1. Purpose: Find - (a) Quantity of Air Supplied
(b) States
(c) Psychrometric Chart
(d) Req. capacity of unit
(e) Amount of liquid drained

Drawings:

SEE ATTACHED

Sources:

Cengel + Boles "Thermodynamics - An Engineering Approach" 8TH Edition

Design Consideration:

- Cooling and Dehumidifying process is ideal
- No influence of outside air
- Constant humidity from states

Data + Variables:

$T_{db} = 75°F$ $\phi = 50\%$

$Q_{IN} = 72{,}000\ Btu/hr$

$\dot{V} = 500\ cfm$

$T_{db\,(OUTSIDE)} = 90°F$ $\phi = 60\%$

PROCEDURE:

- USING PSYCHOMETRIC CHART, FIND ALL STATES
- CALC $\dot{m}$ ~~AT~~ STATE 2
- CALC ϕ
- CALC $\dot{m}_w$

CALCULATIONS:

0

$T_{db} = 90°F$

$\phi = 60\%$

$h_0 \approx 41.8 \ Btu/lbm$

$\omega_0 \approx 0.0182 \ \frac{lbm \ H_2O}{lbm \ AIR}$

$v_0 \approx 14.25 \ ft^3/lb$

$\dot{m}_0 = \frac{cfm}{v} = \frac{500}{14.25}$

$\dot{m}_0 = 35.08$

1

$\phi = 100\%$

$\omega_1 =$

$\dot{m}_1 =$

$h_1 =$

2

$\phi_2 = 100\%$

$\omega_2 = 0.0094$

$T_{db} \approx 55°F$

$v_2 \approx 13.1 \ ft^3/lb$

$h_2 \approx 23.3 \ Btu/lbm$

3

$T_{db_3} = 75°F$

$\phi_3 = 50\%$

$h_3 \approx 28.4 \ Btu/lbm$

$\omega_3 \approx 0.0094 \ \frac{lbm \ H_2O}{lbm \ AIR}$

$v_3 \approx 13.7 \ ft^3/lb$

4

$T_{db_4} = 78°F$

$\phi_4 = 50\%$

$h_4 \approx h_4$

$\omega_4 \approx \omega_4$

$v_4 \approx v_4$

5

$\dot{V}_5 = 500 \ cfm$

$\phi_5 = 50\%$

$\omega_5 \approx \omega_5$

$h_5 \approx h_5$

$v_5 \approx v_5$

$\dot{m}_5 = 36$

$\dot{Q} = \dot{m}(h_3 - h_2)$

$72000 = \dot{m}(28.4 - 23.3)$

$72000 = \dot{m}(5.1)$

$\dot{m} = 14117.6 \left(\frac{1}{60}\right)$

$\dot{m} = 235$ lb AIR/min

$\dot{V} = v_2 \dot{m}$

$(13.1)(235)$

$= \boxed{3078.5 \text{ cfm}}$

$m_1 h_1 = m_0 h_0 + m_4 h_4$

$\hookrightarrow h_1 = \dfrac{m_4 h_4 + m_0 h_0}{m_1}$

$\left\{ \begin{array}{ll} m_4 = m_3 - m_5 & \rightarrow 235 - 36 \\ & = 199 \text{ lbm/min} \\ m_1 = m_4 + m_0 & \rightarrow 199 + 35.08 \\ & = 234.08 \end{array} \right\}$

$h_1 = \dfrac{m_4 h_4 + m_0 h_0}{m_1}$

$= \dfrac{199(28.4) + (35.08)(41.8)}{234.08}$

$h_1 = 30.41$ Btu/lbm

$$\dot{m}_4 \omega_4 + \dot{m}_0 \omega_0 = \dot{m}_1 \omega_1$$

$$\hookrightarrow \omega_1 = \frac{\dot{m}_4 \omega_4 + \dot{m}_0 \omega_0}{\dot{m}_1}$$

$$= \frac{199(0.0094) + 35.08(0.0182)}{234.08}$$

$$\boxed{\omega_1 = 0.01072 \frac{lb_{H_2O}}{lb_{AIR}}}$$

$$\dot{m}_w = \dot{m}_1 (\omega_1 - \omega_1)$$

$$= 234.08 (0.01072 - 0.0094)$$

$$\boxed{\dot{m}_w = 3089 \frac{lb}{min}}$$

$$\dot{Q} = \dot{m}_1 (h_1 - h_1)$$

$$= 235 (20.41 - 23.3)$$

$$\boxed{= 1670.85 \frac{Btu}{min}}$$

Materials:

