Addendum No -1

Tender No : SRO/MKT/TH/523-13.09.2017

Name of the work: Construction of Research Block with Animal Research Facility and connected Infrastructure (Composite Contract)- for the work of “Supply and Installation of Water Chilling Plant-Pkg.4 B1

Title : Technical Specification -Section. D – HVAC works
SECTION. D – HVAC WORKS

DETAILS TO BE FILLED UP BY THE TENDERER BEFORE SUBMISSION OF TENDER

The following data shall be furnished along with the Tender:

Compressor

1. Manufacturer
2. Model
3. Overall dimensions
4. Size of foundation
5. Size of foundation
6. Refrigerant
7. Test pressure (Max) (Kgs. / sq.M.)
8. Maximum revolutions per minute
9. Minimum revolutions per minute for proper lubrication
10. Type of capacity control
11. No. of steps of capacity control
12. Capacity and bhp of the m/c at suction & condensing temperatures (Specify the temperatures)
13. Crank case heaters.
   i) Whether provided
   ii) Power rating (W)
14. Type of drive arrangement
15. No. Of belts in case of V- belt drive
16. Whether oil pump is provided
17. Type of oil pump.
18. IKW and BHP per ton @ 100%, 75%, 50% as per ARI 2000 –550-598 conditions as specified. And IPLV (Tender without this details will be rejected.)

Condenser/chiller

1. Manufacturer
2. Shell dia. (mm)
3. Type of fins in tubes
4. No. of passes
5. Water flow (L.P.M.)
6. Water velocity (MPSO)
7. Pressure Drop
8. Condensing Temperature
9. Tube material
10. Tube outside diameter (mm)
11. Tube thickness (mm)
12. Tube length (mm)
13. No. of Tubes
14. Tube surface, inside (sq.m)
15. Tube surface outside (sq.m)
16. Water temperature
   i) Entering (0C)
   ii) Leaving (0C)

Air handling units
a. Manufacturer
b. Type of fan
c. Fan speed (R.P.M.)
d. No. of fans.
e. Fan wheel diameter (mm)
f. Drive arrangement
g. No. of belts in case of belts drive
h. Material and thickness of fan wheel and blades.
i. Materials and thickness of housing.
j. Fan outlet area. (Sq. M)
k. Outlet velocity. (M.P.M.)
l. Total air quantity (Cfm./Min.)
m. Static pressure at outlet. (mm. of water)
n. Whether statically and dynamically balanced
o. Type of bear
p. B.H.P. Consumed
q. H.P. of the motor

**Cooling coil**

a. Manufacturer
d. Material of fins
d. Material of fins
e. Tube diameter
f. Tube thickness
g. Fin thickness
h. Method of boding of fins
i. No. of fins/cm.
j. No. of raw deep
k. Total tube surface outside (Sq.M)
l. Test pressure
m. Coil face area
n. Flow/Rate of water/Refrigerant (kgs/min or L.P.M.)
o. Volume of water/Refrigerant through tube (M.P.S.)
p. No. of circuits
q. Pressure drop in coil (Kgs/sq.cm or mm of water)

**Air filters**
a. Manufacturer
d. Type of filters
c. Filter medium
d. Material of frame work and its thickness (mm)
e. Face area (Sq.M)
f. Face velocity across filters
g. Pressure drop across filters (mm of water)

**Electric strip heaters**
a. Manufacturer
b. Type
c. Material of sheath
d. Power rating (KW)
e. Surface temperature of the element when tests in still air at 20 0C ambient.

**VENTILATION FANS**
a. Manufacturer
b. Type of fan
c. Fan speed (R.P.M.)
d. No. of fans.
e. Fan wheel diameter (mm)
f. Drive arrangement
g. No. of belts in case of belts drive
h. Material and thickness of fan wheel and blades.
i. Materials and thickness of housing.
j. Fan outlet area. (Sq. M)
k. Outlet velocity. (M.P.M.)
l. Total air quantity (Cfm./Min.)
m. Static pressure at outlet. (mm. of water )
n. Whether statically and dynamically balanced
o. Type of bear
p. B.H.P. Consumed
q. H.P. of the motor

**TREATED FRESH AIR FANS**

a. Manufacturer
b. Type of fan
c. Fan speed (R.P.M.)
d. No. of fans.
e. Fan wheel diameter (mm)
f. Drive arrangement
g. No. of belts in case of belts drive
h. Material and thickness of fan wheel and blades.
i. Materials and thickness of housing.
j. Fan outlet area. (Sq. M)
k. Outlet velocity. (M.P.M.)
l. Total air quantity (Cfm./Min.)
m. Static pressure at outlet. (mm. of water )
n. Whether statically and dynamically balanced
o. Type of bear
p. B.H.P. Consumed
q. H.P. of the motor

**Pumps**
a. Manufacturer
b. Type
c. Overall dimensions
d. Weight (Kgs)
e. Size of foundations (mm)
f. Material
i) Pumps casing

ii) impeller

iii) shaft

iv) shaft sleeve

v) base plate

g. Type of bearing

h. Type and material of steel

i. Speed (R.P.M.)

j. Head (Mtr)

K. Efficiency.

l. Performance curves (Whether enclosed with the tender)

**Chilled Water Piping**

a. Manufacturer

b. Overall dimensions

c. Thickness of pipe

d. Thickness of insulation

e. Thickness of jacket

f. Material - pipe

g. Material – insulation

h. Material – Jacket

i. Density of insulation

**Condenser Water Piping**

a. Manufacturer

b. Overall dimensions

c. Thickness of pipe

d. Material - pipe

**Electrical motors (give separate particulars for each application)**

a. Manufacturer

b. Type and frame references

c. Rated output (KW)
d. Range of working voltage (V)
e. Rated frequency
f. Full load current (Amps)
g. Rated speed (RPM)
h. Class of insulation
i. Efficiency and power factor at the following loadings 100%, 75%, 50%, 20%, of rated full load.
j. Type of bearings

Motor starters (give separate particulars for each application)
a. Manufacturer
b. Type and frame references
c. Rating
d. Whether the following protections are provided
i) Overload
   ii) Under voltage
   iii) single phase protection (for three phase motor starters)
Switch board
a. Manufacturer
b. Type
c. Rated normal current (amps)
d. short circuit rating (MVA)
e. Whether the following are provided
   i) O/L trip
   ii) E/F trip
   iii) Under voltage trip
f. Iron clad switch gears
g. Make of H.R.C./MCCB/ MCB fuse provided

Controls
a. Make and type of thermostats.
b. Make and type of humidistats.
c. Make and type of damper motor.
d. Make and type of other control components.
e. Make and type of expansion valve.
f. Make and type of solenoid valve.
g. Make and type of two way mixing valve.
h. Make and type of motorized valve.
i. Make and type of solenoid valve.
j. Make and type of butterfly valves.
k. Make and type of balancing valves.
l. Make and type of suction guide.
m. Make and type of pressure gauge.
n. Make and type of dial thermometer
o. Make and type of differential pressure switch
p. make & type of air vent
q. make & type of flexible connector

Pressurization system
a. Manufacturer
b. Type
c. Overall dimensions
d. Weight (Kgs)
e. Size of foundations (mm)
f. Tank size
g. Motor details –
h. Controls details –
i. Power supply details -

**Ducting**

a. Material
b. Manufacturer
c. Whether ducting is as per I.S. 655

**Grills & diffuser**

a. Material
b. Manufacturer

**Fire damper**

a. Material
b. Manufacturer

**Insulation (for each application)**

a. Manufacturer.
b. Material and density
c. ‘K’ Value at 10 (C°) mean temperature
d. Thickness.

**SPLIT UNITS**

a. Manufacturer
b. Length (mm)
c. Width (mm)
d. Height (mm)
e. Weight (kg)
f. Nominal capacity
g. Actual capacity at selected discharge and suction temp.
h. No. of Refrigeration circuits.
The scope of work is to provide air-conditioning system for the Research Block.

As given below in the building complex details and basis of design the total air-conditioning requirements considered for various floor works out to 421 TR. Provision is made for 3 X 150 TR Water cooled chiller considering 90% diversity with one chiller 50% stand by.

The details of connected items are more described in the schedule of equipments.

**Brief of Equipment Schedule**

<table>
<thead>
<tr>
<th>ITEM</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHILLER</td>
<td>3 X 150 TR water cooled chiller</td>
</tr>
<tr>
<td>CHILLED WATER PRIMARY PUMPS</td>
<td>4 Nos.</td>
</tr>
<tr>
<td>CHILLED WATER SECONDARY PUMPS</td>
<td>4 Nos.</td>
</tr>
<tr>
<td>CHILLED WATER CONDENSER PUMPS</td>
<td>4 Nos.</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>3 Nos.</td>
</tr>
<tr>
<td>AHU</td>
<td>Lot</td>
</tr>
<tr>
<td>CHILLED WATER PIPING</td>
<td>Lot</td>
</tr>
<tr>
<td>CONDENSER WATER PIPING</td>
<td>Lot</td>
</tr>
<tr>
<td>SHEET METAL WORK</td>
<td>Lot</td>
</tr>
<tr>
<td>VENTILATION SYSTEM</td>
<td>For toilets, equipment rooms etc.</td>
</tr>
<tr>
<td>ELECTRICAL</td>
<td>Lot</td>
</tr>
</tbody>
</table>
Technical data:

Tenderers are required to submit technical data documents as per the format. The data proposal sheets are enclosed. The tenderer shall fill in all the data required.

### BASIS OF DESIGN

The complete air conditioning system has been designed taking into account the following parameters.

**PROJECT** - RGCB - RESEARCH BLOCK

<table>
<thead>
<tr>
<th>Basis Parameter</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside design condition</td>
<td>35 °C DB, 27.77 °C WB</td>
</tr>
<tr>
<td>Inside design condition</td>
<td>22 °C +/- 1.1 °C, RH 55 +/- 5%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No</th>
<th>AREA DESCRIPTION</th>
<th>AREA SQ.FT</th>
<th>OCCUPANCY</th>
<th>NO. OF AIR CH.</th>
<th>Equipment load/Temp/Humidity</th>
<th>TR</th>
<th>Work Time</th>
<th>AIR QTY</th>
<th>UNIT PROPOSED</th>
<th>Fresh air CFM</th>
<th>SHAFT FT Left side</th>
<th>SHAFT RIGHT side</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BMS Room</td>
<td>200</td>
<td>2</td>
<td>5 cfm/person+ 0.06 cfm/sq.</td>
<td>1.5 TR</td>
<td>1.5 TR FCU</td>
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<td></td>
<td></td>
<td>1.5 TR</td>
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<tr>
<td></td>
<td><strong>Total AC Area</strong></td>
<td><strong>200 Sq.ft.</strong></td>
<td><strong>Total Tonnage</strong></td>
<td><strong>1.5 TR</strong></td>
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</tbody>
</table>

### LOWER BASEMENT FLOOR

1. **Zone 1 - Administration**
   - 1470 SQ.FT
   - 20 OCCUPANCY
   - 10 cfm/person+ 0.18 cfm/sq., 1 Air change
   - 3 KW (Lab load, PC Load)
   - 9.0 TR
   - 3600 UNIT PROPOSED
   - 321 cfm Fresh air CFM

