose unlocking should only be done by using a separate setting key and should not be an integral part of the self-locking grip.Only wire and/or supports supplied and/or approved, shall be used with the system.

c. Wire Hangers should have been independently tested by Lloyds Register. APAVE, TUV, CSA, Chiltern International fire, ADCAS, Intertek, ECA, and SMACNA, approved by CSA and comply with the requirements of DW/144 and BSRIA – wire Rope Suspension systems.Wire rope should be manufactured to BSEN 12385: 2002

d. 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 (which incorporates a 5:1 safety factor).

The correct specification of wire hanger required is determined using the following formula.

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

Where the installed wire rope is not vertical then the working load limit shall be reduced in accordance with the recommendations give in the manufacturer's handbook.

The contractor shall select the correct length of wire rope required to support the service. Lengths from 1-10m lengths. Specials can be made, check with manufacturer. No in–line joints should be made in the rope.

Table. 1

Wire (Gripple) Hanger Safe Working Loads		
size	**minimum breaking load of Wire Rope**	**working load limit (kg/lbs)**
No. 1	80kg/176 lbs	0-10 kg / 0-22 lbs
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No. 5	2160kg/4752 lbs	225-325 kg / 496-715 lbs
No. 6	2500kg/5500 lbs	325-500 kg / 715-1100 lbs

The standard range of Hanger Kits should contain galvanized high tensile steel wire rope or stainless steel wire rope as per the application, the minimum specification is as above and should be manufactured to BS 302 (1987), BSEN12385. **Comply with manufacturer's load ratings and recommended installation procedures.**Note the testing is done to the minimum breaking load of the wire thus giving a minimum safety factor of 5:1.

c. **Mechanical Supports – Gripple Hanger Supports are suitable for: Water Pipes, Drainage Pipes, Gas Pipes, Refrigeration Pipes, Condensation Water Pipes, Chill Beams, Heater, Ceiling Grid, Suspended Ceiling and Acoustic Baffle.**

i. **Piping Supports:** Rigid supports may be used in conjunction with Gripple hangers to assist with alignment of services as per the Schedule. These can be at 30m intervals or so depending on the run of the service. Rigid support must also be used in conjunction with Gripple hangers with pipework at each change of direction or connection or as per approved drawings. For insulated pipe, provide protective sleeve to protect the entire circumference of the pipe insulation. Stainless Steel Supports should be available for food, chemical and High Corrosion areas near coastlines.

ii. Any other Gripple solution can be used based on manufacturer's recommendation on site conditions after prior approval. Support piping in accordance with Schedule at the end of this Section.

iii. For insulated pipe, provide protective sleeve to protect the entire circumference of the pipe insulation. Stainless Steel Supports should be available for food, chemical and High Corrosion areas near coastlines.

iv. Refer to manufacturers catalogue and installation guide for further technical information.**Comply with manufacturer's load ratings and recommended installation procedures.All supporting system to be provided by same manufacturer.**

Pipe Hanger Schedule I:

Pipe Size	Weight of pipe + fluid	Weight of pipe + fluid per Rmt	Spacings (pipe + fluid+insulation)	Spacings (pipe + fluid+plaster)	Total Weight of pipe + fluid	Total Weight of pipe + fluid	Gripple Hanger No.	Gripple Hanger No.
(mm)	with insulation (kgs/rmts)	with sand cement plaster (kgs/rmts)	between supports (mts)	between supports (mts)	with insulation (kgs/rmts)	with sand cement plaster (kgs/rmts)	with insulation (kgs/rmts)	with sand cement plaster (kgs/rmts)
12-40	6.99	14	2	2	14	28	2	2
50-65	15.22	20	2	2	30	40	2	3
80	34.73	44.67	2	2	69	89.34	3	4
100-200	73	83	2	2	146	166	4	4
250 and above	Rigid supports to be used as per Pipe Hanger Schedule II							

Pipe Hanger Schedule II:

Rigid Supportsfor pipes to be used in conjunction with wire supports:

Rigid supports if required in conjunction with wire hangers shall be of steel, adjustable for height and Zinc chromate primer coated and finish coated black. Where supports and clamps are of dissimilar materials, a gasket shall be provided in between.

