I.

a) Find $\eta_{TURBINE}$

	T	P	H	S
Point 2	600 C	1000 kPa	3697.4	8.0292
Point 3	350°C	75 kPa	3176.1	8.5191
Isentropic Base Case 3	?	75 kPa	?	8.0292
Point 4	91.79	75 kPa	384.451	1.2131
Point 1	~91.79	1000 kPa	$384.451 + W_{s,PUMP}$	~1.2131

Interpolate for Isentropic base case at point 3

T	~~S~~	H
200	7.9697	2876.6
?	8.0292	?
225	8.0712	2925.8

$$\frac{8.0292 - 7.9697}{8.0712 - 7.9697} = \frac{H_3' - 2876.6}{2925.8 - 2876.6}$$

$$H_3' = 2905.4$$

$$W_{S,TURBINE} = 3176.1 - 3697.4 = -521.3$$

$$W_{S,TURBINE}' = 2905.4 - 3697.4 = -792.0$$

$$\boxed{\eta_{TURBINE} = \frac{521.3}{792} = 0.658}$$

b) find η_{cycle}

Need $W_{S,NET}$; $W_{s,PUMP}$ & Q_H

$$W_{s,PUMP} = V^L(1000 - 75) = 1.037 \frac{cm^3}{gr}(925 \text{ kPa}) = 959 \frac{cm^3\text{-kPa}}{gr}$$

$$959 \frac{cm^3\text{-kPa}}{gr} = \cancel{0.959}\ 959 \times 10^3 \frac{cm^3\text{-kPa}}{kg} \times \frac{8.3145 /mole°K}{8314\ cm^3\text{-kPa}/mole°K} \times \frac{1000 \text{ kJ}}{J} = 0.959 \text{ kJ}/kg$$

$$W_{S,NET} = -521.3 + 0.959 = \boxed{-520.34}$$

$\cancel{B}$ $H_1 - H_4 = 0.959$

$H_1 = 0.959 + 384.451$

$H_1 = 385.41$

$Q_H = 3697.4 - 385.41$

$Q_H = 3312.0$

$$\boxed{\eta_{cycle} = \frac{520.34}{3312.0} = 0.157}$$

II.

First guess, $P_2 = \sqrt{20 \times 500} = 100$ psia

$W_{s1}' = 132 - 113 = 19$

$W_{s1} = 19/0.75 = 25.33$

$H_2 = 113 + 25.3 = 138.3$

$W_{s2}' = 126 - 109 = 17$

$W_{s2} = 22.7$ ~~$H_2 = 131.7$~~

$W_{s,TOTAL} = 48.0$

Second guess

$P_2 = 150$ psia

$W_{s1}' = 138 - 113 = 25$

$W_{s2}' = 118 - 107 = 11$

$W_{s,TOTAL} = 36/0.75 = 48$

Third guess $P_2 = 80$ psia

$W_{s1}' = 130 - 113 = 17$

$W_{s2}' = 130 - 110 = 20$

$W_{s\,TOTAL} = 37/0.75 = 49.3$

$T_2 = 255°F$

$P_2 = 100$ psia

$T_3 = 110°F$

$P_3 = 100$ psia

$T_4 = 278°F$

$P_4 = 500$ psia

Clearly, little difference. Use $P_2 = 100$ psia

$$\boxed{\begin{array}{l}\text{For } P_2 = 100 \text{ psia} \\ W_{S_1} + W_{S_2} = 48.0 \text{ BTU/lbm}\end{array}}$$