2. **Zone 2 - Clean Corridor & Sterile Area**
   - 1495 SQ.FT
   - 3 OCCUPANCY
   - 10 cfm/person+ 0.18 cfm/sq., Room air changes 12-15,
   - 3 KW Equipment load (15% of heat dissipation of auto-clave heater load, 20°C-23°C),
   - 50% RH, 70% Recirculation & 30% Exhaust,
   - Highest positive pressure
   - 16 TR
   - 24 Hrs
   - 4100 UNIT PROPOSED
   - 1,308 cfm Fresh air CFM
<p>| Zone 3 | Animal Rooms &amp; Procedure Rooms | 1355 | 7 | Total number of Rats = 360 x 7 rooms = 2520 Nos @ 28 Kcal/Day, Room air changes 12-15, 2 KW Equipment load, 20°C-23°C, 50% RH, 70% Recirculation &amp; 30% Exhaust, Pressure less than Zone 2 | 16 TR 24 Hrs 2200 1,185 cfm |
| Zone 4 | Cleaning Area | 1670 | 3 | 10 cfm/person + 0.18 cfm/sq, Room air changes 12-15, 2 KW Equipment load, 20°C-23°C, 50% RH, 70% Recirculation &amp; 30% Exhaust, Pressure less than Zone 3 | 22 TR 24 Hrs 5600 1,461 cfm |
| Zone 5 | Contaminated - BSL 3 Level room | 360 | 2 | Total number of Rats = 180 x 2 rooms = 360 Nos @ 28 Kcal/Day, Room air changes 12-15, 3 KW Equipment load, 20°C-23°C, 50% RH, 100% Exhaust, Negative Pressure, 1 No. Bio safety cabinet, 2 Nos. changing room, Laminar Flow system | 12 TR 24 Hrs 1300 1,181 cfm |
| Lobby -03 | | 440 | 10 | 7.5 cfm/person + 0.12 cfm/sq, | 3 TR 1200 3 TR Cassette |
| Conference | | 440 | 16 | 7.5 cfm/person + 0.12 cfm/sq | 4 TR 1600 4 TR Cassette |
| Total AC Area = 7,230 Sq.ft. Total Tonnage = 80.0 TR | | | | 5,456 cfm 0 cfm |
| 1 | Central instrumention Facilities | 1470 | 15 | 10 cfm/person+ 0.18 cfm/sq, 2 Air change | 5 KW Assumed considering 10% to 20% Heat dissipation | 10.0 TR | 24 Hrs | 4000 | 10 TR Double skin floor mounte d AHU with Mixing Box, Fine filter | 643 cfm |
| 2 | Library | 1455 | 25 | 7.5 cfm/person+ 0.12 cfm/sq. | 10.0 TR | 4000 | 318 cfm |
| 3 | Lecture Hall | 1400 | 100 | 7.5 cfm/person+ 0.06 cfm/sq. Ft | 14.0 TR | 5600 | 584 cfm |
| 4 | Bio Informatics / Computer centre | 850 | 25 | 10 cfm/person+ 0.12 cfm/sq. Ft, 2 Air change | 5 KW Assumed considering 10% to 20% Heat dissipation &amp; PC Loads | 8.0 TR | 24 Hrs | 3200 | 8 TR Double skin ceiling suspend ed AHU with Mixing Box | 372 cfm |
| 5 | Admin &amp; Office | 850 | 25 | 5 cfm/person+ 0.06 cfm/sq. Ft | 3 KW Equ. Load considering PC Load | 7.0 TR | 2800 | 186 cfm |
| 6 | Corridor | 940 | 10 | 5 cfm/person+ 0.06 cfm/sq. Ft | 6.0 TR | 2400 | 206 cfm |
| 7 | Lobby -03 | 440 | 10 | 7.5 cfm/person+ 0.12 cfm/sq. | 3.0 TR | 1200 | 3 TR Cassette |
| 8 | Conference | 440 | 16 | 7.5 cfm/person+ | 4.0 TR | 1600 | 2 x 2 TR Cassette |</p>
<table>
<thead>
<tr>
<th></th>
<th>Tissue Culture -1</th>
<th></th>
<th>Tissue Culture -2</th>
<th></th>
<th>Tissue Culture -3</th>
<th></th>
<th>Tissue Culture -4</th>
<th></th>
<th>Staff Room</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0.12 cfm/sq.</td>
<td></td>
<td>7,845 Sq.ft.</td>
<td>Total Tonnage</td>
<td>1.333 cfm</td>
<td>975 cfm</td>
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<tr>
<td>10 cfm/person</td>
<td>200</td>
<td>4</td>
<td>200</td>
<td>4</td>
<td>200</td>
<td>4</td>
<td>200</td>
<td>4</td>
<td>115</td>
<td>3</td>
</tr>
</tbody>
</table>
| 0.18 cfm/sq. |                  | 3 | 0.18 cfm/sq.    | 3 | 0.18 cfm/sq.    | 3 | 0.18 cfm/sq.    | 3 | 0.06 cfm/sq.| 0.06 cfm/sq.
<p>| 24 Hrs, 23°C at Day time &amp; 28°C at Night | 1400 | 1 TR Double skin ceiling suspend ed AHU with fine filter, 1.5KW Heater | 1400 | 1 TR Double skin ceiling suspend ed AHU with fine filter, 1.5KW Heater | 1400 | 1 TR Double skin ceiling suspend ed AHU with fine filter, 1.5KW Heater | 1400 | 1 TR Cassette | 1 TR Cassette | 75 cfm |</p>
<table>
<thead>
<tr>
<th>6</th>
<th>Dark Room</th>
<th>115</th>
<th>3</th>
<th>5 cfm/person + 0.06 cfm/sq. Ft</th>
<th>1.0 TR</th>
<th>24 Hrs</th>
<th>400</th>
<th>1 TR Cassette</th>
<th>75 cfm</th>
</tr>
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<tbody>
<tr>
<td>7</td>
<td>Bacterial Hood</td>
<td>200</td>
<td>4</td>
<td>10 cfm/person + 0.18 cfm/sq., 2 Air change</td>
<td>3.5 TR</td>
<td>24 Hrs, 23 °C at Day time &amp; 28°C at Night</td>
<td>1400</td>
<td>3.5 TR Cassette</td>
<td>87 cfm</td>
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<tr>
<td>8</td>
<td>Common Instrumentation</td>
<td>355</td>
<td>3</td>
<td>10 cfm/person + 0.18 cfm/sq., 3 Air change</td>
<td>4.0 TR</td>
<td>24 Hrs, 23 °C at Day time &amp; 28°C at Night</td>
<td>1600</td>
<td>2 x 2 TR Cassette</td>
<td>233 cfm</td>
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<td>9</td>
<td>Office / Scientist cabin 1</td>
<td>110</td>
<td>2</td>
<td>5 cfm/person + 0.06 cfm/sq. Ft</td>
<td>1.0 TR</td>
<td>24 Hrs</td>
<td>400</td>
<td>1 TR Cassette</td>
<td>24 cfm</td>
</tr>
<tr>
<td>10</td>
<td>Office / Scientist cabin 2</td>
<td>110</td>
<td>2</td>
<td>5 cfm/person + 0.06 cfm/sq. Ft</td>
<td>1.0 TR</td>
<td>24 Hrs</td>
<td>400</td>
<td>1 TR Cassette</td>
<td>24 cfm</td>
</tr>
<tr>
<td>11</td>
<td>Office / Scientist cabin 3</td>
<td>110</td>
<td>2</td>
<td>5 cfm/person + 0.06 cfm/sq. Ft</td>
<td>1.0 TR</td>
<td>24 Hrs</td>
<td>400</td>
<td>1 TR Cassette</td>
<td>24 cfm</td>
</tr>
<tr>
<td>12</td>
<td>Office / Scientist cabin 4</td>
<td>110</td>
<td>2</td>
<td>5 cfm/person + 0.06 cfm/sq. Ft</td>
<td>1.0 TR</td>
<td>24 Hrs</td>
<td>400</td>
<td>1 TR Cassette</td>
<td>24 cfm</td>
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<tr>
<td>13</td>
<td>Common Lab</td>
<td>4270</td>
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<td>10 cfm/person + 0.18 cfm/sq., 2 Air change</td>
<td>15 KW Assumed considering 10% to 20% Heat dissipation</td>
<td>32.0 TR</td>
<td>24 Hrs, 23 °C at Day time &amp; 28°C</td>
<td>12800</td>
<td>2 x 25 TR Double skin Floor mounted AHU with 934 cfm</td>
</tr>
<tr>
<td>Room Type</td>
<td>AC Area</td>
<td>Total Tonnage</td>
<td>AC Area</td>
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<tr>
<td>Lobby -09</td>
<td>540</td>
<td>1600</td>
<td>7,205</td>
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<tr>
<td>Meeting room</td>
<td>215</td>
<td>800</td>
<td>4 TR</td>
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<tr>
<td>General Managers Room</td>
<td>155</td>
<td>480</td>
<td>1.5 TR</td>
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<tr>
<td><strong>Total AC Area</strong></td>
<td>7,205</td>
<td><strong>Total Tonnage</strong></td>
<td>66.7 TR</td>
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<td><strong>FIRST FLOOR</strong></td>
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<tr>
<td>Tissue Culture -1</td>
<td>200</td>
<td>1400</td>
<td>4 TR</td>
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</tr>
<tr>
<td>4</td>
<td>Tissue Culture -4</td>
<td>200</td>
<td>4</td>
<td>10 cfm/person + 0.18 cfm/sq. ft</td>
<td>3 Air change</td>
<td>2.5 KW Assumed considering 10% to 20% Heat dissipation</td>
<td>3.5 TR</td>
<td>24 Hrs, 23°C at Day time &amp; 28°C at Night</td>
<td>1400 4 TR Double skin ceiling suspended AHU with fine filter, 1.5KW Heater</td>
</tr>
<tr>
<td>5</td>
<td>Staff Room</td>
<td>115</td>
<td>3</td>
<td>5 cfm/person + 0.06 cfm/sq. ft</td>
<td>1.0 TR</td>
<td>24 Hrs</td>
<td>400 1 TR Cassette</td>
<td>75 cfm</td>
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</tr>
<tr>
<td>6</td>
<td>Dark Room</td>
<td>115</td>
<td>3</td>
<td>5 cfm/person + 0.06 cfm/sq. ft</td>
<td>1.0 TR</td>
<td>24 Hrs</td>
<td>400 1 TR Cassette</td>
<td>75 cfm</td>
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</tr>
<tr>
<td>7</td>
<td>Bacterial Hood</td>
<td>200</td>
<td>4</td>
<td>10 cfm/person + 0.18 cfm/sq. ft</td>
<td>2 Air change</td>
<td>3.5 TR</td>
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<td>3 Air change</td>
<td>4.0 TR</td>
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<td>Hrs</td>
<td>Tonnage</td>
<td>Cassette</td>
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**TYPICAL FLOOR (SECOND & THIRD FLOOR)**

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<th>CFM/person</th>
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<th>TR</th>
<th>Hrs</th>
<th>Tonnage</th>
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<td>Heat Dissipation</td>
<td>Air Change</td>
<td>TR</td>
<td>Hrs</td>
<td>Heater</td>
<td>Filter</td>
<td>Notes</td>
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<td>23°C at Day time &amp; 28°C at Night</td>
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<td>4 TR Double skin ceiling suspended AHU with fine filter, 1.5 KW Heater</td>
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<td>3.5 TR Cassette</td>
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<td>10 cfm/person + 0.18 cfm/sq. ft, 3 Air change</td>
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<td>24 cfm</td>
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<td>2</td>
<td>5 cfm/PERSON + 0.06 cfm/sq. Ft</td>
<td>1.0 TR</td>
<td>24 Hrs</td>
<td>400</td>
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<td>24 cfm</td>
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<td>5 cfm/PERSON + 0.06 cfm/sq. Ft</td>
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<td>Common Lab</td>
<td>4270</td>
<td>40</td>
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<td>15 KW Assumed considering 10% to 20% Heat dissipation</td>
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<td>CFM/Person</td>
<td>CFM/Sq. Ft</td>
<td>TR</td>
<td>Tonnage</td>
<td>Unit Proposed</td>
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<td>Total AC Area</td>
<td>7,205 Sq.ft.</td>
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<td>3 x 150 TR Water cooled screw chiller (1 chiller 50% stand by)</td>
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<td>Floor</td>
<td>Supply CFM</td>
<td>Return CFM</td>
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<td>1</td>
<td>Animal Research Facility - Upper Basement floor</td>
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<td>3,729 Cfm</td>
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<td>Return CFM</td>
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<td>Ground floor</td>
<td>1,697 Cfm</td>
<td>1,527 Cfm</td>
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<td>First floor</td>
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<tr>
<td><strong>Third Floor</strong></td>
<td>1,697 Cfm</td>
<td>1,527 Cfm</td>
<td><strong>HEAT RECOVERY WHEEL</strong> 8,120 Cfm 7,308 Cfm</td>
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<tr>
<td>Ground floor</td>
<td>1,263 Cfm</td>
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<td>First floor</td>
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<td>1,137 Cfm</td>
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<tr>
<td>Second floor</td>
<td>1,263 Cfm</td>
<td>1,137 Cfm</td>
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<tr>
<td><strong>HEAT RECOVERY WHEEL</strong></td>
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<td>5,424 Cfm</td>
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**VENTILATION SYSTEMS**

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<th>DESCRIPTION</th>
<th>AREA SQ.FT</th>
<th>AIR CHANGE</th>
<th>UNIT PROPOSED</th>
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<td>1</td>
<td>PHE &amp; Fire plant room</td>
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<td>15 A C</td>
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<td>2 X 2250 Cfm Exhaust Blower</td>
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<td>2 X 2250 Cfm Exhaust Blower</td>
</tr>
<tr>
<td><strong>UPPER BASEMENT FLOOR</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Dirty Wash</td>
<td>60.0 Sq.m.</td>
<td>20 A C</td>
<td>2,000 cfm Exhaust Blower</td>
</tr>
<tr>
<td>2</td>
<td>Toilet near lobby 1</td>
<td>2.5 Sq.m.</td>
<td>15 A C</td>
<td>80 cfm Exhaust Blower</td>
</tr>
<tr>
<td>3</td>
<td>Main Toilet</td>
<td>30.0 Sq.m.</td>
<td>15 A C</td>
<td>800 cfm Exhaust Blower</td>
</tr>
<tr>
<td><strong>BASEMENT FLOOR</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Toilet near lobby 1</td>
<td>2.5 Sq.m.</td>
<td>15 A C</td>
<td>80 cfm Exhaust Blower</td>
</tr>
<tr>
<td>2</td>
<td>Main Toilet</td>
<td>30.0 Sq.m.</td>
<td>15 A C</td>
<td>800 cfm Exhaust Blower</td>
</tr>
<tr>
<td><strong>GROUND FLOOR</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Toilet near lobby 1</td>
<td>2.5 Sq.m.</td>
<td>15 A C</td>
<td>80 cfm Exhaust Blower</td>
</tr>
<tr>
<td>2</td>
<td>Main Toilet</td>
<td>30.0 Sq.m.</td>
<td>15 A C</td>
<td>800 cfm Exhaust Blower</td>
</tr>
<tr>
<td>3</td>
<td>Non ac area 01</td>
<td>49.0 Sq.m.</td>
<td>20 A C</td>
<td>1,750 cfm Exhaust Blower</td>
</tr>
<tr>
<td><strong>FIRST FLOOR</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Toilet near lobby 1</td>
<td>2.5 Sq.m.</td>
<td>15 A C</td>
<td>80 cfm Exhaust Blower</td>
</tr>
<tr>
<td>2</td>
<td>Main Toilet</td>
<td>30.0 Sq.m.</td>
<td>15 A C</td>
<td>800 cfm Exhaust Blower</td>
</tr>
<tr>
<td>3</td>
<td>Non ac area 01</td>
<td>49.0 Sq.m.</td>
<td>20 A C</td>
<td>1,750 cfm Exhaust Blower</td>
</tr>
<tr>
<td><strong>SECOND FLOOR</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Toilet near lobby 1</td>
<td>2.5 Sq.m.</td>
<td>15 A C</td>
<td>80 cfm Exhaust Blower</td>
</tr>
<tr>
<td>2</td>
<td>Main Toilet</td>
<td>30.0 Sq.m.</td>
<td>15 A C</td>
<td>800 cfm Exhaust Blower</td>
</tr>
<tr>
<td>3</td>
<td>Non ac area 01</td>
<td>49.0 Sq.m.</td>
<td>20 A C</td>
<td>1,750 cfm Exhaust Blower</td>
</tr>
<tr>
<td>Floor Level</td>
<td>Area Description</td>
<td>Area (Sq.m)</td>
<td>Air Conditioning</td>
<td>Exhaust Blower</td>
</tr>
<tr>
<td>-------------</td>
<td>------------------------</td>
<td>-------------</td>
<td>------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>THIRD FLOOR</td>
<td>Toilet near lobby 1</td>
<td>2.5</td>
<td>15 A C</td>
<td>80 cfm</td>
</tr>
<tr>
<td></td>
<td>Main Toilet</td>
<td>30.0</td>
<td>15 A C</td>
<td>800 cfm</td>
</tr>
<tr>
<td></td>
<td>Non ac area 01</td>
<td>49.0</td>
<td>20 A C</td>
<td>1,750 cfm</td>
</tr>
<tr>
<td>TERRACE FLOOR</td>
<td>Toilet near Lunch room</td>
<td>2.5</td>
<td>15 A C</td>
<td>80 cfm</td>
</tr>
</tbody>
</table>
EQUIPMENT SCHEDULE

1 - SCREW WATER CHILLING PACKAGES

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity (in TR)</td>
<td>as per schedule of quantities</td>
</tr>
<tr>
<td>Type of Compressor</td>
<td>Screw</td>
</tr>
<tr>
<td>Capacity control</td>
<td>100% to 20%</td>
</tr>
<tr>
<td><strong>EVAPORATOR</strong></td>
<td></td>
</tr>
<tr>
<td>Ent. Water temp.</td>
<td>55 Deg F</td>
</tr>
<tr>
<td>Leaving water temp</td>
<td>45 Deg F</td>
</tr>
<tr>
<td>Chilled water flow rate</td>
<td>2.4 Usgpm/TR</td>
</tr>
<tr>
<td>Pressure drops</td>
<td>Max. 10 mtr.</td>
</tr>
<tr>
<td>Fouling factor</td>
<td>0.0001 ARI standards 550/590-98</td>
</tr>
<tr>
<td><strong>CONDENSER</strong></td>
<td></td>
</tr>
<tr>
<td>Ent. Water temp.</td>
<td>90 Deg F</td>
</tr>
<tr>
<td>Leaving water temp</td>
<td>97.5 Deg F</td>
</tr>
<tr>
<td>Condenser water flow. Rate</td>
<td>4 Usgpm/TR</td>
</tr>
<tr>
<td>Pressures drop</td>
<td>Max. 10 mtr.</td>
</tr>
<tr>
<td>Fouling factor</td>
<td>0.00025 ARI standards 550/590</td>
</tr>
<tr>
<td><strong>ELECTRICAL</strong></td>
<td></td>
</tr>
<tr>
<td>Motor output rating</td>
<td>As per supplier's specifications</td>
</tr>
<tr>
<td>Motor input rating</td>
<td>-Do-</td>
</tr>
<tr>
<td>Starting method (soft starting)</td>
<td>-Do-</td>
</tr>
<tr>
<td>Starting current</td>
<td>-Do-</td>
</tr>
<tr>
<td>System parameters</td>
<td>-Do-</td>
</tr>
<tr>
<td><strong>MISCELLANEOUS</strong></td>
<td></td>
</tr>
<tr>
<td>Control Panel</td>
<td>Microprocessor control panel</td>
</tr>
<tr>
<td>Safety devices</td>
<td>-Do-</td>
</tr>
<tr>
<td>Meters/Instruments</td>
<td>Microprocessor Control Panel</td>
</tr>
<tr>
<td>First charge refg./oil</td>
<td>-YES-</td>
</tr>
<tr>
<td>Refrigerant piping &amp; Valves</td>
<td>-YES-</td>
</tr>
<tr>
<td>Mounting frame/base frame/Skid base</td>
<td>-YES-</td>
</tr>
<tr>
<td>Anti-vibration device</td>
<td>-YES-</td>
</tr>
<tr>
<td>Pressure gauges</td>
<td>-YES-</td>
</tr>
</tbody>
</table>
### Differential Flow switches
- At inlet of condenser/chiller