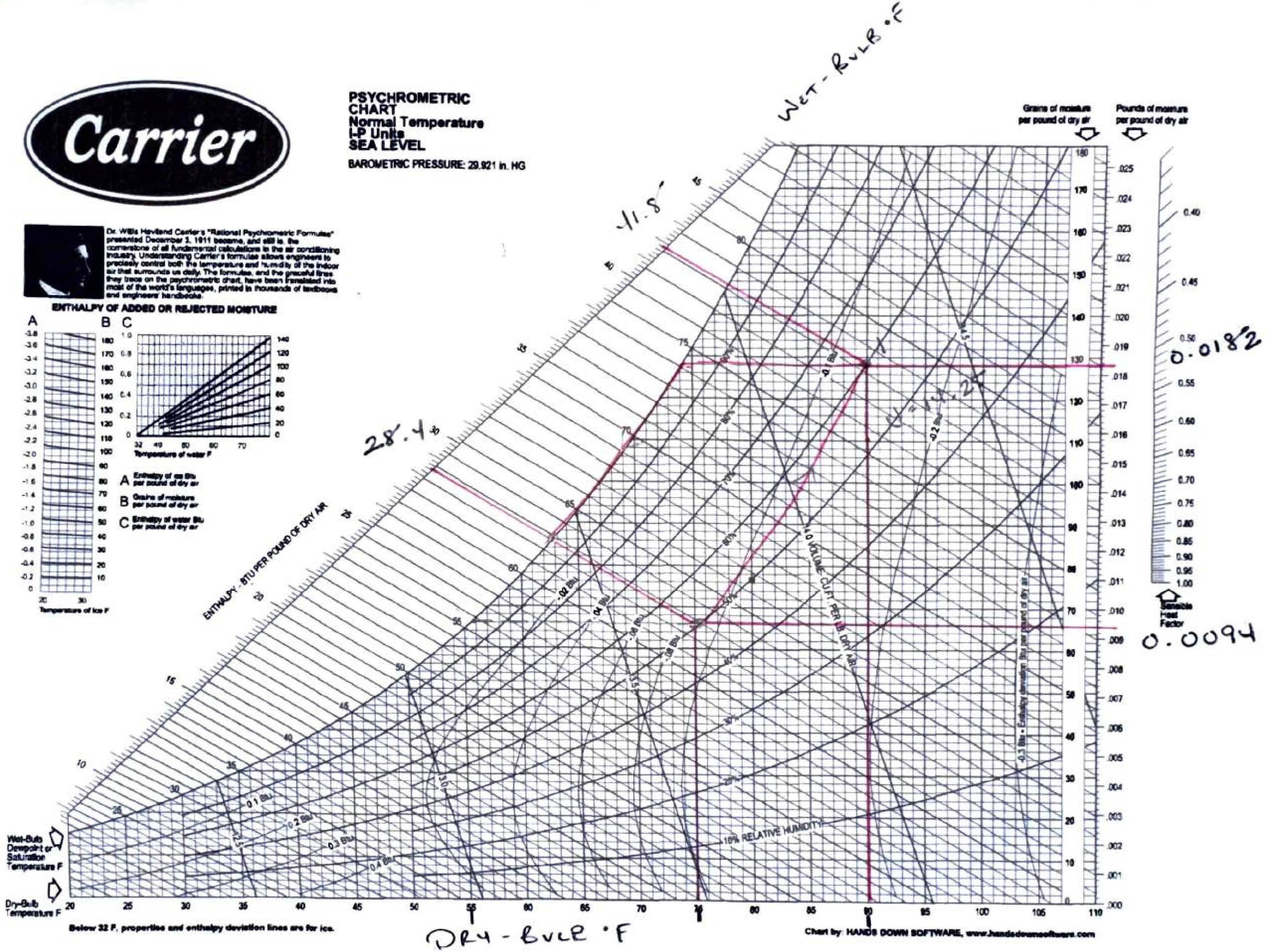
- Air
- Cooling + Dehemidifying unit
- Fan

SUMMARY.

