

$$\omega_m = (.7) \left( .01154 \frac{lb_w}{lb_{da}} \right) + (.3) \left( .0078 \frac{lb_w}{lb_{da}} \right) = .0104 \frac{lb_w}{lb_{da}}$$

Use the psychrometric chart once more to find the relative humidity for the mixed air condition which is now fully defined.

$$\phi_m = 68\%$$

**Answer D**

**41.16 At what temperature will moisture begin to condense out of atmospheric air being cooled from 200°F and 10% relative humidity?**

- A. 101°F
- B. 107°F
- C. 109°F
- D. 117°F

The temperature at which moisture will begin to condense out of air is called the Dew Point Temperature. See **dew-point temperature** in the reference handbook. Use the **high temperature psychrometric chart**. The condition is fully defined. Locate the state point, then follow horizontally to the left until reaching the saturation curve to read the dew point temperature.

$$T_{dp} \approx 107^\circ F$$

**Answer B**

**41.17 The combustion products from an industrial process are passed through a heat exchanger for energy recovery at 30psia. The humidity ratio is  $800 \frac{grains H_2O}{lb_{da}}$ . What is the dew point of the exhaust stream?**

- A. 130°F
- B. 140°F
- C. 150°F
- D. 160°F

Calculate the humidity ratio of the combustion products. Assume the products are similar to moist air i.e. the mixture is comprised of dry air and water vapor. There are 7,000 **grains of moisture** per pound of water.

$$\omega = \frac{800grains}{lb_{da}} \left( \frac{1lb_w}{7000grains} \right) = .1143 \frac{lb_w}{lb_{da}}$$

If the conditions were for standard atmospheric pressure, it would be permissible to use the psychrometric chart and simply follow a horizontal line to the left and read the corresponding dew point temperature for the specified humidity ratio. However, the exhaust stream is at an elevated pressure of  $30\text{psia}$  for which no psychrometric chart is available. Therefore, an alternative approach is to find the partial pressure of water vapor corresponding to the humidity ratio, and use the steam table to find the saturation temperature of water at that pressure. This is another way of defining the dew point.

Use the definition of the humidity ratio based on absolute pressure,  $p$ , and partial pressure of water vapor,  $p_w$ . Rearrange algebraically for  $p_w$  and solve:

$$\omega = \frac{0.622p_w}{(p - p_w)} \rightarrow \omega(p - p_w) = 0.622p_w \rightarrow \omega p - \omega p_w = 0.622p_w$$

$$\omega p = 0.622p_w + \omega p_w \rightarrow \omega p = p_w(\omega + 0.622) \rightarrow p_w = \frac{\omega p}{(\omega + 0.622)}$$

$$p_w = \frac{(.1143)(30)}{(.1143 + 0.622)} = 4.7\text{psia}$$

Go into the steam table by searching **Properties of Saturated Water** (by pressure) and interpolate between the saturation temperatures corresponding to  $P = 4\text{psi}$  and  $P = 5\text{psi}$ .

Pressure	Temperature
$4\text{psi}$	$152.9^\circ F$
$4.7\text{psi}$	$T_{dp}$
$5\text{psi}$	$162.1^\circ F$

$$\frac{4.7\text{psi} - 4\text{psi}}{5\text{psi} - 4\text{psi}} = \frac{T_{dp} - 152.9^\circ F}{162.1^\circ F - 152.9^\circ F}$$

$$T_{dp} \approx 159.3^\circ F$$

**Answer D**