### Thermometers
- At inlet and outlet of Condenser/chiller

---

#### 2 - CONDENSER WATER PUMPSETS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>as per schedule of quantities</td>
</tr>
<tr>
<td>Capacity</td>
<td>[4 Usgpm/ TR]</td>
</tr>
<tr>
<td>Net optg. head</td>
<td>as per schedule of quantities</td>
</tr>
<tr>
<td>Speed</td>
<td>as per schedule of quantities</td>
</tr>
<tr>
<td>Motor rating</td>
<td>As per drawing</td>
</tr>
<tr>
<td>Type of motor</td>
<td>TEFC sq. cage induction motor</td>
</tr>
<tr>
<td>Type of starter</td>
<td>Fully automatic star/delta with single phasing prevention</td>
</tr>
<tr>
<td>Accessories</td>
<td>Common base frame Anti-vibration pads</td>
</tr>
<tr>
<td>Special feature</td>
<td>Bronze impeller</td>
</tr>
</tbody>
</table>

---

#### 3 - CHILLED WATER PUMPSETS (PRIMARY)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>as per schedule of quantities</td>
</tr>
<tr>
<td>Capacity</td>
<td>[2.4 Usgpm/ TR]</td>
</tr>
<tr>
<td>Net optg. head</td>
<td>[45 feet]</td>
</tr>
<tr>
<td>Speed</td>
<td>[1450 RPM]</td>
</tr>
<tr>
<td>Motor rating</td>
<td>As per drawing</td>
</tr>
<tr>
<td>Type of motor</td>
<td>TEFC sq. cage induction motor</td>
</tr>
<tr>
<td>Type of starter</td>
<td>Variable speed drive with single phasing prevention.</td>
</tr>
<tr>
<td>Accessories</td>
<td>Common base frame, Anti-Vibration pads</td>
</tr>
<tr>
<td>Special feature</td>
<td>Bronze impeller</td>
</tr>
</tbody>
</table>
### 4 - CHILLED WATER PUMPSETS (SECONDARY)

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>as per schedule of quantities</td>
</tr>
<tr>
<td>Capacity</td>
<td>[2.4 Usgpm/ TR]</td>
</tr>
<tr>
<td>Net optg.head</td>
<td>[90 feet]</td>
</tr>
<tr>
<td>Speed</td>
<td>[1450 RPM]</td>
</tr>
<tr>
<td>Motor rating</td>
<td>As per drawing</td>
</tr>
<tr>
<td>Type of motor</td>
<td>TEFC sq. cage induction motor</td>
</tr>
<tr>
<td>Type of starter</td>
<td>Variable speed drive with single phasing prevention.</td>
</tr>
<tr>
<td>Accessories</td>
<td>Common base frame, Anti-Vibration pads,</td>
</tr>
<tr>
<td>Special feature</td>
<td>Bronze impeller</td>
</tr>
</tbody>
</table>

### 5 - COOLING TOWER

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>as per schedule of quantities</td>
</tr>
<tr>
<td>Capacity</td>
<td>As per Schedule of quantities</td>
</tr>
<tr>
<td>Flow rate</td>
<td>[ 4 Usgpm]</td>
</tr>
<tr>
<td>Ent. Water temperature</td>
<td>[97.5 Deg F]</td>
</tr>
<tr>
<td>Leaving water temperature</td>
<td>[90 Deg F]</td>
</tr>
<tr>
<td>Ambient wet bulb temp</td>
<td>[82 Deg F]</td>
</tr>
<tr>
<td>Fan type</td>
<td>Axial flow type</td>
</tr>
<tr>
<td>Fan motor HP</td>
<td>As per drawing</td>
</tr>
<tr>
<td>Type of motor</td>
<td>TEFC sq. cage weather proof induction motor</td>
</tr>
<tr>
<td>Starter type</td>
<td>Star-Delta starter with single phasing prevention</td>
</tr>
<tr>
<td>Fill type</td>
<td>Multi layer of PVC</td>
</tr>
<tr>
<td>Connections</td>
<td>Water inlet</td>
</tr>
<tr>
<td>{All connections</td>
<td>water outlet</td>
</tr>
<tr>
<td>Flanged with companion flanges</td>
<td>Make-up &amp; quick fill Overflow drain</td>
</tr>
<tr>
<td>Water distribution arrangement</td>
<td>Automatic sprinkler system with spark head &amp; pipes</td>
</tr>
<tr>
<td>Accessories</td>
<td>Galvanized supporting frame</td>
</tr>
</tbody>
</table>
Galvanized steel ladder
Galvanized fan guard/bird screen
Air inlet screen (galvanism)
Drift eliminator
FRP Water basin
Float valve for make-up
Motor frame assembly

6–OTHER ITEMS

A. PIPES - CONDENSOR WATER/CHILLEDWATER/ DRAIN

TYPE G. I. class ‘B’

TYPE OF CONNECTIONS: *GI ERW piping welded by Resistance elec. welding.

* GI companion flanges for Valves equipment, etc.
Flanges to be drilled as per requirement.

Outdoor piping shall have welded GI flanges at every 18 metre intervals.

SUPPORTS Overhead pipe supports with GI hangers suspended from ceiling for sizes up to 75mm & pipe structure supports for large sizes.
Underground piping shall be supported with concrete or masonry blocks on bed concrete base.

Vertical risers shall be supported with GI
Painted brackets grouted to the walls with concrete.

**PAINTING**

All piping to be painted with Anti corrosive epoxy paint as per ISI colour coding.

**B. VALVES**

**GATE VALVES**

**QUALITY**

As per BIS.

**MATERIALS OF CONSTRUCTION:**

**BODY**

Cast iron for sizes above 65mm

**SEAT**

Gun-metal/Bronze

**BUTTERFLY / BALL VALVE/ DOUBLE REGULATING VALVE**

**QUALITY**

As per BIS.

**MATERIALS OF CONSTRUCTION:**

**BODY**

Cast iron for sizes above 65mm

**SEAT**

Gun-metal/Bronze

**NON-RETURN VALVE**

**QUALITY**

As per BIS.

**MATERIALS OF CONSTRUCTION:**

**SEAT**

Bronze

**BALANCING VALVES**

**TYPE**

Globe valve with flow measuring facility.

**C. PLANT CONTROLS & INSTRUMENTS:**

**PRESSURE GAUGES**

**TYPE**

Borden type with "U" tube & gauge cock.

**THERMOMETERS**

**TYPE**

Dial type for Plant & Industrial type
D. GSS DUCTING:
QUALITY As per BIS.
FABRICATION As per IS 655
HANGERS GI full threaded rod
SUPPORT & ANGLE FASTENERS two coat with zinc coat primer and finished with enamel paint
GRILLES & DIFFUSERS Aluminum Powder Coated
E. INSULATION
PIPING () Expanded polystyrene (Fire retardant quality)
TYPE Moulded Pipe sections
DENSITY Minimum 24kg/cubic meter.
THICKNESS 50 mm

TREATMENT FOR INSULATION
(a) INDOOR 125 Micron polythene sheet, fire resistant Hessian, chicken wire mesh, bitumen, 12mm plaster.
(b) OUTDOOR Same as above but with additional coat of one layer 6mm plaster, layers of vapor barrier mastic with rp tissue & a final two layers of bitumen coated tarfelt.
© DRAIN PIPING 25 MM polystyrene with same specification as for indoor piping

F. INSULATION
DUCTING:
MATERIAL Nitrile Rubber
TYPE Slabs
DENSITY Not less than 24 kg/cubic metre
THICKNESS As per S.O.Q.
TREATMENT 30 SWG Aluminium sheet finish as per specs.

G. AIR HANDLING UNITS:
MATERIAL Pre plasticized sheet/powder coated, extruded aluminum penta post framework,
TYPE Double skin/ sectionalized construction
TREATMENT
A coat of bitumen, insulation using 30 SWG aluminium sheet cover with straps, bolts & nuts or sandwich type panels.

H. ELECTRICAL ITEMS
PANEL –
TYPE
Factory fabricated, powder coated cubicle type dust – vermin proof as per KSEI standards.

APPLICABLE CODES:
The latest edition of the following codes, standards and regulations shall be applicable for this work.

(a) Piping: IS 1239 part I and II, IS 3589
(c) Duct work: ISS 655 (Latest Edition)
(d) Ducting - SMACNA : Sheet Metal and Air Conditioning Contractors' National Association
(e) Sheet metal ducts – BIS 655
(f) Test code for centrifugal fan – BIS 4894
(g) Test code for air moving devices – AMCA 210
(h) Propeller AC Ventilation fan – BIS 2312
(i) Filter – BSS 6450 part 1
(j) V belts for industrial purpose – BIS 2494
(k) V Grooved pulley – BIS 3142
(l) Code for practice for industrial ventilation – BIS – 3103
(m) Specs for Galvanised steel sheets- BIS 277
(n) Motors – BIS 324/325
(o) Piping 1239 Part 1 & 2 – BIS 3601
(p) Welding steel pipes – IS 3589
Drawings:

The tender drawings furnished are essentially diagrammatic and depict general arrangement and approximate locations of the equipment. The intent of these drawings is to aid the Contractor to acquaint himself of the general nature and extend of the work involved and these drawings are not intended to be used for construction. The Contractor shall prepare detailed piping, ducting. Equipment layouts along with shop drawing giving details of fixing arrangements, foundations, etc. as required for the above work shall be submitted along with detailed selection charts and catalogs of equipments for approval of the Architect as per the time schedule/program. The contractor shall commence the work only after the shop drawings are approved by the Architect.

Equipment:

All the equipment offered shall be brand new from the factory. The Contractor shall submit for approval a list of equipment he intends to use along with the detailed selection charts, catalogs, etc. before ordering of equipment. Any equipment or machine ordered or installed without the approval of owner shall be at Contractor's risk and shall be removed and replaced as directed, without additional expense to the owner.

Precautions:

All the equipment shall be so designed as to prevent rusting, corrosion and deterioration, the design of equipment shall be such that moisture, dust, vermin, etc. shall not find access to interior parts and components. All moving parts shall be provided with suitable cages to prevent accidental contact.

Operation and Maintenance:

Four complete sets of operating & maintenance instructions for every equipment and component shall be furnished properly bound. The Contractor shall depute, for a period of ten working days, a competent engineer or manufacture's representative to instruct employer Engineers/ Representatives in the operation and maintenance of air conditioning system.
WATER COOLED SCREW CHILLER

Type

Water cooled screw type chilling machines of latest design manufactured in India/abroad shall be supplied. The criteria for selection shall be overall performance and economy of operation. The approved makes of Screw chilling machines shall be as follows.

Capacity

Capacity As per Schedule of quantities (Actual under design operating conditions and fouling factors).

Components

The screw water-chilling machine shall comprise of the following major components, which shall be generally as per the supplier’s standard of manufacture:

a) Semi Sealed/Sealed compressor and drive motor.

b) Water Cooled Condenser.

c) Chiller.

d) Microprocessor based Control panel.

e) Refrigerant piping.

f) Solid State Starter (Soft starter, part winding, double delta, star delta).

All the components shall be totally factory assembled, skid mounted and shall be ready for installation and rigging.

Compressor :

Construction features of the compressor shall be as per manufacture’s standard/principals standard. A detailed technical literature shall be supplied for scrutiny of constructional features of compressors along with the technical bids. Compressors shall semi sealed or sealed type working on R134a. The lubrication system shall be force feed type and shall comprise of necessary pump, filters with bypass and relief valves, pressure and control valves. Electrically operated oil heaters shall be built in thermostat suitable for specific power supply. Heaters shall be automatically actuated when the compressor is stopped by means of auxiliary contracts, and indicating light and push button switch for testing the continuity of the heater element shall be provided with compressor. Shaft steel
shall be positive acting type in order to prevent leakage of refrigerant of air during compressor operation and idle period.

**Compressor motor:**

The drive motor shall be totally enclosed two pole squirrel cage, induction motor (cooled by refrigerant for hermetic machines). In case of refrigerant cooled motor, the contracted capacity shall be accomplished without any additional input energy or refrigeration charge. Motor hp/kw suggested is only for guidance. Refrigerant cooled motors for hermetic machines shall be specially treated to prevent reaction of refrigerant/oil/moisture with the winding insulation.

**Starter:**

Fully automatic starter as per schedule of equipment in accordance with the supplier's standard.

**Shaft-seal:**

This is required only for open type compressor.

**Capacity control:**

Automatic capacity control device to modulate load from 100% down to 20% with electronic temperature controller, control device for advance operation, temperature sensor in chilled water circuit, etc.

**Condenser:**

**Water-cooled condenser:**

- a) Horizontal shell-and-tube with MS shell and copper tubes finned or specially treated.
- b) Individually replaceable tube design.
- c) Baffle plate to distribute refrigerant and also to prevent high velocity impingement on the tubes.
- d) Accessories:
  - Pressure relief valve.
  - Purge collection chamber.
  - Operable water heads for cleaning of tubes.
  - Flanged connections for water-inlet & outlet.
Test pressure on waterside 15-kg/sq.cm. Refrigerant side test pressure shall be twice the working pressure.

**Chillers:**

a) Horizontal shell-and-tube type with MS shell & copper tubes.

b) Liquid distribution systems consisting of distributor though at the length of the shell and perforated distributor plate.

c) Multi-mesh screen to prevent liquid carry-over to the compressor located above the tube-bundle.

d) Accessories:

Water boxes at the chiller ends to provide required No. Of passes.

Flanged connections for chilled water inlet and outlet.

e) Test pressure on water side 15 kg/sq cm.

**Refrigerant, refrigerant piping & oil:**

The refrigerant shall be R-134A.

Piping shall be of factory installed refrigerant piping with filler-drier, controls, etc. Required as per standard of manufacturer shall be installed. The first charge of refrigerant and oil shall be carried out.