PIPE SIZE (mm)	PIPE SUPPORT
UP TO 50 Ø	40×40×6 M.S ANGLE
80Ø TO 100Ø	50×50×6 M.S ANGLE

PIPE SIZE (mm)	HORIZONTAL SUPPORT	VERTICAL SUPPORT
125Ø TO 200Ø	75×40 M.S CHANNEL	50×50×6 M.S ANGLE
250Ø TO 300Ø	100×50 M.S CHANNEL	75×40 M.S CHANNEL
300Ø TO 400Ø	150×75 M.S CHANNEL	100×50 M.S CHANNEL
450Ø TO 600Ø	200×75 M.S CHANNEL	200×75 M.S CHANNEL

12. ELECTRICAL INSTALLATION

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.

2 GENERAL

Work shall be carried out in accordance with the accompanying specifications and shall comply with the latest relevant Indian Standards and Electricity Rules and Regulations.

All motor control centres shall be CPRI approved and shall be suitable for operation on 3 phase/single phase 415/240 volts, 50 cycles power supply system.

3 CONSTRUCTIONAL FEATURES

The Motor Control Centre (MCC) electrical panels shall be sheet steel cabinet for indoor installation, dead front, floor mounting/wall mounting type. The control panel shall be totally enclosed, completely dust and vermin proof and shall be with hinged doors with Neoprene gasket. Control panel shall be suitable for the climatic conditions as specified in Specifications. Steel sheets used in the construction of Control panel 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 confirm to IS 8623 – 1977 (Part-1) for factory built assembled switchgear and control gear for voltage up to and including 1100 AC Supply.

All 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 Control panels. A base channel of 75 mm x 75 mm x 5 mm thick shall be provided at the bottom for floor mounted panels. Minimum clearance of 200 mm shall be provided between the floor of control panel and the lowest unit.

The control panel shall be of adequate size with a provision of 25% spare space to accommodate possible future breakers. Breakers 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.

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, Cables shall be sized by applying proper de-rating 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.

5 CIRCUIT COMPARTMENT

Each circuit breaker, contactor and relay 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.

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.

7 BUS BAR CONNECTIONS

Bus bar and interconnections shall be of high conductivity electrolytic copper and of rectangular cross section suitable for carrying the rated full load current and short circuit current without overheating of phase and neutral bus bar and shall be extendable on either side. Bus bar and interconnections shall be insulated with heat shrinkable sleeve and shall be colour coded and 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 bar shall be provided in a separate chamber and all connections shall be done by bolting. Additional cross sectional area shall be added to the bus bar to compensate for the holes. All connections between bus bar and breaker shall be through solid copper strips of proper size to carry full rated current as per approved for construction shop drawing and insulated with insulating sleeves. Bus bar shall be rated for current density of 1.28 amps/mm^2 cross section area.

8 TEMPERATURE - RISE LIMIT

Unless otherwise specified, in the case of external surface of enclosures of bus bar trunking system 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) 1998.

9 CABLE COMPARTMENTS

Cable compartment of adequate size shall be provided in the control 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.

10 AIR CIRCUIT BREAKERS (ACB)

Air Circuit Breakers shall be sheet metal enclosed 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 4 pole with modular construction, draw out, manually operated and shall be capable of providing short circuit, overload and earth fault protection through micro processor based control unit sensing the true RMS valve to ensure accurate measurement meeting the EMI/EMC requirement as per standard.

The circuit breakers shall be for continuous rating and service short Circuit Breaking capacity shall be as specified on the single line diagram and shall be equal to the short circuit withstand values.

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 and integral with the breaker. The ACB shall be provided with a door interlock. The contacts shall be of silver plated copper with a feature of contact wear inspection, indicating the life of the contacts. The ACB shall have double insulation (Class-II) with moving and fixed contacts totally enclosed for enhanced safety and inaccessibility to live parts.

11 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.

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.
Maintenance	:	Circuit breaker fully outside the panel ready for maintenance after the cubicle door is opened.

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

12 PROTECTIONS

a. The Microprocessor based release unit shall be provided on circuit breaker for short circuit, over current and earth fault protection with adjustable settings.