PROBLEM 1 TESTED STUDENTS' KNOWLEDGE OF FINDING AND SOLVING DIFFERENT PARTS OF A COOLING AND DEHUMIDIFYING SYSTEM. ALSO TESTED HOW WELL WE UNDERSTOOD USING A PSYCHOMETRIC CHARTS.

ANALYSIS:

THE DESIGN ALLOWS FOR COOLING AND DEHUMIDIFYING OF A CONTROLLED SPACE. THE BIGGEST PROBLEM I RAN INTO, WAS USING THE CHART ITSELF. FROM WHAT I KNOW, I TRIED TO FIND AND USE CORRECT VALUES


Carrier
PSYCHROMETRIC CHART
Normal Temperature
I-P Units
SEA LEVEL
BAROMETRIC PRESSURE: 29.921 in. HG
Dr. Willis Haviland Carrier's "Rational Psychrometric Formulae" presented December 3, 1911 became, and still is, the cornerstone of all fundamental calculations in the air conditioning industry. Understanding Carrier's formulae allows engineers to precisely control both the temperature and humidity of the indoor air that surrounds us daily. The formulae, and the graceful lines they trace on the psychrometric chart, have been translated into most of the world's languages, printed in thousands of textbooks and engineers' handbooks.
ENTHALPY OF ADDED OR REJECTED MOISTURE
Temperature of ice F
Temperature of water F
A Enthalpy of ice Btu per pound of dry air
B Grains of moisture per pound of dry air
C Enthalpy of water Btu per pound of dry air
ENTHALPY - BTU PER POUND OF DRY AIR
Grains of moisture per pound of dry air
Pounds of moisture per pound of dry air
Sensible Heat Factor
14.0 VOLUME CU.FT. PER LB. DRY AIR
10% RELATIVE HUMIDITY
Wet-Bulb Dewpoint or Saturation Temperature F
Dry-Bulb Temperature F
Below 32 F, properties and enthalpy deviation lines are for ice.
Chart by: HANDS DOWN SOFTWARE, www.handsdownsoftware.com
WET-BULB °F
11.8
28.4
0.0182
0.0094
DRY-BULB °F

2\.

PURPOSE :

USING VALUES FROM PROBLEM 1, FIND ALL STATES OF THE EVAPORATOR AND COMPRESSOR. ALSO THE COP, MASS FLOW RATE, POWER REQ. AND HEAT WASTE

DRAWINGS : SEE P-v + T-s DIAGRAMS

SOURCES : CENGEL + BOLES "THERMODYNAMICS - AN ENGINEERING APPROACH" 8TH EDITION

DESIGN CONSIDERATION :

EVAPORATOR (SUPERHEATED) 2.7°C

CONDENSOR (SUBCOOLED) 6.8°C

$\eta = 0.8$

R-134A

DATA + VARIABLES :

+/- 10°C difference of air in + out the evaporator + condensor

2. VAPOR - COMPRESSOR REFRIGERATION

R-134 A

R-134 A LEAVES EVAP $T_{EXIT} = 2.7°C$ (SUPERHEATED)

R-134 A LEAVES CONDENSOR $T_{EXT} = 6.3°C$ (SUBCOOLING)

$\eta_c = 80\% = 0.80$

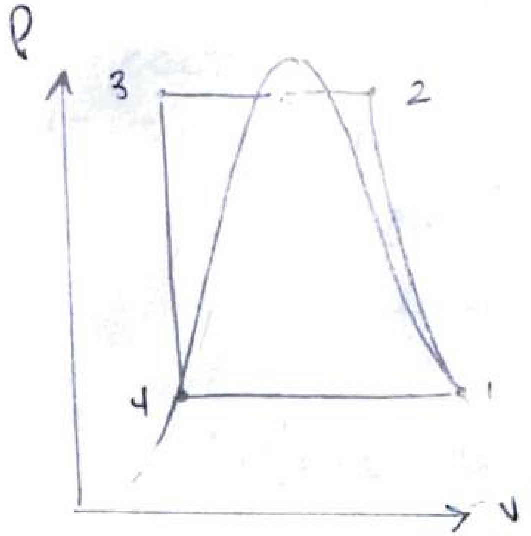
Assumptions:

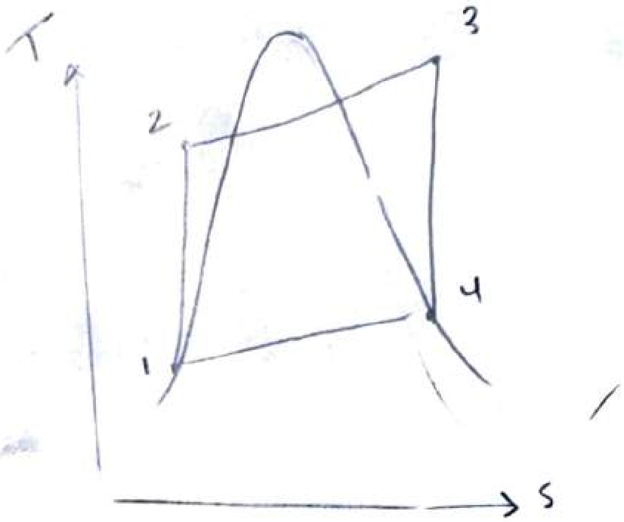
INDOOR TEMP. = 25°C

OUTDOOR TEMP. = 35°C

EVAP. TEMP. = 10°C P = 414.89 kPa

CONDENS. TEMP. = 40°C P = 1017.1 kPa





1 (EXIT EVAP) SUPERHEATED

$T_1 = 12.7°C$

$P_1 = 414.89$ kPa

$h_1 = 257.71$ kJ/kg

$s_1 = 0.925$ kJ/kg-K

2 (COMP EXIT) ACT

2s (EXIT INSENTROPIC) COMP

$P_{2s} = 1017.1$ kPa

$s_{2s} = s_1$

$T_{2s} = 42.02°C$

$h_{2s} = 273.96$ kJ/kg

3 (COND EXIT) SUBCOOLED

$T_3 = 33.7°C$

$P_3 = 1017.1$ kPa

$h_3 = 107.93$ kJ/kg

4 (EXIT EXPANSION VALVE)

$P_4 = 414.89$ kPa

$h_4 = h_3$

PROCEDURE:

1) DRAW P-v and T-s DIAGS
2) GATHER ALL STATE INFO
3) CALC. COP
4) CALC. $\dot{m}$
5) CALC. POWER REQ OF COMP (HP)
6) CALC. RATE OF WASTE HEAT

CALCULATIONS:

$$\eta_s = (h_{2s} - h_1) / (h_2 - h_1)$$

$$\hookrightarrow h_2 = h_1 + (h_{2s} - h_1) / \eta_s$$

$$= 257.71 \frac{(273.96 - 257.71)}{0.8}$$

$$= 342.45 \text{ kJ/kg}$$

$$X_4 = (h_4 - h_f) / h_{fg}$$

$$= \frac{(107.93 - 22.83)}{85.10}$$

$$\boxed{X_4 = 1}$$

$$COP = \frac{q_{IN}}{W_{IN}} = \frac{h_1 - h_4}{h_2 - h_1} = \frac{257.71 - 107.93}{342.45 - 257.71}$$

$$\boxed{= 1.76}$$

Assume $\dot{Q} = 5\text{kW}$

$$\dot{m} = \frac{\dot{Q}}{q_{IN}} = \frac{5000}{h_1 - h_4} = \frac{5000}{257.71 - 107.93}$$

$$\boxed{= 0.0334 \text{ kg/s}}$$

$$\dot{W} = \dot{m}(h_2 - h_1)$$

$$= 0.0334\,(342.45 - 257.71)$$

$$= 2.83 \text{ kW}$$

$$\rightarrow \boxed{3.79 \text{ HP}}$$

$$\dot{Q}_{OUT} = \dot{m}(h_2 - h_3)$$

$$= 0.0334\,(342.45 - 107.93)$$

$$\boxed{= 7.83 \text{ kW}}$$

MATERIALS:

R-134A

SUMMARY:

PROBLEM 2 TESTS OUR ABILITY TO SOLVE VAPOR COMPRESSION CYCLES.

ANALYSIS:

THE CYCLE LOOKS TO BE EFFECTIVE. THIS SYSTEM SEEMS TO HAVE A LARGE AMOUNT OF HEAT WASTE.