**Miscellaneous:**

a) **Purge system**

Continuous purge system with automatic purging of non-condensable gases/refrigerant.

b) **Refrigerant flow control:**

This shall be provided.

c) **Safety devices & control panel:**

The unit shall be provided with a control panel comprising of meters/indicators (Generally as per the supplier's standard of manufacture) the following safety devices shall also be incorporated:

a) 0-500 Voltmeter with selector switch.

b) 0-600 amp. With 3 Nos. CTs & selector switch.
c) Hours meter.
d) Lube oil heater signal/lamp.
e) Power signal lamp.
f) Set running signal lamp.
g) Purge unit operation running signal lamp.
h) Condenser high pressure trip lamp
i) Evaporator low pressure trip lamp.
j) Chilled water low temperature trip lamp.
k) Low chilled water flow trip lamp.
l) Low condenser water flow trip lamp.
m) Lube oil failure trip lamp.
n) Lube oil high tempr. lamp
o) Motor overload trip lamp.
p) Start/stop/remote/reset switch.
q) Purge unit operation switch (auto/manual/stop).
r) Capacity control switch (auto/manual/stop.)
s) High condenser pressure cut-out.
t) Low evaporator pressure cut-out.
u) Chilled water low temperature cut-out.
v) Lube-oil low pressure cut-out.
w) Condenser water suspension cut-out.
x) Chilled water suspension cut-out.
y) Motor winding high temperature cut out or motor over-current cut-out.
z) Time delay mechanism.

These controls shall shut-off the unit and provide audio-visual alarm/signal to the operator. The signal lamps shall be on control panel.

d) Thermometers & pressure gauges:
Pr. gauges Oil pressure, condensing pressure, evaporating pressure.

Thermometer  Lube oil thermometer.

e) Instruments (Generally as per the standard of the supplier)

   a) Auxiliary relays.
   b) Temperature controller.
c) Thermal relay and contractor for oil pump.
d) Alarm buzzer or indication lamps.
e) Fuses for voltmeter etc.

f) Vibration isolator (Generally as per the standard of the supplier)
   a) Corrugated ribbed rubber pads to provide sufficient deflection to minimize vibration.
   b) Base plates.

g) Insulation
Chiller & refrigerant suction line insulation as per standards of manufacturer.

h) Tools
Standard & special tools for operation & maintenance. A list of such tools shall be furnished along with the technical bids.

Installation
The screw chiller package shall be installed as per recommendations of the manufacturer. The rate quoted shall include all materials/labor/tools etc. as required for completion of the installation, testing & commissioning.

Charging of the unit:
The refrigerant piping & system shall be tested for any leakage and rectified. The system shall be vacuumized and vacuum maintained for required period of time as per standard practice or as directed by the Architect. The refrigerant shall be charged to the required capacity. The contractor shall set all the controls, safeties and inter-locks properly before starting the unit.

Testing:
Performance test of the chiller package shall be carried out and the test results along with computations shall be submitted for scrutiny. The computed results shall tally with specified ratings, otherwise test will be declared unsuccessful.
DOUBLE SKIN AIR HANDLING UNITS

Types:

Air handling unit shall be state-of-the-art design, original factory manufactured, powder coated, sectionalized design of penta post construction with removable standard panels, double skin with sandwich insulation of fire retardant quality and shall not emit toxic gases under fire conditions.

Components:

AHU shall be provided with the following:

a) Fan Section
b) Coil section
c) Filter section
d) Drain pan.

b) Construction features:

Construction features/specifications of sectionalized AHUs shall generally be as per the standard of the manufacturer. The tenderer shall submit detailed tech. specs. and leaflets of AHU offered by them along with a letter of commitment from the original manufacturer as to the compliance of their own specs. in actual practice. The minimum requirements for such AHUs shall be as given below:

a) AHU shall be made of Aluminium sheets or CRCA sheet steel, formed, reinforced and powder coated. Thickness of the sheets for cabinet shall be 0.63 mm for outer skin and 0.63 mm for inner skin. Drain pan shall be of 1.8 mm thickness.

b) The panel thickness shall be 40mm injected with poly urethane foam insulation having density of 42 kg/m3 and having thermal conductivity of 0.022W/m K.

c) It shall be possible to interchange panels of AHU to suit site conditions.

d) The plug fan section shall have suitable for static pressure of 40 mm and shall be statically and dynamically balanced.

e) Coil section shall be of cartridge type with easily removable cooling coil made of copper tube & aluminium fins properly bonded. The coil face area and no. of rows shall be able to
meet the duty specified. Computerized coil selections shall be furnished along with technical bid documents. No. of fins per cm shall not be less than 4.

f) Pre-filter section shall have washable HDPE/ Synthetic media filters of 48 mm thickness, 90% efficiency down to 20 microns and the filter face area shall be so selected as to limit the air velocity across the filter 100 mt/sec.

g) Drain pan shall also be insulated as (b) above and shall be provided with threaded pipe connections at both ends.

h) Drive package shall compromise of TEFC sq. cage motor, v-belts and pulley, motor mounting arrangement, drive guard etc. Drive motor shall preferably be factory installed and aligned. The drive motor shall be installed on an adjustable base.

i) VFD

j) Sectionalized AHU’S shall be accompanied by original factory certificate incorporating the following if required:

   i. Balancing of fan (Static & Dynamic)
   ii. Pneumatic testing of cooling coil
   iii. Galvanizing of the casing
   iv. Static pressure at rated cfm.

Accessories:

Air handling units shall be provided with the following accessories:

a. Automatic starter (DOL/STAR-DELTA) for driving motor. Motor of above 7.5 HP shall have STARDELTA starter.

b. Single phasing preventer.

c. Industrial type thermometers with metal guard and thermo well screwed to thermometer pockets at inlet/outlet of the cooling coil,

d. Pressure gauge with U tube abd gauge cock at inlet and outlet of the cooling coil,

e. Anti/vibration isolation arrangement using 2 x 12 mm

f. Provision for installing 2 way mixing/magnetic valve’ in chilled water connection if specifically called for in the schedule.

  g. Air tight door for side and bottom access for coil/fan inspection or open able side panels.
**Cooling coil:**

The fins shall be of aluminium and shall have integral spacing collars. The tubes shall be mechanically/hydraulically expanded to provide uniform and permanent fin-tube bonding. The return bends shall be deformed and brazed to the tubes. A 6mm (1/4") FPT plugged vent/drain shall be provided on each nozzle connection. Coil shall be circuited to provide on each nozzle connection. Coil shall be circuited to provide for design water velocity in tubes w/o exceeding the total water pr. drop as per standards. All coils shall have same end connections, regardless of no. of rows deep. Complete coil, including headers, connections, return bends, shall be tested.

**Fan drive motor, etc.**

Fan blowers shall be Plug fans designed for discharging the required quantity of air at the specified extl. Static pressure. The blower shall be supported on steel shaft of suitable design. The fan shaft shall be corrosion resistant. Fan wheels/blowers and shafts shall be designed for continuous operation at max. rated speed and motor horsepower.

Fan bearings shall be leaked-in, ball-type, self-aligning rubber/steel pillow block or flange type, mounted & located conveniently for re-lubrication.

Drive motor shall be TEFC sq.cage induction motor of rated speed of 1450 rpm. The motor shall have class "B" insulation. The drive package shall comprise of V-belts, pulleys, adjustable mountings plate for motor, drive guard, etc. The drive motor rating shall be as per equipment schedule or 125%of sum of fan bhp. The starters shall incorporate, thermal overload and under voltage protection. Starters shall also have in built single phasing preventors.

**Installation**

AHUs shall be installed as shown in the drawings. The unit shall be installed on anti vibration mount of adequate size. The operation of AHUs shall be smooth and shall not transmit undue vibration to the structure (90% vibration isolation desired).

**Testing**

Air handling units shall be tested for their design performance and test results shall be computed and submitted for scrutiny. If the computed results are not found to be satisfactory, further tests shall be conducted.
COOLING TOWERS

A. General:

SITC factory-assembled, induced draft, counter/ cross flow cooling tower with vertical air discharge, conforming in all aspects to the specifications, schedules and as shown on the plans.

- Thermal Capacity: The cooling towers shall have capacity as per SOQ. Additionally, the thermal performance shall be certified by the Cooling Technology Institute in accordance with CTI Certification Standard STD-201. The cooling tower(s) shall comply with the energy efficiency requirements of ASHRAE Standard 90.1.

- Corrosion Resistant Construction (standard): Unless otherwise noted in this specification, all casing panels shall be FRP and structural members shall be constructed of heavy-gauge hot-dip galvanized steel.

- Quality Assurance: The cooling tower manufacturer shall have a Management System certified by an accredited registrar as complying with the requirements of ISO9001:2000 to ensure consistent quality of products and services. Manufacturers that are not ISO9001 Certified shall not be acceptable.

- Wind Loads: When supported as recommended, the unit shall be suitable for applications requiring equipment anchorage to resist wind loads for that particular area.

B. Construction Details

- Structure: The cooling tower shall be constructed with a sturdy structural frame designed to transmit all wind, seismic and mechanical loads to the equipment anchorage.

- Casing Panels: Casing panels shall be constructed of corrosion and UV-resistant fiberglass reinforced polyester (FRP) to minimize maintenance requirements and prolonged equipment life.

- Cold Water Basin: The cold water basin shall be constructed of fiberglass reinforced polyester (FRP). Basin shall include a depressed center section with drain/clean-out connection. The basin area under the fill shall be sloped toward the depressed center section to facilitate cleaning. Standard basin accessories shall include a PVC make-up valve with large diameter plastic float for easy adjustment of the operating water level.

- Water Outlet: The water outlet connection shall be beveled for welding and grooved for mechanical coupling or bolt hole circle designed to accept an ASME Class 150 flat face
flange. The outlet shall be provided with large-area lift out strainers with perforated openings sized smaller than the water distribution nozzles and an anti-vortexing device to prevent air entrainment.

- Water Distribution System: The hot water distribution basins shall be the open gravity type for easy cleaning, and constructed of FRP. The basins must be accessible from outside the unit and serviceable during tower operation. Basin weirs and plastic metering orifices shall be provided to assure even distribution of the water over the fill.

- Cooling Tower should be designed for minimizing water loss, like drift loss and splash loss.

C. Mechanical Equipment

- Fan: Fan shall be heavy-duty, axial flow with aluminum alloy blades selected to provide optimum cooling tower thermal performance with minimal sound levels.

- Bearings: Fan and shaft shall be supported by heavy-duty, self-aligning, grease-packed ball bearings with moisture proof seals and integral slinger collars.

- Fan Drive: The fan shall be driven by a one-piece, multi-groove, solid back V-type power band with taper lock sheaves designed for 150% of the motor nameplate horsepower. The power band shall be constructed of neoprene reinforced polyester cord and be specifically designed for cooling tower service.

- Sheaves: Fan and motor sheave shall be fabricated from corrosion-resistant materials to minimize maintenance and ensure maximum drive and power band operating life.

- Fan Motor: Fan motor shall be totally enclosed air over (TEAO), reversible, squirrel cage, ball bearing type designed specifically for cooling tower service. The motor shall be furnished with special moisture protection on windings, shafts and bearings and labeled appropriately for cooling tower duty.

- Variable frequency drives for the fan motors which operates on temperature shall be provided.

D. Fill and Drift Eliminators

The fill and integral drift eliminators shall be formed from self-extinguishing (per ASTM-568) polyvinyl chloride (PVC) having a flame spread rating of 5 per ASTM E84 and shall be impervious to rot, decay, fungus and biological attack. The fill shall be manufactured, tested
and rated by the cooling tower manufacturer and shall be elevated above the cold water floor to facilitate cleaning.

E. Access Door

Access door shall be provided for access into the plenum section.

F. Sound

Sound Level: To maintain the quality of the local environment, the maximum sound pressure levels (dB) from the cooling tower operating at full fan speed shall not exceed 85 dB in free field condition

G. Accessories

- **Vibration Cutout Switch:** Provide a mechanical local reset vibration switch. The mechanical vibration cutout switch will be guaranteed to trip at a point so as not to cause damage to the cooling tower.

- **Ladder & Handrails:** A hot-dip galvanized steel ladder shall be provided for access to the fan deck. The handrails shall also be provided.

- **Internal Platform:** An internal walkway and an internal platform shall be provided for inspection and maintenance. Other components of the cooling tower, i.e. basin and fill/drift eliminators, shall not be considered an internal working surface.

**PUMPS**

**Construction:**

Pumps shall be as per I.S 1520/1960 and shall be of the following construction:

1. Casing Cast Iron/Cast Steel
2. Impeller Bronze
3. Shaft High Tensile Steel
4. Bearings Heavy Duty Ball/ Roller Bearings
5. Base Plat Cast Iron/ Fabricated M.S
6. Flanges To I.S.S 1536/1960
7. Packing Graphited Asbestos
8. Maximum Speed 1450 R.P.M
9. Driver TEFC Motor
10. Starter As per Schedule of Equipment
Driver ratings shown are only tentative and Tenderers shall select their drivers at least 5% in excess of the maximum B.H.P of the pump plus transmission losses, if any

**Accessories and Fittings:**

The following accessories shall be provided with each pump among other standard accessories required

- a) Coupling guard
- b) Lubrication fittings and seal piping
- c) Test and/or air vent

**Installation**

Pumps shall be installed as per manufacturer's recommendations. Pump set shall be mounted on concrete block, which in turn is mounted on machinery isolation cork or any other equivalent vibration isolation fittings. The PCC base will be made by the Owner and the foundation shall be provided as per the drawings and specifications by the contractor and the isolation pads shall also be supplied by the contractor. The contractor shall ensure that the foundation bolts are correctly embedded.

Pumps sets shall preferably be factory aligned. However, necessary site alignment shall be done by competent persons. Before the foundation bolts are grouted and the couplings bolted, the bed plate levels and the alignment results shall be submitted to the Engineer.

**Testing:**

The contractor shall submit the performance curves of the pumps supplied by them. They shall also check the capacity and total head requirements of each pump to match piping and equipment layout.

On completion of the entire installation, pumps shall be tested, for their discharge head, rate of flow and B.H.P and test results shall be furnished as per section-'TEST READINGS'. Test results shall correspond to the performance curves.

The contractor shall furnish the required testing instruments and arrange for their connection as required.

**Painting:**

s, accessories and fittings shall be given two coats of approved finishing paint.
The pumps shall be factory painted, after complete installation and testing, touch-up painting shall be done if required.

**Variable Speed drives for Pumps**

**A. Adjustable Frequency Drive**

1. The adjustable frequency drive(s) shall be pulse width modulation (PWM) type, microprocessor controlled design.

2. The AFD, including all factory installed options, shall have UL & CSA approval.

3. Enclosure shall be wall mounted or free standing depending on amp rating. A Hand–off–auto switch and speed potentiometer shall be functional via AFD keypad.

4. AFD shall utilize a diode bridge rectifier to convert three phase AC to a fixed DC voltage. Power factor shall be remain above 0.98 regardless of speed or load. AFDs employing power factor correction capacitors shall not be acceptable.

5. Insulated Gate by- Polar Transistors shall be used in the inverter section to convert the fixed DC voltage to three phase, adjustable frequency, and AC output. An internal line reactor shall be provided to lower harmonic distortion of the power line to increase the fundamental power factor.

6. Input Voltage shall be AC 450 V +/- 10% 3 ph 50 Hz

7. Minimum Input / Output capabilities (AI, DI, AO, DO)

**C. Pump Logic Controller**

1. The controller shall be specifically designed for variable speed pumping applications.

2. The controller shall function to a proven program that safeguards against damaging hydraulic conditions including:
   
   a) Motor overload
   
   b) Pump flow surges
   
   c) Hunting
   
   d) End of curve protection

The pump logic controller, through a factory pre-programmed algorithm, shall be capable of protecting the pumps from hydraulic damage due to operation beyond their published end–of–curve. This feature requires an optional flow meter for activation.
3. The pump logic controller shall be capable of staging de-staging pumps based on efficiency optimization program to provide the lowest KW draw. This optimization program requires an optional flow meter, KW meter, and system differential pressure sensor for activation.