The release shall incorporate an 8-bit micro-computer 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 :

- Overload or long time protection.
- Short circuit or short time protection with intentional delay.
- Instantaneous protection with no intentional delay.
- Ground fault protection.
- 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. Available pick-up and time delay settings shall have flexibility for over two million different I-t characteristics to suit different applications.

d. Trip Indication

Electromechanical fault status indicators shall be provided to display the type of fault that caused a trip, without any auxiliary supply or battery, resulting in faster fault diagnosis and reduced system down time.

e. Test Facility

Test facility to test the operation of the release in different protection zones by simulating CT inputs externally through a testing kit.

f. Self powered

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

g. Tripping of the breaker

The release shall trip the breaker through a flux shift device which shall directly act on the breaker trip rod.

h. 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.

i. Rated insulation voltage shall be 1000 volts AC.

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.

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 heat generated in the contacts due to tripping under fault conditions shall be very nominal. All air circuit breakers shall be labelled.

13 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.

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. Arc Chute covers wherever necessary shall be provided.

V. 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 current transformers.

VI. 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.

14 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.

a) 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 (thermal for overload and 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

b) 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.

c) 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.

15 MINIATURE CIRCUIT BREAKER (MCB)

Miniature Circuit Breaker shall comply with relevant BIS Codes and shall be quick make and break type for 230/415 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.

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 and TPN miniature circuit breakers shall have a common trip bar independent to the external operating handle.

16 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.

17 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.

18 METERS

a) All voltmeters and indicating lamps shall be through MCB's.

b) Meters and indicating instruments shall be plug type.

c) All CT's connection for meters shall be through Test Terminal Block (TTB).

d) CT ratio and burdens shall be as specified on the Single line diagram.

19 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 secondaries for operation of associated metering.

The CTs shall confirm 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.

20 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.

21 STARTERS

Each motor shall be provided with a starter of suitable rating. Starters shall be in accordance with relevant IS Codes. All Star Delta and ATS Starters shall be fully automatic.

22 CONTACTOR

Contactor 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.

Starters 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.

23 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 element, positive acting ambient temperature compensated time lagged thermal over load relays with adjustable setting. Relays shall be directly connected for motors up to 35 HP capacity. C.T. operated relays shall be provided for motors above 35 HP capacity. Heater circuit contactors may not be provided with overload relays.

24 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.

25 INDICATING LAMP AND METERING

All meters and indicating lamps shall be in accordance with BS 37 and BS 39. The meters shall be flush mounted type. The indicating lamp shall be of low wattage . Each MCC and control panel shall be provided with voltmeter 0-500 volts with three way and off selector switch, CT operated ammeter of suitable range with three nos. CTS of suitable ratio with three way 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.

26 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.

27 PUSH BUTTON STATIONS

Push button stations shall be provided for manual starting and stopping of motors / equipment Green and Red colour 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.

28 CONDUITS

Conduits and Accessories shall conform to relevant Indian Standards. Wall thickness shall be 16 gauge up to 32 mm dia and 14 gauge above 32 mm dia conduit. Screwed G.I.conduits shall be used. Joints between conduits and accessories shall be securely made, to ensure earth continuity. All conduit accessories shall be threaded type only. All raw metal shall be painted with bitumastic paint.

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.

Maximum permissible number of 650/1100 volt grade PVC insulated wires that may be drawn into rigid non metallic or GI 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
25	--	--	2	4	6
35	--	--	--	3	5

29 CABLES

M.V. Cables shall be PVC insulated aluminium conductor and armoured cables conforming to IS Codes. Cables shall be armoured and suitable for laying 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.

30 CABLE LAYING

Cable shall be laid in accordance with IS code of Practice. Cables shall be laid on 14 gage factory fabricated perforated galvanized sheet steel cable trays, and cable drops / risers shall be fixed to ladder type cable trays factory fabricated out of galvanized steel angle. Access to all cables shall be provided to allow cable withdrawal / replacement in the future. Where more than one cable is running on a cable tray, one dia spacing shall be provided between cables to minimize the loss in current carrying capacity. Cables shall be suitably supported with Galvanized saddles when run on walls / trays. When buried, they shall be laid in 350 mm wide and 750 mm deep trench and shall be covered with 250 mm thick layer of soft sifted sand & protected with bricks/tiles. Special care shall be taken to ensure that the cables are not damaged at bends. The radius of bend of the cables when installed shall not be less than 12 times the diameter of cable.

