Monsoon 80mm
Crate Heat Load
Crate Parts

**HEAT EXCHANGERS** connect in series with ¼” copper tube

**MONSOON CARDS** (10)
plug in on this side
(6U x 160mm Eurocards)

**HEAT EXCHANGER** on **CHILLER PLENUM**
(one at each end of main MONSOON cards)

**92mm FAN** (x2) on **FAN PLENUM** (one at each end of transition cards)

**60mm FAN** (x2) on **MAIN PLENUM** (at both ends, only this end shown here)

FAN power supply is in the middle (at both ends)

**TRANSITION CARDS** (8)
(6U x 80mm)
Crate (without shield)

VICOR power supply with built-in 80mm fan, 30cfm listed, pressure drop unknown (x2)

POWER SUPPLY PLENUM

MAIN PLENUM
Air Heat Load Diagram

- **PWR SUPPLY PLENUM**
  - FAN 9 W
  - FAN 9 W
  - FAN PS 8 W

- **FAN PLENUM**
  - FAN 12 W
  - FAN 12 W

- **COLD PLENUM**
  - COLD WATER HEAT EXCH -201 W
  - 120 CFM

- **MONSOON TRANSITION CARDS**
  - 60 CFM
  - 50 W

- **MONSOON MAIN MODULES**
  - 120 CFM
  - 205 W

- **COLD WATER HEAT EXCH -205 W**
  - 120 CFM

- **MAIN PLENUM 2**
  - FAN 12 W
  - COLD WATER HEAT EXCH -205 W
  - 120 CFM

- **MAIN PLENUM 1**
  - FAN 12 W
  - COLD WATER HEAT EXCH -201 W
  - 120 CFM

- **VICOR PS 31 W**
  - 30 CFM
  - 80 mm built in

- **VICOR PS 20 W**
  - 30 CFM
  - 80 mm built in

- **FAN PS 8 W**
  - 30 CFM

- **FAN PS 20 W**
  - 30 CFM

- **FAN PS 20 W**
  - 30 CFM

- **FAN PS 20 W**
  - 30 CFM
Heat Exchanger Thermal Performance for Water

The design uses a Lytron M05-050 heat exchanger.

For the target of 120 CFM air flow, and ½ gpm water flow, the heat removed is 24W for each °C difference between the water in and the air in.

To remove 216W of heat, the water must be 9°C colder than the air.
Air Temperature Change Chart

For 200W at 120 CFM air flow, the air should rise about 3°C
Water Temperature Change Chart

For 200W at ½ GPM water flow, the rise is about 1.5°C
Heat Exchangers in Series

- To minimize the water flow needs, we can pipe the heat exchanger water in series
- If we choose 12°C for the inlet water into the 1\textsuperscript{st} heat exchanger, it should be about 13.5°C into the 2\textsuperscript{nd}
- If the input air into the 1\textsuperscript{st} heat exchanger is 21°C, then 216 watts of heat is removed, and exit air is 18°C
- The input air into the 2\textsuperscript{nd} heat exchanger should be 21°C, 180 watts of heat removed, exit air is 18°C
- Equilibrium should be about 20°C for the electronics
Air Temperature Diagram

**MONSOON TRANSITION CARDS**

- VICOR PS 31 W (80 mm built in)
- VICOR PS 20 W (80 mm built in)

**MONSOON MODULES**

- COLD WATER HEAT EXCH -180 W
- COLD WATER HEAT EXCH -216 W

**COLD PLENUM**

- 120 CFM at 18°C
- 120 CFM at 21°C

**FAN PLENUM**

- 60 CFM at 18°C
- 60 CFM at 21°C

**FAN**

- 12 W
- 9 W
- 8 W

**FAN PS**

- 31 W
- 20 W
- 12 W

**PWR SUPPLY PLENUM**

- 30 CFM at 18°C
- 30 CFM at 21°C

Temperatures:

- 15°C
- 13.5°C
- 12°C
The design uses a Lytron M05-050 heat exchanger.