4. The pump logic controller shall be capable of accepting analog inputs from zone sensor/transmitters indicated on the plans. The controller shall scan each analog input a minimum of once every 500 milliseconds. It shall then select the analog signal that has deviated the greatest amount from its set point. This selected signal shall be used as the common feedback input for a hydraulic stabilization function to minimize hunting. Each input signal shall be capable of maintaining a different set point value.

5. The pump controller shall be capable of controlling 3 Pumps in parallel.

6. The controller shall be field expandable to control up to 6 pumps in parallel and accept up to 16 analog inputs. This modification shall consist of nothing more than the addition of analog input modules and shall not require the use of special tools or factory reprogramming.

7. 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.

8. The pump logic controller shall be self-prompting. All messages shall be displayed in plain English. The operator interface shall have following features:
   a) Multi – fault memory and recall
   b) On – screen help functions
   c) LED pilot lights and switches
   d) Soft – touch membrane keypad switches

9. The readout shall be four lines of forety 0.50” brightly-fit fluorescent characters capable of displaying the following values:
   a) Flow in GPM
   b) Pressure in PSIG
   c) Differential pressure in PSIG
   d) Temperature in degree F or C
   e) Differential Temperature in degrees F or C
WATER PIPING

Chilled water & Condenser Water piping:

All pipes & fittings shall be brand new and shall be of approved make. The material and type of piping shall be as given here under:

<table>
<thead>
<tr>
<th>Pipe size (mm)</th>
<th>Class of Material</th>
<th>Joints &amp; Fittings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 65</td>
<td>Mild steel pipes as Per IS: 1239</td>
<td>Screwed fittings, unions &amp; screwed flanges.</td>
</tr>
<tr>
<td>Up to 150</td>
<td>-do-</td>
<td>Welded fittings, slip on flanges</td>
</tr>
<tr>
<td>200 &amp; above</td>
<td>Pipes as per IS: 3589</td>
<td>Welded fittings, slip on flanges, etc.</td>
</tr>
</tbody>
</table>

All fittings for piping with welded joints shall be welded as per welding standards. Fittings for screwed piping shall be of malleable iron. The fittings shall have the same pressure rating as that of piping. Valves of 75mm dia. and above shall be as per IS: 780, with cast iron body with flanged connection and nonrising spindles. Spindle, valve seat, wedge nut, etc shall be of gun metal or bronze. For piping of 50 mm dia. and below GM valves with screwed connection may be used. The valves shall be suitable for a test pressure as per equipment schedule. Globe/balancing valves shall be installed for controlling flow of water on discharge side condensers, chillers and water coil outlets. Globe valves shall conform to relevant BIS in all respects.

Flanges:

Flanges wherever used shall conform to the requirements of latest edition of BIS. The flanges shall be of forged steel. Generally slip-on flanges shall be used for pipe sizes 75mm and above. or smaller pipes, screwed flanges shall be incorporated. Supply of flanges shall include bolts, nuts, washers and sealing materials.

Check valves (Non-return valves)

Check valves shall be provided at locations shown on drawings of and wherever required. Check valves up to 65mm size shall be of gun metal with screwed female ends. Valves of 65mm and above shall be of CI with flanged ends. Check valves shall be supplied, if specially called for & agreed to.
**Butterfly Valve**

Butterfly valve shall perform the function of isolating valves. Butterfly valve shall cast iron body with black nitrile seat. All butterfly valves shall be provided with locking devices. Valve above 300 mm dia shall be gear driven.

**Two Way Type Pressure Independent Balancing Cum Modulating Flow Control Valve**

Supply, Installation, testing and commissioning of Pressure independent type 2 way modulating flow Control valves in a single Unit of Valve. PN 16 Rating. DN 15 to DN 32 Brass Body Ext. Threaded DN 40 & DN 50 Cast Iron Body, Ext. Threaded DN 65 to DN 100 Cast Iron body, Flanged Ends Connection Duly mounted with a BMS compactable Modulating actuator IP54 Type suitable for 24V AC for AHU / FCU as per specification

**SPECIFICATIONS**

The Self balancing flow control valves that are pressure independent, two-way, modulating to accept Input signals from the control system. Each Air Handling Unit / Fan Coil Unit shall be provided with 2Way Pressure Independent Balancing Cum Control Valve with Integrated in a single Body with Globe Type in Construction. FCU Valves Should be Provided with Spring Return Function Actuators Only. Regarding 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.

**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 are microprocessor based with self calibrating feature. Valve should be of linear control characteristics with stepless Characteristics.

**GENERAL SPECIFICATIONS**

1. Pressure Independent Balancing Cum Control Valve Shall be Provided/Installed at each Outlet of Cooling Coil Unit., AHU & FCU
2. 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.
3. Control valve shall accurately control the flow, with help of Modulating Actuator
4. Valve actuator housing shall be rated to IP 54. Control/Dip Switch Setting should be easy to Manual Access to avoid Manual Contact to directly with Integrated IC Circuit of the system.

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

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

7. Valve should be Globe Type in Construction and not with cylinder type cartridge. Globe construction valves are accepted as the most accurate characteristics valves. (i.e. they very closely follow the graphs made for valve opening and flow characteristics.)

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

9. Only Liner characteristics should not be acceptable as with this valve + actuator characteristic, the resultant energy characteristic will not remain linear and this shall lead to improper control leading to overflow/underflow phenomenon.

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

11. Actuator should not play a part in balancing process. This will ensure that even an operational issue in the actuator will not lead to loss of Balancing.

Valve Actuator housing shall made of non Corrosive Material.

12. Valve actuator housing shall be rated to IP 54 Protection (Weather Proof: Dust & Water Protected).

13. Flow Setting (Commissioning) for the Pressure Independent Valves should be simple and fool proof.

Flow setting (commissioning)

- 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.
**Strainers:**

Pot strainers or Y strainers with cast iron or MS body shall be designed for test pressure specified for valves. Each strainer shall be provided with removable cover and brass screen. The screen shall be of brass sheet, having perforations, to provide a minimum net free area of 4 times the cross section area of piping connected to the strainer. Strainers shall be provided with threaded sockets or flanges depending upon the pipe size. Strainers shall be provided on suction of each pump. Strainers shall be provided with drain plug.

**Installation**

Piping shall be installed only after thoroughly cleaning and painting with one primer coat of red oxide paint. Pipes shall be cut square and free suspended from stands, clamps, hangers as specified and required. The pipe supports or hangers as specified and required. The pipe supports or hangers shall be designed to withstand combined weight of pipe, pipe fittings, fluid in pipe and insulation. Pipe supports shall be of steel and coated with rust preventing paint and finished with two coats black enamel paint. "Vibration Isolation" hangers shall be installed close to the source of vibration. The supports designed to minimize vibrations shall be heavy enough to damp out vibrations and shall have relatively wide bearing surface to avoid swivel action. The following spacing are recommended for pipe supports.

<table>
<thead>
<tr>
<th>Pipe (MM)</th>
<th>Spacing (MTR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 25</td>
<td>2.0 to 2.2 meter</td>
</tr>
<tr>
<td>32 to 65</td>
<td>2.4 to 2.7 meter</td>
</tr>
<tr>
<td>75 to 125</td>
<td>2.7 to 3.0 meter</td>
</tr>
<tr>
<td>150 &amp; above</td>
<td>3.0 to 3.6 meter</td>
</tr>
</tbody>
</table>

Pipe supports shall be spaced at a maximum interval of 1.5 mtrs at heavy fittings and valves. Wherever piping passes through walls, pipe sleeves of diameter 50mm larger than that of piping shall be provided. Pipe sleeves shall be of steel or cast iron pipe. Sleeves shall not be installed in structural members except where indicated, or approved. Where pipes pass through fire walls/fire partition, a seal of asbestos rope, mineral wool or any other non-combustible material shall be used for packing the sleeve. Where off-sets have to be laid 45 degree elbows shall be preferably used. Wherever "Tees" are installed, they should be installed such the "Bull heading" is prevented. Vertical pipe risers shall be installed straight and true to the plumb. All connections to and from the water headers shall be through shoe connections in the direction of flow of water. The risers shall be fixed parallel to walls and
columns. The risers shall be provided with two support at each floor when passing from floor to floor. Supports for insulated pipes shall not be in direct contact with the pipe. Further, supports shall be arranged and fixed in such a way that undue pressure is not exerted on the insulation. The outlets required for passage of various pipes are shown in the drawings. The contractor should carefully examine the same and point out any discrepancies or deviations. Tee off connection shall be through reducing tees. Wherever tees cannot be installed, a direct connection may be provided with shoe connection in the direction of flow. No restriction shall be imposed to water flow in the header. Reducers wherever used in horizontal runs of piping shall be eccentric type, to provide for free drainage wherever required. In other locations, concentric reducers may be used.

**Flanges & Union**

Flanges and unions shall be provided in each line preceding the connection to each equipment, which require maintenance. Union shall be installed in between the equipment and each valve for piping with screwed or welded joints. Flanges/unions will not measured & shall be treated as part of piping.

**Air Venting**

Air valve shall be provided at the summit of piping system for air venting. Globe valve of same size as air valves shall be incorporated. The sizes of air valves shall be as specified hereunder. All such valves will be measured & paid.

<table>
<thead>
<tr>
<th>MAINS</th>
<th>AIR VALVES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 100 mm</td>
<td>25 mm</td>
</tr>
<tr>
<td>101 to 300 mm</td>
<td>40 mm</td>
</tr>
</tbody>
</table>

**Drains**

Drains shall be provided at all low points in the system. 25mm dia. gate valve with the same size GI piping up to the nearest drain or floor trap shall be provided for each drain point. The piping shall be pitched towards the drain points. Air venting valves shall also be connected to the nearest floor trap/drain through equal sized GI pipe. All such pipe & valves will be measured and paid.
Sockets for pressure gauges

Pressure gauges shall be provided at the following locations.

a. Supply and return of chillers and condensers.

b. All pumps-suction and discharge.

c. Heat exchangers-inlet and outlets.

Sockets for Thermometer

Direct reading 225mm long industrial thermometers having reading mercy shall be provided at the inlet and outlet of all heat exchangers to read water entering and leaving temperature. The thermometers shall be installed in separate wells. Thermometer shall be of appropriate range and shall be calibrated before installation. Thermometers for insulated piping shall be installed in extended neck to avoid damage or deformation of the insulation. The thermometers will not be measured and paid and shall be treated as part of equipment.

Expansion Tank

Expansion tank made of PVC/HDPE and completely insulated and provided with overflow, make up connection, vent pipe and float valve, shall be provided at location shown on the drawings. The size of the expansion tank shall be as per the requirements.

Insulation

Chilled water piping, condensate drain piping, etc. shall be insulated as per the specification enumerated under the specification "Insulation".

Testing

A) Piping shall be cleaned thoroughly.

B) Piping shall be tested to hydrostatic test pressure at least 2.5 times the maximum working pressure for a period of 24 hours. However, minimum test pressure shall be 10 Kg/sq. cm. The defects in joints and leaks observed during the test shall be rectified to the entire satisfaction of the Engineer-in-charge and piping shall again be subjected to pressure test. The testing of piping system shall conducted in presence of employer's representative. No insulation shall be carried out till the satisfactory completion of pressure testing. The contractor shall furnish all the necessary equipment, tools, instruments and labor to perform the test, to re water and clean space.
Balancing

After the completion of installation and testing of piping, all the piping system shall be adjusted and balanced to deliver the water quantities as specified/as required/as directed. The instruments/equipment required to adjusting the balancing of water system shall be accurately calibrated before taking any measurement. Calibrated orifices and portable flow meters may be used to adjust and balance the water flow. The contractor shall furnish a certified balancing report to the Engineer-in-charge for evaluation and approval.

Painting

After successful completion of installation, testing and insulation all exposed piping shall be given two coats of approved synthetic enamel paint as per the color coding requirement.

INSULATION

Materials of Insulation:

The following insulating materials shall be used:

a) For Piping

GENERAL

All underground and aboveground chilled water lines shall be insulated with pre-insulated PUF.

INSULATION

The service pipe insulation shall be polyurethane foam with 36 kg/cu m minimum density, 90% minimum closed cell content, minimum compressive strength of 40 psi and thermal conductivity of 0.14 Btu-in/hr/ft²/OF. The insulation shall completely fill the annular space between the service pipe and jacket and shall be bonded to both, the service pipe & jacket.

The insulation shall be provided to the minimum thickness specified below:

<table>
<thead>
<tr>
<th>Chilled water Pipe Size (mm)</th>
<th>Minimum insulation thickness mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 150</td>
<td>30</td>
</tr>
<tr>
<td>150 to 300</td>
<td>50</td>
</tr>
<tr>
<td>&gt;300</td>
<td>50</td>
</tr>
</tbody>
</table>
However the exact thickness could vary marginally for underground piping based on the exact sizes of HDPE pipes available.

**INSULATION JACKET**

**Over ground Piping:**

For over ground piping the jacket shall be out of Spirally wound GI/Al tubes as per following specs

**GI /AL**

<table>
<thead>
<tr>
<th>Jacket OD (mm)</th>
<th>Minimum Jacket Thickness Gauge</th>
</tr>
</thead>
<tbody>
<tr>
<td>OD ≤ 250</td>
<td>26</td>
</tr>
<tr>
<td>250 to 500</td>
<td>24</td>
</tr>
<tr>
<td>&gt;500</td>
<td>24</td>
</tr>
</tbody>
</table>

**Buried piping:**

The outer protective insulation jacket shall be seamless, extruded, black, uv resistant, high-density polyethylene (HDPE). The minimum thickness of the HDPE jacket shall be as follows:

<table>
<thead>
<tr>
<th>Jacket OD (mm)</th>
<th>Minimum Jacket Thickness (mm.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OD ≤ 300</td>
<td>3.5</td>
</tr>
<tr>
<td>300 to 600</td>
<td>5</td>
</tr>
<tr>
<td>&gt; 600</td>
<td>7</td>
</tr>
</tbody>
</table>

**FITTINGS**

**Over ground pipe insulation fittings:**

Use factory fabricated fittings & pour chemicals supplied at site to make composite insulation.

**Buried pipe insulation fittings:**

Take off fittings wherever underground should be factory insulated pipe with mitred HDPE outer covering to suit Carrier pipe fitting.
FIELD JOINTS INSULATION:

Field joints insulation shall consist of PUF poured manually in a prefabricated GI sheet metal mold fixed around the joint. Then a neat shrinkable sleeve with a closure patch is applied & heat shrunk over the insulation to finish the joint.

UNDER GROUND PIPING & INSULATION EXECUTION:

Underground systems shall be buried in a trench of not less than 600 mm deeper than the top of the pipe & not less than 450mm wider than the combined OD of all piping systems. A minimum thickness of 600mm of compacted backfill over the top of the pipe is desirable.