b) heat load $= \Delta H_{2\to 3}$

$H_{2,\text{ACTUAL}} = 138.3$

$H_{3,\text{ACTUAL}} = 109$

$$\boxed{\Delta H = Q = 29.3 \text{ BTU/lbm}}$$

R-500

Blue = actual
Red = isentropic base case

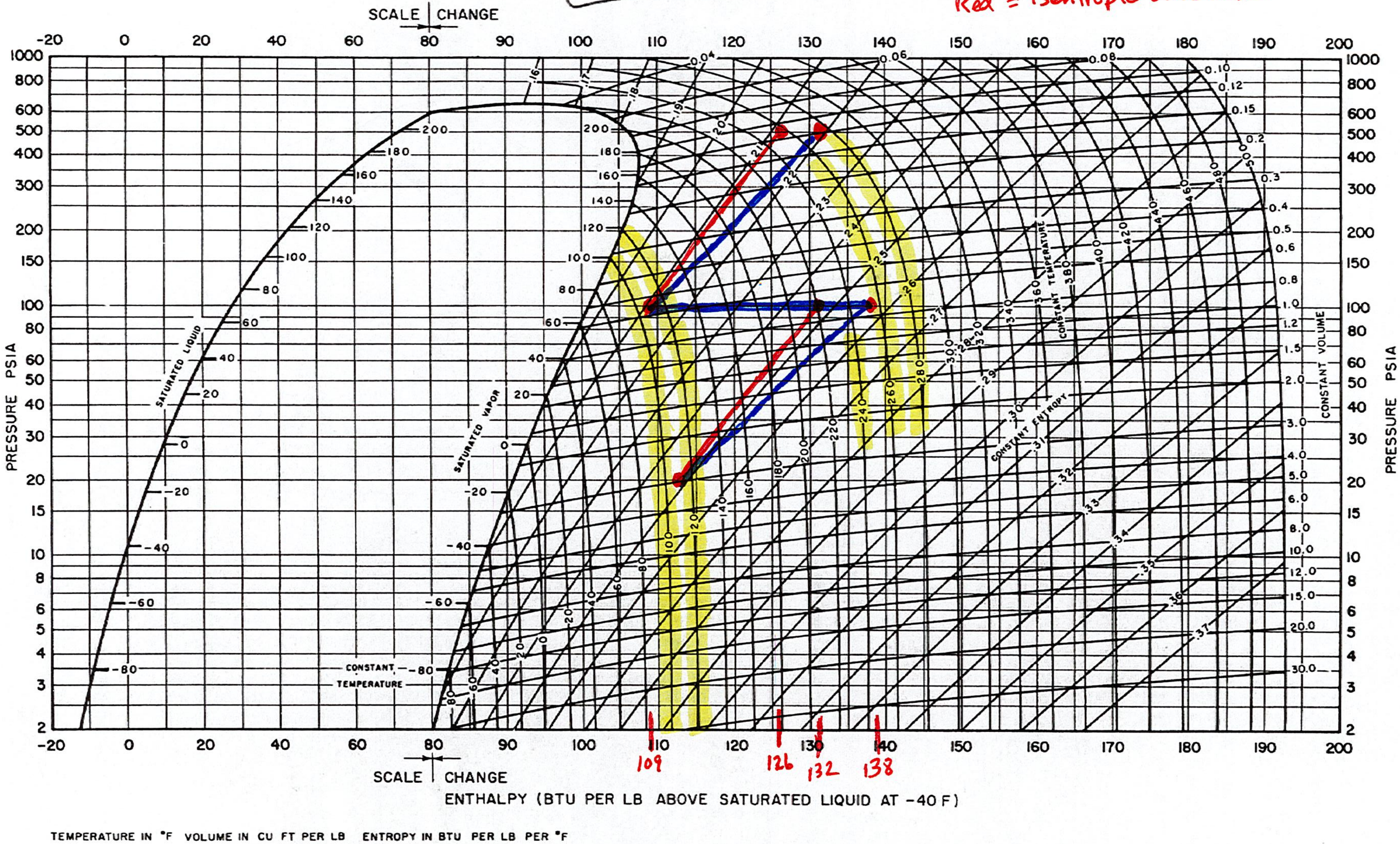

Fig. 9-11. Pressure-enthalpy diagram for refrigerant R-500. Note that 0 of enthalpy scale is taken at −40 °F (−40 °C). Also note that enthalpy scale changes at 80 Btu per lb. to help technician read superheat values.