31 WIRE AND WIRE SIZES

1100 volts grade PVC insulted copper conductor wires in conduit shall be used. For all single phase/ 3 phase wiring, 1100 volts grade PVC insulated copper conductor FRLS 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.	Up to 5 HP motors/ 5 KW heaters	3 x 4 sq. mm copper conductor wires.
ii.	From 6 HP to 10 HP motors 6 KW to 7.5 KW heaters	3 x 6 sq. mm copper 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.

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	Star Delta	25 amps	9-15 amps
12.5	HP Motors	Star Delta	16 amps	9-15 amps
15	HP Motors	Star Delta	25 amps	9-15 amps
20	HP Motors	Star Delta	32 amps	14-23 amps
25	HP Motors	Star Delta	32 amps	14-23 amps
30	HP Motors	Star Delta	40 amps	20-33 amps
35	HP Motors	Star Delta	40 amps	20-33 amps

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

32 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 up to 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.

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

i.	3 phase switches 60 amps rating.	2 nos. 3 mm dia copper and control panels up to 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 200 amps rating.	2 Nos. 6 mm dia copper panels 125 amps to wires.
iv.	3 phase switches, control 200 amps rating.	2 Nos. 3 mm x 25 mm panels, bus ducts, above copper tapes.

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.

33 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.

34 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 :

35 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.

36 MEASUREMENT OF ELECTRICAL CONTROL PANELS

Panels shall be counted as number of units. Quoted rates shall include as lumpsum (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.

37 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.

QUALITY ASSURANCE,INSPECTION, TESTING AND COMMISSIONING

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.

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 pre-commission and commissioning.

V. After commissioning, submit site test records, as-built drawings, manufacturer's operation maintenance manuals and list of recommended spares and tools.

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.

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 Programme

c. Organization Structure showing inter relationships.

d. Functional responsibilities and levels of authority.

e. Lines of communication.

f. Customer relations.

g. Laboratory Facilities.

5 WORKS QUALITY ASSURANCE PROGRAMME (WQAP)

I. The WQAP shall identify the Contractor's Quality Assurance Programme at works applicable throughout all phases of Contract performance, including design, procurement, manufacture, inspection and testing. It shall identify each of the programme 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.

6 FIELD QUALITY ASSURANCE PROGRAMME (FQAP)

I. This programme shall identify the Contractor's Quality Assurance Programme 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.

j. Pre-commissioning.

k. Commissioning.

l. Control of Non-conformances.

m. Corrective Action.

n. Control of Inspection, Measuring and Test Equipment.

p. Records.

q. Complétion Documents.

r. List of recommended spares and tools.

s. Personal Training.

t. Servicing during Defects Liability Period.

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 programmes.

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 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.

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.

10. TESTS AT MANUFACTURER'S WORKS

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 be held at the Contractor's of Sub-contractor's works). The subject items should remain available for Owner's site representative inspection and test up to a minimum 10 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.

II. 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.

III. 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 witnesses, or if necessary for any changes required to the proposed programme of tests to be agreed.

IV. 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 himself with the progress made and the quantity of the work to date.

V. 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.

VI. 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.

VII. 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 from complete with index and four copies of each volume shall be supplied to Consultant/ Owner's site representative.

VIII. Stage wise inspection of equipment in factory in waived.

11 PERFORMANCE TESTS AT MANUFACTURER'S WOKS

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. Pumps, fans, compressor, and other rotating equipment shall be given full load tests, and run to 15% over speed 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 Quality 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.