Trench bottom shall have a minimum of 150 mm of sand, pea gravel or specified backfill material, consolidated to suit operating weight & to act as a cushion for the piping

b) For Ducting

For Thermal insulation: 9 mm thick class o nitrile rubber insulation with adhesive as per the recommendation of the manufacture with density 45-55kg/m3

For Acoustic insulation: 10 mm thick insulation with adhesive as per the recommendation of the manufacture with density 140-180kg/m3

For non ac area: - 19 mm thick insulation with adhesive as per the recommendation of the manufacture

Acoustic lining of AHU rooms, walls and ceiling with 10 mm thick class o nitrile rubber with adhesive as per the recommendation of the manufacture with density 45-55kg/m3

Exposed roof insulation - 10 mm thick class o nitrile rubber with adhesive as per the recommendation of the manufacture with density 45-55kg/m3

Duct Insulation:

Sheet metal/Aluminium ducts shall be insulated as described below:

a) Thickness of insulation: Material: 9/10 mm Nitrile Rubber

<table>
<thead>
<tr>
<th></th>
<th>Conditional Space</th>
<th>Unconditional Space</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) Supply air duct (as shown in the dwgs)</td>
<td>9mm insulation</td>
<td>19mm insulation</td>
</tr>
<tr>
<td>ii) Return Air ducts</td>
<td>-Nil-</td>
<td>19mm insulation</td>
</tr>
<tr>
<td>iii) Plenums /acoustic Internal lining with 10mm thick insulation as specified on the drawing</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
DUCT ACOUSTIC LINING

Material shall be processed Open cell Nitrile Rubber foam. The material should be fiber free. The density of the same shall be within 140-180 Kg/m³. The material should have a thermal conductivity not exceeding 0.050 W/mK. The maximum surface temperature the material should withstand is 1050°C and minimum temperature should be -200°C. Thickness of the material shall be as specified for the individual application. The material should conform to Class 1 rating for surface spread of Flame as per BS 476 Part 7. The recommended thickness is 10/15 mm.

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 (or 30% of the duct length whichever is more) 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.

ACOUSTIC LINING OF MECHANICAL ROOMS

Two walls and ceiling of air conditioning plant room and air handling unit rooms may be provided with acoustic lining. Material shall be processed Nitrile Rubber foam. The material should be fiber free. The density of the same shall be within 140-180 Kg/m³. The material should have a thermal conductivity not exceeding 0.050 W/mK. The maximum surface temperature the material should withstand is 1050°C and minimum temperature should be -200°C. Thickness of the material shall be as specified for the individual application. The material should conform to Class 1 rating for surface spread of Flame as per BS 476 Part 7. The recommended thickness is 20/25 mm.

Installation Method

Thoroughly cleaned wall surface should be applied with a layer of adhesive recommended by the manufacturer. A layer of Adhesive also to be applied to Precut 1mtx1 mt foam sheet and stuck the same to the adhesive applied wall surface when the adhesive on both surfaces are tack dry. The whole acoustic foam area can be covered with one layer of glass cloth to give additional mechanical protection.

Acoustic lining of walls shall be terminated approximately 15 cm above the finished floor to prevent damage to insulation due to accidental water-logging in plant/AHU rooms.
DUCT ACOUSTIC LINING

Material shall be processed Open cell Nitrile Rubber foam. The material should be fibre free. The density of the same shall be within 140-180 Kg/m3. The material should have a thermal conductivity not exceeding 0.050 W/mK. The maximum surface temperature the material should withstand is 1050°C and minimum temperature should be -200°C. Thickness of the material shall be as specified for the individual application. The material should conform to Class 1 rating for surface spread of Flame as per BS 476 Part 7. The recommended thickness is 10/15 mm.

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 (or 30% of the duct length whichever is more) 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.

Valves & Fittings :

All valves, fittings, flanges, strainers etc. in the piping, operating below normal temperature, shall be insulated in the manner described above. Care should be taken to ensure that no damage would be caused to the insulation when valve or strainer is used or serviced.

Pumps & Accessories :

Chilled water pumps and accessories shall be provided with insulation of same thickness as that of pipes to which they are connected. The application of insulation shall generally conform to the method described above. Proper care shall be taken while insulating the pumps such that dismantling of pumps will not cause damage to the insulation.

Expansion Tank :

All tanks such as expansion tank, make-up tank associated with chilled water shall be insulated to the same thickness as for pipes to which they are connected. The method of application of insulation shall be as described for outdoor piping.
Equipment

Air Handling Units:

a) Drain Pan:

25 mm thick expanded polystyrene fire-retardant quality with 2 layers of bitumen.

b) Fan/Coil Section:

Insulation from inside as per equipment schedule & BOQ.

Water Chillers/equipment:

Water chillers or equipment operating below the ambient temperatures shall be insulated with 75mm thick thermoses/equal expanded polystyrene insulation. The equipment surface shall be given a coat of zinc chromate’s primer and two coats of Koldfas compound. Insulation shall then be applied butting all the joints tightly. The joints shall be properly sealed with adhesive. The insulation shall be wrapped with 24swgx19mm GI wire netting and two coats of smooth sand-cement plaster shall be applied to a total thickness of 12mm. The surface thus prepared shall give two coats of synthetic enamel paint of approved shade.

Sheet Metal Work

Erect GSS Factory Fabricated rectangular duct as per drawings. complete with all fittings such as tee bends, special off-chutes, turning vanes, splitter dampers, ins.doors, transformation pieces etc. as reqd. as per IS 655 including suspension and supporting arrangement for plenums, complete as reqd. and as per specs.(only hi-tech supports shall be used) ducts, joining with easy slip on flange, gasket, corner piece, cleat etc wall opening as good as same

Material for Ducting:

All duct work shall be constructed out of best quality cold annealed, flat galvanized sheet steel (galvanized to specifications of IS : 277 (latest edition)).

The joints shall be finished straight and neat. The duct work shall be supported/secured from roof slab or any other building member using angles, rods as may be required. (Only Hi-tech supports)
Thickness of sheets shall be as shown in the tables given below:

<table>
<thead>
<tr>
<th>Maximum size of Rectangular Duct (in mm)</th>
<th>RoundDuct dia.(mm)</th>
<th>Thickness of GS Sheet in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 750</td>
<td>Up to 600</td>
<td>0.63(24G)</td>
</tr>
<tr>
<td>751 to 1500</td>
<td>601 to 750</td>
<td>0.80(22G)</td>
</tr>
<tr>
<td>1501 to 2250</td>
<td>750 to 900</td>
<td>1.00(20G)</td>
</tr>
<tr>
<td>2251 &amp; above</td>
<td>901 &amp; above</td>
<td>1.25(18G)</td>
</tr>
</tbody>
</table>

The fabrication of duct shall be done as per IS: 655 (latest edition). Transverse joints, connections, bracing, seam etc. shall be generally as per IS: 655. All the ducts over 300mm in either dimension shall be cross broken except those on which rigid board insulation is applied. Stiffening angles shall be black structural steel and riveted to the cut work. The longitudinal seam on all ducts may be Pittsburgh seam hooked and hammered. Ducts of size 600 mm and above shall be reinforced between the joints. Where drive-slips are used, angles shall be riveted to the ducts 50mm from slips.

**Duct Construction:**

The intent of the above specification, is to obtain duct pieces that are robust and rigid enough to preclude flutter & to achieve minimum amount of air leakage. The contractor may fabricate ducts conforming to any other approved standard to achieve the desired result. However, detailed specifications shall be submitted for approval before adopting the same. Suitable rubber gaskets shall be provided between the duct flanges. Ducting shall be supported from independent hangers fixed to the building structure. In any case the duct shall not be supported from false ceiling, ceiling hangers, light fixtures, support for light fixtures or piping work etc. In case the structure is under construction, inserts and anchors required for duct support shall be set in the building structure at the time of pouring concrete. The Contractor shall prepare, detailed drawings of hangers and supports and submit for the approval of consultants.

Dimensions of duct sections shown are inside dimension of bare ducts. Where ducts are required to be lined or insulated on inner surface, their dimensions have to be enlarged so that the cross section area is not reduced as compared to those shown on the drawings.
**Elbows, Vanes Etc.**

Simple elbows, transformation sections, shall be formed with Pittsburgh corner seams. Complicated fittings shall be constructed with double corners. Elbows, bends and offset pieces shall have a center line radius of not less than 1.5 times the radial of width of the duct. Turning vanes should be provided at required spacing such that the aspect ratio of each individual elbow formed by the vanes shall not be more.

**Transformation**

Duct transformation shall be made with a side slope of 10mm to 70mm. However, if the duct cross section area need to be reduced, a maximum reduction of 20% of the original area shall be allowable.

**Obstructions**

Where ducting has to avoid building structural members, piping, electrical pipes and cables, ducts shall be transformed, divided or curved to one side. The reduction in area shall not exceed 20% of the original area.

**Take offs**

The branch take-offs and collars shall be provided with turning vanes. Straightening vanes shall be provided in the collars wherever practicable.

**Dampers & Splitters**

Dampers shall be provided in the duct work for proper control and balancing of air distribution. Dampers shall have easily accessible operating mechanism. The operating mechanism shall consist of links, levers and quadrants as required for proper control and setting in a desired position. The position of the handle of Damper operating mechanism shall be clearly visible and it shall indicate the position of the damper in duct. Dampers, splitters and their operating mechanism shall be fabricated of GS sheets of two gauges heavier than duct piece having theses fittings and shall be easily accessible through suitable access doors in the ducts. Dampers shall be installed in duct at all required locations such as chutes, branches etc.

**Fire Dampers**

Fire dampers shall be provided in the ducting as shown on the drawings and wherever required as per the local codes. However, fire dampers shall be provided in the ducts passing through fire walls and where the ducts serves more than two floors Fire Dampers shall have
same fire resistance as that of fire walls, ceiling, etc. The fire damper shall be installed in the duct in such a manner that vibration and rattling does not occur due to the passage of air. Fire damper with solenoids (solenoids shall be supplied & installed by AC Contractor).

**Apparatus and Equipment connections**

Equipment’s such as air handling units shall be connected to the duct by means of double canvas sleeve of 15 ounce, woven asbestos cloth connection of at least 150mm long.

Duct sleeves made of 20 gauge thick galvanized sheet steel shall be used for ducts passing through load bearing walls or partitions. sleeves shall provide 25mm clearance all around as per duct or insulated duct. The space between sleeve and duct shall be packed with twisted asbestos.

All the sheet metal plenums required to confine the flow of air through filters and fans, shall be fabricated out of 18 gauge galvanized sheet steel, suitably braced as required. Suitable access doors shall provided for plenums.

**Access Doors**

Hinged or bolted access doors shall be provided in ducting for fire dampers, coils, plenums and any apparatus requiring frequent servicing for inspection. Access doors shall be rigid and shall be provided with air tight rubber gaskets. Insulated ducts shall be provided with insulated doors

**Diffusers, Registers & Grilles**

All side wall supply grilles shall be double deflection type with both horizontal and vertical vanes being adjustable. Grilles shall be provided with multi-louver damper for volume control with adjustable handle from the from of the grille. Side wall grille shall be similar to Tuttle & Bailey. All return air and exhaust grilles shall have only horizontal louvers and similar to Tuttle and Bailey Aerovane T-70 D or equivalent. Ceiling diffuser shall be provided with volume control dampers, which can be operated from below. Ceiling diffusers shall be similar to Tuttle & Bailey type 5-aerofuse.

All the diffusers and grilles shall be of mild steel/powder coated aluminium. Diffusers and grilles shall be provided with sponge rubber gasket between flanges and wall or ceiling. Samples of grilles/diffusers shall be approved by consultant before installation.
**Installation**

The installation of ducting shall conform to standard practice of the trade. The contractor shall provide and neatly erect all the sheet metal work as shown on the approved drawings.

The Contractor shall prepare detailed shop drawings of ducting for approval by Architect. The drawings shall indicate the exact route of ducting, ducting dimensions, details of splitters, vanes, dampers, fire dampers, heaters, filters etc. as specified and required. The drawings shall also incorporate cross section indicating beams, obstruction, piping, cables etc. The ducting shall be suitably designed to avoid all obstructions and at the same time utilizing a minimum number of bends/transformations/divisions etc. Every duct layout drawing shall clearly indicate the location & spacing of supports & hangers.

Ducting over the false ceiling area shall be supported from the ceiling slab or from beams. In no event, the ducting shall be supported from false ceiling hangers, cable trays/racks, pipe supports or be permitted to rest on the false ceiling. All the ducts shall be rigid and shall be adequately supported and braced wherever required with tees, angles or adequate size to prevent buckling, Vibration or breathing. The contractor should mention the total quantity of various sizes ducting sheet along with each floor drawing of duct layout.

**Insulation:**

Duct work shall be insulated as per specification given under insulation.

**Testing:**

After completion of ducting, the entire system shall be tested for air leakages. The max. allowable air leakage shall be 10% on commissioning of the plant, the entire air distribution system shall be balanced to supply the required air quantities to various regions and rooms to maintain the specified inside conditions. The readings of air quantities, after final balancing of the system through each register, diffuser or grille shall be recorded and submitted to the Architect.

**Round ducting:**

Round duct shall be machine fabricated as per BIS standards. Ducting covering the insulation shall also be factory fabricated including reducers, tees, elbows etc. The entire exposed ducting shall be painted with two coats of paint/primer after subsequently cleaned as explained in the painting methods else wherever in this tender.
CONTROLS AND INSTRUMENTATION

Refrigeration Machine Safety Controls

Centrifugal Machines:

The unit shall be provided with a control panel comprising of meters/indicators (Generally as per the supplier's standard of manufacture) the following safety devices shall also be incorporated generally

a. 0-500 Voltmeter with selector switch.
b. 0-600 amp. with 3 Nos. CTs & selector switch.
c. Hours meter.
d. Lube oil heater signal/lamp.
e. Power signal lamp
f. Set running signal lamp
g. Purge unit operation running signal lamp.
h. Condenser high pressure trip lamp.
i. Evaporator low pressure trip lamp.
j. Chilled water low temperature trip lamp.
k. Low chilled water flow trip lamp.
l. Low condenser water flow trip lamp.
m. Lub oil failure trip lamp.
n. Lube oil high temp. trip lamp.
o. Motor overload trip lamp.
p. Start/stop/remote/reset switch.
q. Purge unit operation switch (auto/manual/stop).
r. Capacity control switch (auto/manual/stop.)
s. High condenser pressure cut-out.
t. Low evaporator pressure cut-out.
u. Chilled water low temperature cut-out.
v. Lube - oil low pressure cut-out.
w. Condenser water pressure suspension cut-out.
x. Chilled water suspension cut-out.
y. Motor winding high temperature cut-out or motor ever current cut-out.
z. Time delay mechanism.
These controls shall shut-off the unit and provide audio-visual alarm/signal to the operator. The signal lamps shall be on control panel.

**Capacity control :**

Screw compressors shall be provided with automatic capacity of control system to control partial load conditions. The capacity control system shall be capable of varying the capacity from 100% down to 20% of the full load under normal operating conditions, in step less manner.

The capacity control shall be effected by inlet guide vanes or by employing suction side variable speed diffusers. The controlled variable shall be either chilled water thermostat or temperature sensor.

**Instruments :**

Refrigeration machines shall be provided with the following instruments:

a) Refrigerant pressure gauge on suction and delivery of compressors.

b) Oil pressure gauge.

c) Water temperature Thermometer on inlet and outlet of chiller and condensers.

d) Water pressure gauges on both inlet and outlet connections of chillers, condensers and pumps.

e) Voltmeter and Ammeter.

f) Hours meter.

g) Indicating lamps as specified.

