Homework #1 Solution

Problem 1.4 - Estimate the size of cooling and heating equipment that is needed for a new bank building in middle America that is 140 ft by 220 ft by 12 ft high.

\[
\text{Area}_{\text{floor}} := 140\text{ ft} \times 220\text{ ft} \times 12\text{ ft} = 3.08 \times 10^4 \text{ ft}^2
\]

\[
\text{Volume} := (140\text{ ft})(220\text{ ft})(12\text{ ft}) = 3.696 \times 10^5 \text{ ft}^3
\]

From Table 1.1 - AC for bank \(\sim 250\text{ ft}^2/\text{ton}\) and heating for bank \(\sim 3.0\text{ Btu/hr-ft}^3\)

\[
\text{Cooling}_{\text{est}} := \text{Area}_{\text{floor}} \div 250\text{ ft}^2/\text{ton} = 123.2\text{ ton}
\]

\[
\text{Heating}_{\text{est}} := \text{Volume} \times \left(3.0\frac{\text{BTU}}{\text{hr-ft}^3}\right) = 1.109 \times 10^6 \text{ BTU/hr}
\]

ANSWERS

Problem 2.51 - Given room conditions of 75°F dry bulb and 60% rh, determine the air vapor mixture (a) humidity ratio, (b) enthalpy, (c) dew-point temperature, (d) specific volume, and (e) degree of saturation without using the psychrometric charts.

(a) Assume atmospheric conditions so \(P_m = 14.7\text{ psia}\)

\[
\phi := 0.60 \quad t := 75\text{-degF} \quad P_m := 14.7\text{-psi} \quad \text{degF} := 1\cdot\text{R}
\]

\[
P_w := 0.43008\text{-psi} \quad P_m := 14.7\text{ psi} \quad P_w := 0.258\text{ psi}
\]

\[
W := 0.62198 \times \frac{P_w}{P_m - P_w} \quad W = 0.011 \text{ lbmv/lbma}
\]

(b) \(h := 0.24\frac{\text{BTU}}{\text{lb-R}} \times t + W \left(1061\frac{\text{BTU}}{\text{lb}} + 0.45\frac{\text{BTU}}{\text{lb-R}} \times t\right) \quad h = 30.167\text{ BTU/lb}
\]

(c) \(t_d = t_{\text{sat}}(P_{\text{sat}}=0.258\text{ psia})\) from steam tables (pg. 2.9) \(t_d = 60.2\text{ F}
\]

(d) \(T := t + 460\cdot\text{R} \quad T = 535\text{ R} \quad \text{Temperature needs to be absolute for ideal gas law}
\]

\[
R_a := 53.34\frac{\text{ft-lbf}}{\text{lb-R}} \quad P_a := P_m - P_w \quad P_a = 14.442\text{ psi}
\]

\[
v := \frac{R_a \cdot T}{P_a} \quad v = 13.722\text{ ft}^3/\text{lb} \quad \text{units are actually ft}^3/\text{lbma}
\]

(e) \(W_s := 0.62198 \times \frac{P_{ws}}{P_m - P_{ws}} \quad W_s = 0.019 \text{ lbmv/lbma}
\]

\[
\mu := \frac{W}{W_s} \quad \mu = 0.593
\]
Problem 2.54 - Using the ASHRAE Psychrometric Chart complete the following table:

<table>
<thead>
<tr>
<th>Dry Bulb</th>
<th>Wet Bulb</th>
<th>Dew Point</th>
<th>Humidity Ratio</th>
<th>Relative Humidity</th>
<th>Enthalpy</th>
<th>Specific volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>F</td>
<td>F</td>
<td>lbv/lba</td>
<td>%</td>
<td>Btu/lba</td>
<td>ft^3/lba</td>
</tr>
<tr>
<td>80</td>
<td>64</td>
<td>53.7</td>
<td>0.009</td>
<td>41</td>
<td>29.2</td>
<td>13.8</td>
</tr>
<tr>
<td>70</td>
<td>55</td>
<td>43</td>
<td>0.0058</td>
<td>38</td>
<td>23.1</td>
<td>13.47</td>
</tr>
<tr>
<td>100</td>
<td>78</td>
<td>70</td>
<td>0.0158</td>
<td>39</td>
<td>42</td>
<td>14.47</td>
</tr>
<tr>
<td>97</td>
<td>76.5</td>
<td>68.5</td>
<td>0.0151</td>
<td>40</td>
<td>40</td>
<td>14.36</td>
</tr>
<tr>
<td>79</td>
<td>65</td>
<td>57</td>
<td>0.01</td>
<td>47</td>
<td>30</td>
<td>13.8</td>
</tr>
<tr>
<td>86</td>
<td>60</td>
<td>40</td>
<td>0.0052</td>
<td>20</td>
<td>26.4</td>
<td>13.86</td>
</tr>
<tr>
<td>40</td>
<td>29</td>
<td>(can't read)</td>
<td>0.001</td>
<td>20</td>
<td>10.8</td>
<td>12.6</td>
</tr>
<tr>
<td>74.5</td>
<td>65</td>
<td>60</td>
<td>0.011</td>
<td>60</td>
<td>30</td>
<td>13.7</td>
</tr>
<tr>
<td>85</td>
<td>69.5</td>
<td>62</td>
<td>0.012</td>
<td>47</td>
<td>33.8</td>
<td>14</td>
</tr>
<tr>
<td>80</td>
<td>80</td>
<td>80</td>
<td>0.0224</td>
<td>100</td>
<td>43.8</td>
<td>14.1</td>
</tr>
</tbody>
</table>

Problem 2.57 - Without using the psychrometric chart, determine the humidity ratio and relative humidity of an air-water vapor mixture with a dry bulb temperature of 90°F and thermodynamic wet bulb temperature of 78°F. The barometric pressure is 14.7 psia.

\[ P_m := 14.7 \text{ psi} \quad t_{wb} := 78 \text{ degF} \quad t_{db} := 90 \text{ degF} \]

\[ P_{ws90} := 0.69889 \text{ psi} \quad \text{From steam tables (pg. 2.9) at 90F} \]

\[ P_{ws78} := 0.47510 \text{ psi} \quad \text{From steam tables(pg. 2.9) at 78F} \]

\[ W_s := \frac{P_{ws78}}{P_m - P_{ws78}} \quad W_s = 0.021 \]

\[ W := \left( \frac{287}{t_{wb}} - 0.556 \frac{t_{wb}}{\text{degF}} \right) W_s + 0.24 \left( \frac{t_{db} - t_{wb}}{\text{degF}} \right) \]

Eqn. 2-27b

\[ W = 0.018 \text{ lbmv/lbma} \]

\[ P_w := \frac{P_m W}{0.62198 + W} \quad P_w = 0.412 \text{ psi} \]

\[ \phi := \frac{P_w}{P_{ws90}} \quad \phi = 0.59 \]

\[ W = 0.018 \text{ lbmv/lbma and } \phi = 59\%. \]