15. PAINTING AND FINISHES

1 SCOPE

The scope of this section comprises of colour scheme required for each piece of equipment

2 COLOUR SCHEME

Description	Standard Colour & Reference	Lettering Colouring
Exposed Duct Work (other than plant room) instruction	To Architect's	
Air Conditioning Duct Work (Plant Rooms)	BSS 111 Pale Blue	Black
Ventilation Duct Duct Work (Plant Rooms)	BSS 111 Pale Blue	Black
Conditioner Casings, Air Handling Units, Filter Plenums	BSS 111 Pale Blue	Black
Electrical (Conduit Ducts and Motors)	BSS 557 Light Orange	Black
Drains	Black	White
Vents	White	Black
Fans	BSS 111 Pale Blue	Black
Valves and Pipe Line Fittings	White with black handles	Black
Beltquards	Black and yellow diagonal stripes (45 25 mm wide)	
Switchboards - exterior - interior	BS 366 Light Beige White	
Machine Bases, Inertia Bases and Plinths	Charcoal Grey	

16. IDENTIFICATION OF SERVICES

1 SCOPE

The scope of this section comprises of identification of services for each piece of equipment

2 VALVE LABELS AND CHARTS

Each valve shall be provided with a label indicating the service being controlled, together with a reference number corresponding with that shown on the Valve Charts and " as fitted" drawings. The labels shall be made from 3 ply (black / white/ black) Traffolyte material showing white letters and figures on a black background. Labels to be tied to each valve with chromium plated linked chain.

A wall mounted, glass covered plan to the approval of the Architect / Engineer shall be provided and displayed in each plant room showing the plant layout with pipe work, valve diagram and valve schedule indicating size, service, duty, etc.

3 IDENTIFICATION OF SERVICES

Pipe work and duct work shall be identified by colour bands 150 mm. wide or colour triangles of at least 150 mm. / side. The bands of triangles shall be applied at termination points, junctions, entries and exits of plant rooms, walls and ducts, and control points to readily identify the service, but spacing shall not exceed 4.0 metres.

i. **Pipe work Services :-**

For pipe work services and its insulation the colours of the bands shall comply with BS. 1710: 1971.

Basic colours for pipe line identification :

Pipe Line Contents	**BS. 4800 Colour Reference**	**Colour.**
Oils	06 C 39	Brown
Gas	08 C 35	Yellow / Brown
Air	20 E 51	Blue
Drainage	00 E 53	Black
Electrical	06 E 51	Orange

Colour code indicator bands shall be applied as colour bands over the basic identification colour in the various combinations as listed below :-

Pipe Line Contents	Colour Bands to BS. 4800
Water Services :	
Cooling	00 E 55
Fresh / drinking	18 E 53
Boiler feed	04 D 45/00 E 55 / 04 D 45
Condensate	04 D 45/14 E 53 / 04 D 45
Hot Water Supply	00 E 55/04 D 45/00 E 55
Hydraulic Power	04 C 33
Sea / River Untreated	Basic Colour only
Fire Extinguishing	04 E 53

Oils:	
Diesel	00 E 55
Lubricating	14 E 53
Hydraulic Power	04 C 53
Transformer	04 D 45
Drainage and other fluids :	Basic Colour only
Electrical Services :	Basic Colour only

In addition to the colour bands specified above all pipe work shall be legibly marked with black or white letters to indicate the type of service and the direction of flow, identified as follows :-

High Temperature Hot Water	HTHW
Medium Temperature Hot Water	MTHW
Low Temperature Hot Water	LTHW
Condenser Water	CONDW
Steam	ST
Condensate	CN

Pipe shall have the letters F and R added to indicate flow and return respectively as well as directional arrows.

ii **Duct Work Services**

For Duct work services and its insulation the colours of the triangles shall comply with BS.1710 : 1971. The size of the symbol will depend on the size of the duct and the viewing distance but the minimum size should not be less than 150 mm. length per side. One apex of the triangle shall point in the direction of airflow.

Services	**Colour**	**BS.4800 Colour Reference**
Conditioned Air	Red and Blue	04 E 53 / 18 E 53
Ward Air	Yellow	10 E 53
Fresh Air	Green	14 E 53
Exhaust / Extract / Recirculated Air	Grey	AA 0 09
Foul Air	Brown	06 C 39
Dual Duct System Hot Supply Air	Red	04 E 53
Cold Supply Air	Blue	18 E 53

In addition to the colour triangles specified above all duct work shall be legibly marked with black or white letters to indicate the type of service, identified as follows:-

Supply Air	S
Return Air	R
Fresh Air	F
Exhaust Air	E

The colour banding and triangles shall be manufactured from self-adhesive cellulose tape, laminated with a layer of transparent ethyl cellulose tape.