**Air handling Units Controls**

Air handling shall be provided with chilled water flow control device comprising of the following:

a) Modulating 2 way Mixing/Magnetic valve with modular motor.

b) Proportional thermostat

A centralized control panel shall be provided for control indication of refrigeration units, air handling units, pumps etc. The Control Panel shall have indicating lamps, "ON". "OFF" indication lamps for all the equipment’s as enumerated in the schedule of equipment’s. The
Control Panel shall be of free floor standing cubicle type, complete with all internal wiring etc. Control panel shall also indicate failure of any of the safety devices or controls separately.

**Testing**

The entire system and instrumentation shall be tested for proper operation after commissioning of the plant.

**MOTORS & MOTOR CONTROL CENTERS:**

**General:**

These specifications cover all types of motors used for pumps, air handling units, compressors, machines etc. The motor installation, wiring control shall be carried out strictly in accordance with the specification hereinafter laid down.

**Motors**

**a) Rating:**

The ratings of the motors shall be as indicated in schedule of quantities. The rating shall be selected on the basis of ambient temperature and allowable maximum temperature rise as specified.

**b) Standards**

All motors shall comply with IS: 325, in respect of general requirements and performance. Motors shall also conform to IS: 1231, for foot-mounted motors and IS: 2223 for flange mounted motors.

c) In general all the motors above 1 hp. shall be 3 phase unless otherwise specified. Bhp motors may be either 3 phase or single phase as required.

d) Motors shall run at all loads without appreciable noise or hum. Motors shall be one of the following design as specified in equipment schedule:

   i. Squirrel cage,

   ii. Wound Rotor

   iii. Totally enclosed

   iv. Totally enclosed, fan cooled.

Winding of motors shall be class 'B' insulated and fully enclosed.
e) Motors shall be rated for continuous duty as defined in IS:325. All motors shall have suitable torque characteristics as required by the duty of driven equipment. Motors shall be suitable for operation on 415 volts, 3 phase, 50-HZ, AC supply (or 230 volts single phase 50 Hz AC supply if required).

f) Motors shall be provided with ball/roller bearings. Bearings shall have ample capacity to deal with any axial thrust. Suitable grease nipples shall be provided for re-greasing the bearing.

g) Motors shall be provided with a cable box to suit aluminium conductor, PVC insulated, PVC sheathed and steel armored cable.

h) Motors, except fractional horse power motors of 1/8 hp and below, shall be provided with running over current protection generally by means of a bimetallic thermal overload protective device incorporated in the starter panel. Motors larger than 100 hp shall be provided with full thermal protection with a thermostat detector in the stators winding, measuring unit, tripping relay, and necessary wiring. All these shall be part of stators/panel.

k) The type of stators to be used shall be as follows:

<table>
<thead>
<tr>
<th>Type of Motors</th>
<th>Starting Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Squirrel cage motors up to &amp; including 7.5hp</td>
<td>Automatic Direct on line starters</td>
</tr>
<tr>
<td>b. Squirrel cage motors of 10 hp and above</td>
<td>Automatic Star/Delta starters.</td>
</tr>
</tbody>
</table>

The starting current of the motors shall be limited by using the above mentioned starters, as required.

**Motor Starters**

a. Motor Starters shall be in accordance with IS-1882. The starters shall be totally enclosed, metal clad, dust and vermin proof construction. The starters shall be of continuous rating and shall be of automatic type. All starters shall be suitable for 415 volts, 3 phase, 50 HZ, AC supply.

b. Contractors shall have the number of poles as required for appropriate duty. The making capacity of the contractors shall be as per AC23 of ISS.
c. Unless otherwise specified, all starters shall have integral start/stop push buttons. Start push buttons shall be colored green and shall be shrouded to prevent inadvertent operation. Stop push buttons shall have mushroom heads and shall be colored red. All push buttons operated contractors shall be provided with a hold-on/running contact.

d. All remote control circuit connected to the starters shall operate at 230 volts or lower voltage.

e. Motor starters shall be provided with thermal overload relay with adjustable settings, on each phase for three phase motor.

   The motors of 100 hp and above shall be provided with current transformer operated thermal overload relays. The thermal overload relays shall have thermal characteristics suitable for the associated motor, its starting characteristics and suitably compensated for ambient air temperature variations. Single phase preventers shall be provided for all three phase motors.

f. Terminal block with integral insulating barriers shall be provided for each starter.

g. All the starter shall be provided with a schematic diagram on a durable material fixed permanently within each lid or cover.

h. Starters shall be provided with sufficient extra N/O contacts for interlocks, indicating lamps, etc.

i. Automatic Star/Delta starters shall be provided with adjustable timers.

j. Starters for wound rotor motors shall be rotor resistance type and shall be oil/air immersed, metal clad construction with combination of drum type rotor resistance starter and starter switch. Rotor starter shall be used for starting only. The starter switch shall be of heavy duty, with trip free mechanism. The tripping mechanism shall not reset until the starter handle is in `OFF' position.

**Installation of Motors**

a. Installation of the motors shall be in accordance with BIS:900. Motors shall be mounted on a common foundation with the driven machine or equipment coupled through a flexible coupling or through belt drive. The drive arrangement shall be provided with a safety guard.
b. The motor along with its driven machine or equipment shall be provided with vibration isolation arrangement. Motors shall generally be provided with slide rails fixed to the base with nuts and bolts to facilitate belt installation and subsequent belt tensioning.

c. Motors shall be wired as per the detailed specification and drawings. All motor frame shall be earthed with 2 Nos. earthing conductors of size not less than 8 SWG. Schedule of wiring cables and earthing conductors has been shown on the relevant drawings.

d. Motors shall be tested at works in accordance with the relevant Indian Standard Specifications and test certificates shall be furnished in triplicate. Motors shall be tested at site after erection for insulation resistance.

e. All the motors and frames shall be painted with two coats of synthetic enamel paint.

Motor Control Centers

a) General:

Motor control centers shall be provided and installed wherever specified for controlling motors. Motor control centers shall comprise circuit breakers, switch fuses, starters, control and indicating equipment as specified. The motor control centers shall be totally enclosed, metal clad, flush front and back, cubicle pattern suitable for front and rear access. The motor control centers shall generally conform to IS:8623. (fully conformity not called for).

b) Construction:

Motor control centers shall be free standing type with basic structure being fabricated out of 2.0 mm steel with reinforcing frame welded in place. All the doors shall be 14 gauge steel. The enclosure of motor control shall be rigid and strong. The motor control centers shall have a bus bar chamber and required a number of feeder compartments of dimensions as in vertical section. Breaker and switch handles and starter push button shall be mounted on the devices and not on the doors. Suitable screw and raw device shall be provided on each compartment door for locking the doors in position on the side of each vertical feeder/control compartment section a vertical cable alley shall be provided with separate doors. Cable Alley doors shall be hinged type or otherwise as specified.
c) **Bus Bars:**

All bus bars shall be suitable for 415 volts, 3 phase, 4 wire, 50 Hz, AC supply. Main and vertical bus bars shall be made of high conductivity aluminium. The thermal short circuit capacity of horizontal bars shall not be less than 35 MVA rms. Bus bars shall be supported and braced at regular intervals on suitable insulating material such as SMC/DMC. All the bus bars shall be adequately shrouded and isolated from unit compartments and wire ways. Special care shall be taken in the design of bus bars with regard to safety aspects.

d) **Earthing:**

Entire motor control center shall be provided with GI earth bus running throughout the length of the panel. Motor control centers shall be provided with 2 Nos. earthing bolts for connections to the local earth grid shall be provided with 2 nos. earthing bolts for connections to the local earth grid.

e) **Unit Compartments:**

Unit compartments shall be of adequate dimension to house the feeder equipment and also to maintain the same. Each feeder compartment shall have a independent door. The door shall have rubber gasket.

f) **Interlocking Arrangement:**

Motor control centers shall be provided with the following safety interlocks.

i. All the switches/breakers shall be interlocked with door so that the unit cannot be closed unless the unit door is closed. This interlock shall also prevent opening the unit door unless the switch/breaker is in 'OFF' position.

ii. An integral operating handle shall be provided for each switch/breaker. The position of the breaker/switch shall be indicated by the operating handle.

iii. A suitable de-interlocking device shall be provided for deliberate inspection of feeder switch/breaker without having to switch off the feeder.

g) **Switch Disconnector Fuse Unit.**

All the switch Disconnector fuses shall confirm to IS. 13947 (part 1 & 3) & IEC 6094-(Part 1 & 3) for isolation duty, with rated insulation voltage of 660 volt, impulse with stand voltage 8 KV and fused short circuit breaking capacity of 80 KA.
h. Air circuit breaker

All air circuit breaker shall conform to ISI 13947 (part 1 & 2) & IEC 60947-(part 1 & 2) with stored energy, drawn out mechanism. All the internal auxiliaries should front mounded with inbuilt fault indications.

i. Molded case circuit breaker

All MCCB shall conforms to IS 13947 & IEC 60947 with adjustable centralized thermal setting (80% to 100%) and line load reversibility. All MCCB’s should have impulse with stand voltage of 8KV (VIMP = 8KV) and should be suitable for aluminum termination.

j. MPCB

This should confirm fully to IEC 947 standards, operational voltage 690 V, impulse fifth stand voltage 6 KV operating temperature upto 60°C grade should be suitable for isolation with minimum power loss / pole lesser than or equal to 2.5 W.

k. Feeder/Control equipment :

Feeder and control equipment shall be provided as per the drawings and schedule of quantities.

1) Switch fuses : All the switch fuses shall conform to IS:4064, IS:4047.

2) Air circuit breakers : All air circuit breakers shall conform to IS:2516 and draw out type.

3) Molded case circuit breakers: All molded case circuit breakers shall conform to relevant ISS.

4) Starters: All starters shall be as specified herein before.

5) Current Transformers: All CTS shall be as per IS specification.

6) Indicating Lamps : Suitable Red 'ON' Green 'OFF' indicating lamps shall be provided on each feeder/starter compartments.

7) Ammeters: CT operated ammeters of suitable range as specified shall be provided for each feeder/starter compartments.

l. Wiring :

All control and auxiliary wiring shall be carried out with copper conductor, PVC insulated wires. Wiring shall be properly colour coded and laid out neatly in bunches and firmly
fastened to the sides in the trolley. The terminations for conductors shall be done by crimping lugs on to the conductor ends.

Suitable printed PVC ferrules shall be carried out using copper conductor PVC insulated wires of adequate current ratings suitable for the equipment. The wiring shall be color coded using red, yellow, blue and black for 3 phases and neutral respectively. All terminations shall be carried out by crimping lugs on to the conductor ends. The lugs shall be fastened to the equipment using suitable washers and screws. All the wiring shall be neatly bunched and fastened to the sides of the trolley. Wiring selection for power shall be done considering the effects of temperature rise, bunching. All conductors shall be provided with printed PVC ferrules for easy identification.

**m. Enclosure and Surface Treatment:**

Motor control center shall be of dust and vermin proof construction suitable for indoor installation. All doors shall have rubber gaskets. Adequate protection shall be provided so that ingress of dust and vermin moisture encountered in indoor installation shall not in any amount be sufficient to interfere with the satisfactory operation of enclosed equipment. Sheet metal components and accessories of motor control treatment shall be given a rigorous anti-rust phosphating before the primer paint is applied. The sheet metal then painted enamel paint with approved colors shall also be painted.

**n. Name Plate:**

Motor control centers as well as their individual compartments shall be provided plastic black anodized screwed name plates.

**o. Diagram**

Each compartment of MCC shall be provided with a circuit diagram of its components and wiring and fixed on to the inner surface of door or lid.

**p. Danger Plate**

Standard danger plate indicating the voltage grade shall be provided on the motor control center.

**q. Testing:**

The panels shall be tested after fabrication, assembling and wiring.
1. Wiring shall be carried with 1000 volt megger to ensure adequate insulation resistance. (at manufacturer's works)

2. H.T. test shall be carried out with 2.5 KV rms for one minute to check the insulation of bus bars. (at manufacturer's works)

**r. Installation:**

Motor control centers shall be installed at the locations shown on the drawings. All motor control centers shall be provided with an integral base channel frame for grouting the motor control centers to the floor. The MCC’s shall be supplied with required number of anchor bolts.

The contractor shall supply foundation drawings for the motor control center. The motor control centers shall be installed on the concrete foundations and fixed to the floor by means of foundation bolts. Wherever RCC foundation is not feasible/provided, robust steel channels with trapped holes shall be embedded in the floor for installing the control centers. The required cables shall be brought and terminated at the motor control centers, using cable glands, lugs and sockets. All the cables shall be properly arranged and led through the cable alley. The various power and control cables shall be clamped firmly on to the sides of the cables alley.

The tightness of all main and auxiliary bus bar connections shall be checked. All wiring terminations and bus bar joints shall be tightened wherever necessary before energizing the motor control centers.

**ELECTRICAL INSTALLATION**

**General**

Work shall be carried out in accordance with the specifications, local rules I.E. Act 1910 as amended up to date and rules issued thereunder, regulations of the Local Fire Insurance Association and Indian Standards code of practice No. IS : 732-1963 and CPWD General specifications for Electrical Work(Internal) -2013 and Kerala State Electrical Inspectorate standards.
TESTING OF AIR-CONDITIONING SYSTEM:

Routine and type tests for the various items of equipment shall be performed at the Contractor's works and test certificates furnished if required. Functional tests shall be conducted at site.

The performance tests to determine whether or not the full intent of the specification is met shall be conducted by the contractor. After notification to the employers that the installation has been completed and the plant has run continuously for a period of at least one week, the Contractor shall conduct under the direction and in the presence of the employer's representative such tests as specified to establish the capacity of various equipment supplied and installed by the Contractor.

The Contractor shall operate, test and adjust the air conditioning system units, fan, motors, all air handling appliances including adjustment of regulators, dampers etc. All test equipment, labor, operating personnel, oil and refrigerant required for these tests shall be furnished by the Contractor to enable the plant to be put in a continuous running test. The Contractor will be provided with electric power and water.

Procedure:

Design Conditions:

The inside and outside dry bulb and wet bulb temperatures shall be recorded by means of a sling psychrometer with mercury thermometers. The relative humidity shall be computed from the psychometric chart. The inside dry bulb temperature and relative humidity shall fall within the specified limits.

Capacity of the plant

The following aspects shall be checked before conducting the performance tests

a. The outside conditions shall be as close to the design values as possible.

b. The internal loads of various spaces shall be close to the design values as far as possible. Otherwise internal loads shall be simulated to a value required to satisfy the design condition.

c. The plant shall be fully loaded and the temperature stabilized.

d. Hourly readings of water flow shall be recorded.

e. Hourly readings of pressure, temperature, electrical current, voltage and power factor shall be properly recorded. The capacity of the plant and various other equipment and accessories shall be ascertained as follows.
**Cooling coils of air-handling units & fan coil units**

The flow of air over the cooling coil will be measured by recording the velocity of air across each filter placed before the cooling coil. The velocity shall be measured by means of an anemometer.

Air quantity across the filters = Velocity of air across the filter in FPM x Net filter area in sq. ft.

