Problem 14-15

The overhead vapor from the C_2 splitter in Fig. 3-13 is partially condensed in E-601. The process conditions for the vapor entering the condenser are:

Temperature	-30.1ºC (sat.)
Pressure	1945.8 kPa (sat.) (changed from 2944 kPa)
Flow rate into condenser	
CH_4	3×10^{-3} kg/s
C_2H_4	64.52 kg/s
C_2H_6	6.26×10^{-2} kg/s

A shell-and-tube exchanger has been selected for this heat transfer process to condense 73.5% of the overhead vapor. Use an appropriate software package (based on TEMA guidelines) to obtain the overall heat-transfer coefficient and the area required for the condensation if the tubes have an outside diameter of 0.0127 m and an inside diameter of 0.0094 m. Assuming that the maximum length of the tubes is 3.05 m, how many tubes will be required and what shell diameter is recommended? Propylene at -46 ºC serves as the coolant for the condensation process. Additional Questions: Identify the largest resistance to heat transfer in the exchanger and determine the total purchase cost of the exchanger in Feb 2025.

Important Note: There is a typo in the process conditions listed in the problem statement. At -30.1 ºC and 2944 kPa the overhead vapor would be completely condensed, and this is not feasible for overhead vapors leaving a distillation column. To fix this issue, we flash the stream at -30.1 ºC while fixing the vapor fraction to 1 in CHEMCAD, giving the correct process stream pressure of 1945.806 kPa. There is another typo in Fig. 3-13. The correct temperature is -30.1 ºC, not -46 °C.

Problem 14-16

Air used in a catalytic oxidation process is to be heated from 15 to 270 ºC before entering the oxidation chamber. The heating is accomplished with the use of product gases, which cool from 380 to 200 ºC. A steel one-pass shell-and-tube heat exchanger with cross-flow on the shell side has been proposed. The average absolute pressure on both the tube side and the shell side is 1010 kPa, with the hot gases being sent through the tubes. The flow rate for the air has been set at 1.9 kg/s. The inside and outside diameters for the tubes are 0.0191 and 0.0254 m, respectively. The tubes will be arranged in line with a square pitch of 0.0381 m. The exchanger operates for 8000 h/yr. The properties of the hot gases can be considered identical to those of air. The cost data for the exchanger are given in Fig. 14-19.

Installation costs are 15 percent of the purchased cost, and annual fixed charges including maintenance are 20 percent of the installed cost. The cost for power delivered is \$0.12/kWh. Under these conditions, determine the most appropriate tube length and the purchased cost for the optimum heat exchanger.