At ½ GPM water flow, the water pressure drop is ½ PSI, or 1 PSI for the 2 in series.
Water Supply

According to COPPER.ORG:
“In general, the mains that serve fixture branches can be sized as follows:
Up to three 3/8-inch branches can be served by a 1/2-inch main.
Up to three 1/2-inch branches can be served by a 3/4-inch main.
Up to three 3/4-inch branches can be served by a 1-inch main.”

The M05-050 uses 3/8-inch copper tubes, so we need a ½-inch main for the supply, with a flow of 2 CFM
Pressure Loss in Piping

Pressure Loss of Water Due to Friction in Types K, L and M Copper Tube
(ksi per linear foot of tube)

<table>
<thead>
<tr>
<th>Flow GPM</th>
<th>1/4</th>
<th>3/8</th>
<th>1/2</th>
<th>3/4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>K</td>
<td>L</td>
<td>M</td>
<td>K</td>
</tr>
<tr>
<td>1</td>
<td>0.138</td>
<td>0.118</td>
<td>N/A</td>
<td>0.036</td>
</tr>
<tr>
<td>2</td>
<td>N/A</td>
<td></td>
<td></td>
<td>0.130</td>
</tr>
<tr>
<td>3</td>
<td>N/A</td>
<td>0.275</td>
<td>0.177</td>
<td>0.159</td>
</tr>
<tr>
<td>4</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Pressure Loss in Fittings

Pressure Loss in Fittings and Valves Expressed as Equivalent Length of Tube, feet

<table>
<thead>
<tr>
<th>Nominal or standard size, inches</th>
<th>Fittings</th>
<th>Valves</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standard Ell</td>
<td>90° Tee</td>
</tr>
<tr>
<td></td>
<td>90°</td>
<td>45°</td>
</tr>
<tr>
<td>3/8</td>
<td>.5</td>
<td>–</td>
</tr>
<tr>
<td>1/2</td>
<td>1</td>
<td>.5</td>
</tr>
<tr>
<td>5/8</td>
<td>1.5</td>
<td>.5</td>
</tr>
<tr>
<td>3/4</td>
<td>2</td>
<td>.5</td>
</tr>
<tr>
<td>1</td>
<td>2.5</td>
<td>1</td>
</tr>
<tr>
<td>1-1/4</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>1-1/2</td>
<td>4</td>
<td>1.5</td>
</tr>
<tr>
<td>2</td>
<td>5.5</td>
<td>2</td>
</tr>
<tr>
<td>2-1/2</td>
<td>7</td>
<td>2.5</td>
</tr>
<tr>
<td>3</td>
<td>9</td>
<td>3.5</td>
</tr>
<tr>
<td>3-1/2</td>
<td>9</td>
<td>3.5</td>
</tr>
<tr>
<td>4</td>
<td>12.5</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>16</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>19</td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td>29</td>
<td>11</td>
</tr>
</tbody>
</table>

NOTES: Allowances are for streamlined soldered fittings and recessed threaded fittings. For threaded fittings, double the allowances shown in the table. The equivalent lengths presented above are based upon a C factor of 150 in the Hazen-Williams friction loss formula. The lengths shown are rounded to the nearest half foot.
Pressure Loss for Gravity

Pressure will be lost in lifting the water to the highest point in the system.

To account for this, multiply the elevation of the highest point, in feet, by the factor 0.434, the pressure exerted by a 1-foot column of water.

This will give the pressure in psi needed to raise the water to that level.

For DES, the difference in height of about 40 feet reduces the available pressure by 18 psi \( (40 \times 0.434 = 17.36) \).
Pressure Loss Total

Approximately 10 3/8” elbows and connectors per heat exchanger is equivalent of 5 ft. of tubing. This is only about a 0.2 psi loss, but allow 1.0 psi.

The camera is at least 40 feet from the ground, so allow about 100 feet of 1/2” tubing (each way) to the refrigeration unit. This is about a 7.0 psi loss, but recalculate for 3/8” tubing to allow for thicker walls, so use 26 psi.

The pressure loss from gravity is 18 psi. (But may be recovered on the return trip?)

Worst case loss should be about 45 psi.
CONCLUSION

• The calculations above are for water, but we will need a water-alcohol mixture to avoid freezing.

• We will need a refrigeration unit which can dissipate 1500 W at a flow of 2 GPM and output 45psi at 10°C.