(2) Product $\Delta h_f = 207 \times 10^3$ J/kg

$$\phi_p = 2800 \times 27.2 \times \left[\frac{3.6\times10^6}{1010} \times (10 - -1) + 207\times10^3 + \frac{1.9\times10^6}{1010}(-1 - -20)\right] / (24\times3600)$$

$$= 76160[39.2\times10^3 + 207\times10^3 + 35.7\times10^3] / 86400$$

$$= 248.5\times10^3 \text{ W} = 248.5 \text{ kW}$$

Lights

$$\phi_l = 550 \times \tfrac{10}{24} = 229 \text{ W} = 0.2 \text{ kW (negligible)}$$

Fans

$$Q = 8 \times 2.2 \times 1.55 \times 3.2 = 87.3 \text{ m}^3/\text{s}$$

$$\Delta p = 54 \times \tfrac{248}{25.4} = 527 \text{ Pa}$$

$$\phi_f = 87.3 \times 527 / (0.63 \times 0.93) = 78600 \text{ W} = 78.6 \text{ kW}$$

Operational time = 167 of 168 hours - treat as continuous operation and ignore any effect of defrost

Mechanical devices - Nil

People :- low temp, allow 450 W/person

$$\phi_{pe} = 2 \times 0.45 \times {}^{10}/_{24} = 0.4 \text{ kW (negligible)}$$

Infiltration

$$\text{Area} = 2(4\times20 + 8\times4 + 8\times20) = 544 \text{ m}^2$$

Room volume = $4\times8\times20 = 640 \text{ m}^3$. Assume $E_i = 1.3$

$$\phi_i = \frac{0.026}{0.15} \times 544(-16 - -35) \times 1.3 = 2330 \text{ W}$$

Air interchange

$$Q = 0.5 \times 2 \times 1 \times 1.05 = 1.05 \text{ m}^3/\text{kg}$$

At -35°C, any RH $\rho_a = 1.48$ kg/m^3

If RH is unknown usually assume about 70%

-35°C, 70% RH $\Rightarrow$ $h_i = 66$ kJ/kg

-16°C, 70% RH $\Rightarrow$ $h_o = 85$ kJ/kg

$$\phi_{ai} = 1.05 \times 1.48 \times (85 - 66) = 29.5 \text{ kW}$$

$$\phi_a = 29.5 \times {}^{10}/_{24} = 12.3 \text{ kW}$$

Structure cooling - Nil

Total heat load = 248.5 + 0.2 + 78.6 + 0.4 + 2.3 + 12.3 = 342 kW on 24h basis