The wet bulb temperature of air entering the coil and that leaving the coil shall be measured. The enthalpy of entering and leaving air shall be noted from the psychometric chart, corresponding to the WB temperature recorded.

Say, \( h_e = \text{Enthalpy of entering air in Btu/lb} \) \( h_l = \text{Enthalpy of leaving air in btu/lb} \).

**Chiller**

The temperatures of inlet and outlet water, water flow and pressure drop shall be measured as suggested for the condenser.

The capacity of plant in TR = \( \frac{\text{Water flow through chiller (in gpm) x } dT \text{ (OF)}}{24} \)

Where \( dT = (\text{Temperature of entering water-Temperature of leaving water}) \)

**Note:** Rotometer and energy meter duly calibrated shall be arranged by the contractor and test should be conducted for the duration as required to enable at least a record of six table readings under different load condition.

**Compressor:**

The following readings shall be recorded:

a) Suction gas pressure.

b) Discharge gas pressure.

c) Suction gas temperature.

d) Discharge gas temperature.

e) Readings of ammeter, voltmeter & power factor meter.

Same pressure gauge shall be used for different measurements and the same thermometer shall be used for different temperature measurements. The capacity of the compressor shall be computed from the performance chart supplied by the manufacturer.
On of the compressor = \( \frac{\text{Power Input in KW}}{0.746 \times \text{Compressor capacity in TR}} \)

**Cooling Tower:**

Temperature of hot water, Temperature of cold water in the sump and wet bulb temperatures shall be measured. The cooling tower efficiency shall be computed as follows:

\[
N = \frac{\text{Temperature of hot water} - \text{Temp. of cold water}}{\text{Temperature of hot water} - \text{Ambient wet bulb temp}}.
\]

Wet bulb approach = [Temp. of cold water in sump]--[Ambient wet bulb temperature]

**Air balancing:**

After the desired inside conditions are achieved the quantity of air through every outlet shall be measured.

Air Qty (CFM) = Air velocity at the outlet in FPM \( \times \) Effective area of the outlet in Sft.

**Testing at various loading conditions:**

The performance tests shall be conducted for various loads such as 100%, 75%, 50% of the capacity of the plant.

**Functional Tests**

**Electrical Equipment**

1) All the cables shall be tested for continuity and absence of cross phasing. Insulation resistance between

the phase conductors and the earth shall be measured with the help of a 500-V meter

Note: B/F - to enable at least a record of 6 stable readings under different load condition.

**Motors**

a. Insulation Resistance of all motors shall be tested with a meter and the value shall not be less than

b. 1 Meg-ohm. If the observed value is less than 1 Meg-ohm the motor winding shall be dried out and windings shall be given a coat of approved insulating vanish.

c. Starting current shall be recorded every time the motor is started.

d. Starter operation shall be checked for single phasing by removing one of the phases.
e. Overload protection shall be checked for single phasing by removing one of the phases.

**Safety Devices & Controls**

1. Interlocks for compressor motor with that of chilled water pumps, condenser water pumps and cooling tower fan shall be checked.
2. Flow switches in condenser water and chilled water lines shall be throttling the valves.
3. High pressure-stat shall be checked by varying the setting of the cutout.
4. Low pressure stat shall be tested by closing the pilot solenoid valve.
5. Anti-freeze thermostat shall be tested by varying the setting.
6. Oil failure switch shall only by tested by varying the setting.

**Capacity Control**

The capacity control arrangement shall be tested by varying the load on the plant. Any other procedure recommended by the manufacturer's may be adopted with the prior permission of the employers and consultants.

**Format For Test Readings After Commissioning**

The following readings shall be recorded hourly during the tests and capacity of the plant shall be computed.

**Compressor**

1. Suction pressure - Kg/Cm2 (psi)
2. Suction temperature - °C (°F)
3. Discharge pressure - Kg/Cm2 (psi)
4. Condensing Temper. - °C (°F)
5. Oil pressure - Kg/Cm2 (psi)
6. Compressor Speed - rpm

**Motor**

a. Rated capacity - HP
b. Rated Volts - Volts
c. Rated current - Amps
d. Starting current - Amps

**Power Consumption for 100%, 75% & 50% loads**

a. Motor current in amps.
b. Voltage
c. Starting current.

Power details:

<table>
<thead>
<tr>
<th>%Load</th>
<th>Cond.EWT</th>
<th>Evap.LWT</th>
<th>KW</th>
<th>KW/Ton</th>
<th>Tonnage</th>
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<td>25</td>
<td>---------</td>
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</tr>
</tbody>
</table>

The above power consumption shall be tested in presence of the Architect.
and test certificate shall be furnished.

Condenser

1. Refrigerant condensing pressure - Kg/cm2 (psi)
2. Refrigerant condensing Temp. - 0C (0F)
3. Water flow rate - lit/sec. (gpm)
4. Entering water temp. - 0C (0F)
5. Leaving water temp. - 0C (0F)
6. Pressure drop through condenser - Kg/cm2 (psi)

Chiller

1. Refrigerant evaporating pressure - Kg/cm2 (psi)
2. Refrigerant evaporating Temp. - 0C (0F)
3. Water flow rate - lit/sec. (gpm)
4. Entering water temp. - 0C (0F)
5. Leaving water temp. - 0C (0F)
6. Pressure drop through chiller - Kg/cm2 (psi)

Cooling Tower

1. Water flow rate - lit/Sec (gpm)
2. Entering water temperature - 0C (0F)
3. Leaving water temperature - 0C (0F)
4. Outside temperature
   a. DB temperature - 0C (0F)
   b. WB temperature - 0C (0F)
5. Wet bulb approach

Air handling units & fan coil units

1. Air velocity - M/Hr (FPM)
2. Coil face area - M2 (SFT)
3. Air quantity - M3/Hr (CFM)
4. Entering air temp DB - °C (°F)
5. Entering air temp WB - °C (°F)
6. Leaving air temp DB - °C (°F)
7. Leaving air temp WB - °C (°F)
8. Entering water temp - °C (°F)
9. Leaving water temp - °C (°F)
10. Entering water pressure - Kg/cm² (psi)
11. Leaving water pressure - Kg/Cm² (psi)

12 Motor
a. Rated Horse Power - HP
b. Rated Volts - Volts
c. Rated Current - Amps
d. Actual current - Amps
e. Actual Volts - Volts
f. Starting current - Amps

Pumps
1. Flow Rate
2. Discharge Pressure - lit/Sec. (gpm)
3. Suction pressure - Kg/Cm² (psi)

Motor
a. Rated HP - HP
b. Rated current - Amps
c. Rated Volts - Volts
d. Actual current - Amps
e. Starting current - Volts

Electric Motors
1. Insulation resistance - Meg ohm
2. Starting current - Amperes
3. Full load current - Amperes
4. Line voltage - Volt
5. Power factor - Watt
Supply Air Grilles

1. Area of Grill - M2 (Sft)
2. Velocity - M/Hr (FPM)
3. Air flow rate - M3 (FPM)
4. Temperature DB - 0C (0F)
5. Temperature WB - 0C (0F)

Filters

1. Total area - M2 (Sft)
2. Effective area - M2 (Sft)
3. Velocity of air - M/Hr (FPM)
4. Quantity of air - M3/Hr (CFM)

Controls, Interlocks, etc.

The observations of the test shall be recorded for each item separately.

I.S. STANDARDS AND SAFETY STANDARDS

BIS. STANDARDS

The air-conditioning plant equipment’s and installation shall confirm generally to latest I.S. Standards as given below/and in accordance with the latest Indian standards in force.

I.S. 277 - Galvanized steel sheets
I.S. 325 - Three phase induction motors
I.S. 655 - Metal air ducts
I.S. 732 - Code of practice for Electrical wiring and fittings
I.S. 778 - Gun metal gate, Globe and check valves for general purposes
I.S. 900 - Code of practice for installation and maintenance of induction motors
I.S. 996 - Single phase small A.C. and Universal motors
I.S. 1239 - Mild steel tubes, tubular and other wrought steel fittings
I.S. 1248 - Direct acting electrical indicating instruments.
I.S. 1554 - PVC insulated (Heavy duty) electric cables for working voltages up to and including 1100 volts.
I.S. 1520 - Horizontal centrifugal pumps and for clear cold, fresh water.
I.S. 1822 - Motor starters of voltage not exceeding 1000 volts.
<table>
<thead>
<tr>
<th>I.S.</th>
<th>Specification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2208</td>
<td></td>
<td>HRC cartridge fuse-links up to 650 volts.</td>
</tr>
<tr>
<td>2372</td>
<td></td>
<td>Timber for cooling tower.</td>
</tr>
<tr>
<td>2516</td>
<td></td>
<td>A.C. circuit breakers.</td>
</tr>
<tr>
<td>2592</td>
<td></td>
<td>Recommendation for methods of measurement of fluid flow by means of orifice plates and nozzles</td>
</tr>
<tr>
<td>3589</td>
<td></td>
<td>Electrically welded steel pipes for water gas and sea gauge</td>
</tr>
<tr>
<td>3624</td>
<td></td>
<td>Bourden tube pressure and vacuum gauges</td>
</tr>
<tr>
<td>4047</td>
<td></td>
<td>Heavy duty air break switches and fuses for voltages not exceeding 1000 volts.</td>
</tr>
<tr>
<td>6392</td>
<td></td>
<td>Steel pipe flanges</td>
</tr>
<tr>
<td>7403</td>
<td></td>
<td>Code of practice for selection of standard worm and helical gear boxes.</td>
</tr>
</tbody>
</table>
SECTION. E – FIRE PROTECTION WORKS

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2. Pumps and Accessories

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4. Batteries and Battery Charger

5. Hydrant System and Piping

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7. Power Supply Of Panel
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9. Control Cable
10. Cable Glands
11. Cable Connectors

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(Fire Detection and Alarm System)

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2. Testing

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6. Makes And Type/ (Model Numbers) Of Following Items
Electrical Items

Heat Detectors

Loop Isolators

Loop Hooters

Fire Control Panel

Battery (Fcp)

Makes Of Following Items
hydrants where pressure exceeds 7 Kg per Sq. cm.

17. Hose reel

The hose reel shall consist of 30 m long 20 mm dia. Thermo plastic(fabric Reinforced) hose mounted on heavy duty circular MS drum complete with gun-metal shut-off valve, nozzle, etc. The hose reel bracket shall be of MS fabricated or cast iron swing type suitable for 90deg. smooth and free rotation in vertical plane conforming to IS-884.

18. Hose boxes

The fire hose boxes shall be of size 750x250x600 mm, 16 SWG sheet steel with front side glass of 4 mm thick, lockable hinged door and painted with one coat of primer and two coats of synthetic enamel paint of approved colour.

19. Couplings

All couplings shall be of the instantaneous spring-lock type and the nozzles shall be of not more than 16 mm dia. All couplings in the branch pipes and nozzles shall be of gunmetal and shall comply with IS-903. The hose shall be attached to the coupling. Spare hoses and nozzles to the extent of 10 % of the total requirements shall be supplied by the contractor as per BOQ.

21. Fire brigade inlets

The fire brigade collective breach shall be with 150 mm flange outlet connection with gunmetal collecting head having 4 instantaneous connections with built-in check valves. The fire brigade breach shall be connected to the main header.

22. Delivery Hose

Delivery Hose for fire fighting. 100% synthetic hose 63 mm dia 15 m long confirming to IS636 1988 ( Type A), circular woven jacketed rubber lined Hose, with instantaneous male and female gun metal coupling and copper wire binding. Both hose and coupling shall confirm to relevant Indian Standards and shall have ISI marking. Also have burst pressure 35 Kg/cm2 and working pressure of 14 kg/cm2.
INSPECTION AND TESTING

CPWD, General Specifications For Electrical Works Part • V (Wet Riser & Sprinkler Systems), 2006., shall be adhered to for the Inspection & testing of the hydrant system.

(Hydrant System)

1. Inspection – General

All site fabricated work/ material shall be subject to inspection in cleaned condition, prior to erection. At no event, site fabricated work /material shall be installed in position without inspection and approval by Architect. The Contractor shall ensure that each stage of fabrication is carried out in compliance with the procedures specified in the IS /NBC standards as applicable and/or specified in this document.

The contractor shall conduct sample tests of all the materials supplied at reputed laboratories/agencies as directed by RGCB / Architect at his own cost and test reports are to be submitted. Inspecting officials of RGCB / Architect and Local Authorities shall have the right to access the premises of the work at any time with or without giving prior notice. All the formalities or procedures for conducting the inspections by the authorities as required by them shall be arranged by the contractor free of cost.

All testing shall be carried out in the presence of RGCB / Architect in Charge/statutory authorities and test registers shall be maintained by the contractor. The contractor shall provide all material, tools, equipment, instruments, services and personnel required to perform the tests and remove debris/water resulting from cleaning and after testing free of cost.

The original test certificates of all tests conducted are to be forwarded to RGCB / Architect. After conducting the tests, any defects found on materials, equipment, piping, etc. shall be got rectified / repaired by the Contractor without any extra cost.

2. Testing

Before energizing electrically operated equipment, care shall be taken to meet the localelectrical rules and regulations, earthing of the body, verifying availability of safe insulation resistance value, etc. Also confirm the motor enclosure to the level of protection required for the particular application.
### D HVAC WORKS

<table>
<thead>
<tr>
<th>MATERIALS</th>
<th>MAKES/BRANDS NAME</th>
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<tbody>
<tr>
<td>Chiller</td>
<td>Trane / York/ Dunhambush/ Carrier/ climaveneta / Daikin Mcquay/Hitachi</td>
</tr>
<tr>
<td>VRV/ Split unit / Package unit</td>
<td>Diakin / Carrier / LG/ Hitachi/Samsung/ Toshiba/ Mitsubishi /Bluestar/ Panasonic/ETA/General/Volts/Trane</td>
</tr>
<tr>
<td>Chilled water &amp; condenser water pumps</td>
<td>Grundfos /ITT/Armstrong</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>Marley / Baltimore/CANI</td>
</tr>
<tr>
<td>Air handling unit</td>
<td>York/Carrier/ Trane/VTS/Edgechtech/Zeco/system air</td>
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<tr>
<td>Heat recovery wheel</td>
<td>Dynair/ Bryair/</td>
</tr>
<tr>
<td>Fan coil unit</td>
<td>Sinko / Carrier/ Trane / Media</td>
</tr>
<tr>
<td>VAV</td>
<td>Honeywell/ Staefa / Johnson Controls/TROX</td>
</tr>
<tr>
<td>MS/ GI piping</td>
<td>Tata / Jindal</td>
</tr>
<tr>
<td>Pre insulated piping</td>
<td>Seven star/Zeco</td>
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<tr>
<td>Drain piping</td>
<td>Supreme / Finolex</td>
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<tr>
<td>Butterfly valves</td>
<td>SKS/Econosto/ Audco</td>
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<td>Ball valves</td>
<td>Danfoss/ Tour &amp; Anderson/CIM/econosto</td>
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<td>Non return valves</td>
<td>Danfoss/ Tour &amp; Anderson/SKS</td>
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<td>Balancing valves</td>
<td>Danfoss/ Tour &amp; Anderson /Advance /Flowcon /Belimo</td>
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<td>Y strainer/Suction guide</td>
<td>Sant/ RB/ Emerald</td>
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<td>Anergy / ITT</td>
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<td>Air separator</td>
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