PROBLEM 11.32.

KNOWN: p-v-T data for saturated ammonia are available from Table A-13E.

FIND: Determine at 20°F $h_{fg}$, $u_{fg}$, $s_{fg}$, and compare with table values.

ANALYSIS: From Table A-13 $h_{fg} = 552.95$ Btu/lb, $u_{fg} = 500.46$ Btu/lb, $s_{fg} = 1.1528$ Btu/lb °R.

The value of $h_{fg}$ can be determined from saturated p-v-T data using the Clapeyron equation, Eq. 11.40: $h_{fg} = T rac{dP}{dT}$ at $T_s$.

A graphical method can be used to obtain $(dP/dT)_s$ at $T_s$, as follows:

![Graphical method diagram]

Inserting values into Eq. (1)

$$h_{fg} = \left(479.67 \times 0.01\right) \frac{150.9 \text{ Btu/lb}}{9 \text{ ft}^2/\text{lb}} = 546.7 \text{ Btu/lb}$$

Then, with Eq. 11.38

$$s_{fg} = \frac{h_{fg}}{T} = \frac{546.7}{479.67 \text{ °R}} = 1.1397 \text{ Btu/} \text{lb °R}$$

Time now $h = u + p v$

$$u_{fg} = h_{fg} - p v = 546.7 - \frac{48.72 \times 1.1397 \times 9 \text{ Btu}}{1778.17 \text{ ft}^2/\text{lb}} = 494.2 \text{ Btu/lb}$$

Each of these is about 1% less than the corresponding table value. The values obtained using the graphical approach are sensitive to the accuracy of the slope $(dP/dT)_s$ determined graphically, as above.

Alternatively, an IT solution like that of Example 11.4 can be employed.
Problem 11-32 continued

\[\begin{align*}
IT \text{ Code} \\
T &= 20 \degree \text{F} \\
dT &= 0.01 \\
T1 &= T - dT \\
T2 &= T + dT \\
\end{align*}\]

\[\begin{align*}
p2 &= \text{Psat}_T(\text{"Ammonia"}, T2) \\
p1 &= \text{Psat}_T(\text{"Ammonia"}, T1) \\
dpdT_{\text{sat}} &= ((p2 - p1) / (T2 - T1)) \times 144 \\
p &= \text{Psat}_T(\text{"Ammonia"}, T) \\
v_g &= \text{vsat}_Px(\text{"Ammonia"}, p, 1) \\
v_f &= \text{vsat}_Px(\text{"Ammonia"}, p, 0) \\
h_{fg} &= ((T + 459.67) \times (v_g - v_f) \times dpdT_{\text{sat}}) / 778.17 \\
s_g &= \text{ssat}_Px(\text{"Ammonia"}, p, 1) \\
s_f &= \text{ssat}_Px(\text{"Ammonia"}, p, 0) \\
s_{fg} &= h_{fg} / (T + 459.67) \\
u_{fg} &= h_{fg} - p \times (v_g - v_f) \times 144 / 778.67 \\
\end{align*}\]

\[\begin{align*}
IT \text{ Results} \\
(\partial p/\partial T)_{\text{sat}} &= 152.5 \text{ lbf/ft}^2 \cdot \degree \text{R} \\
h_{fg} &= 552.6 \text{ Btu/lb} \\
s_{fg} &= 1.152 \text{ Btu/lb} \cdot \degree \text{R} \\
u_{fg} &= 500.2 \text{ Btu/lb} \\
\end{align*}\]