[414.371 Offshore Equipment, 2019 Spring Semester, Prof. Yutaek Seo]

3-stage Separator

1. What is 3-stage separation?

Stage separation is a process in which hydrocarbon mixtures are separated into vapor and liquid phases by multiple equilibrium flashes at consecutively lower pressures. A two-stage separation requires one separator and a storage tank, and a three-stage separation requires two separators and a storage tank. The storage tank is always counted as the final stage of vapor-liquid separation. Stage separation reduces the pressure a little at a time, in steps or stages, resulting in a more stable stock-tank liquid. Usually a stable stock-tank liquid can be obtained by a stage separation of not more than four stages.

Although three to four stages of separation theoretically increase the liquid recovery over two-stage separation, the incremental rarely pay out the cost of the additional separators. It has been generally recognized that two stages of separation plus the stock tank are practically optimum. The increase in liquid recovery for two-stage separation over single-stage separation usually varies from 2% to 12%, although 20% to 25% increases in liquid recoveries have been reported.

The first-stage separator operating pressure is generally determined by the flow line pressure and operating characteristics of the well. Pressures at low-stage separations can be determined based on equal pressure ratios between the stages (Campbell, 1976).

2. Examples of Separation stages

[Figure 1] deals with a simple single-stage process. That is, the fluids are flashed in an initial separator and then the liquids from that separator are flashed again at the stock tank. Traditionally, the stock tank is not normally considered a separate stage of separation, though it most assuredly is. [Figure 2] shows a 3-stage separation process. The liquid is first flashed at an initial pressure and then flashed at successively lower pressures two times before entering the stock tank.

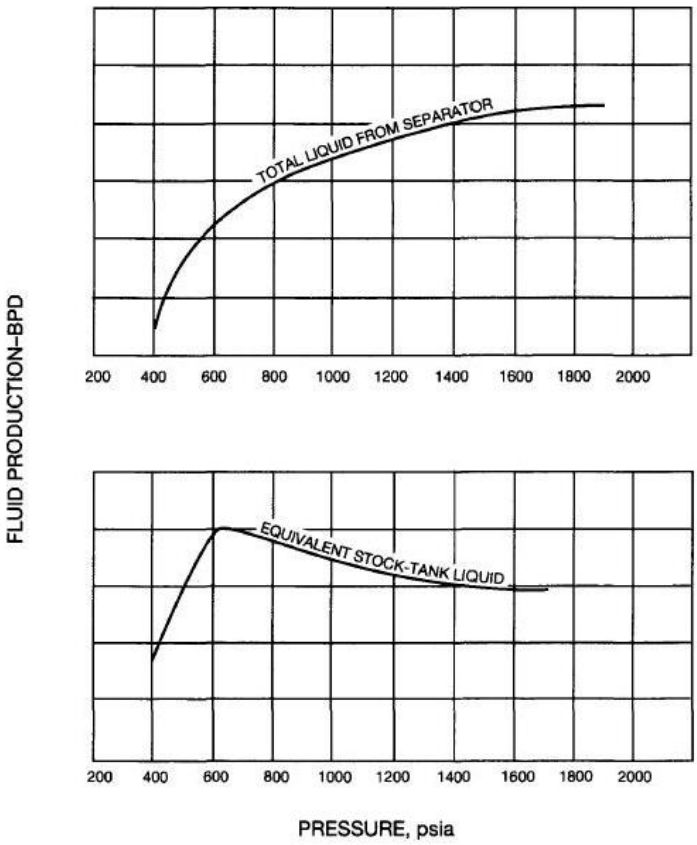

Figure 1. Effect of separator pressure on stock-tank liquid recovery

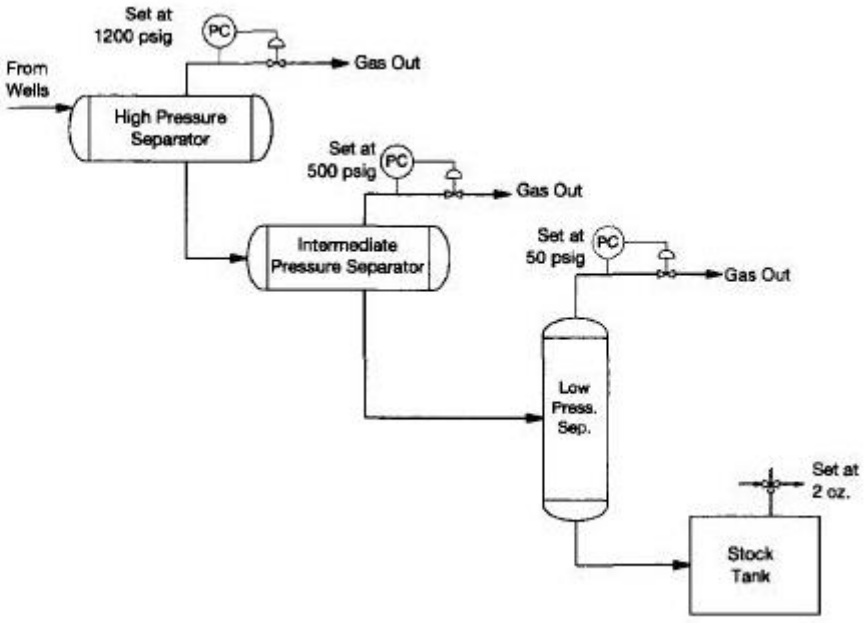

Figure 2. Stage separation

Because of the multi component nature of the produced fluid, it can be shown by flash calculations that the more stages of separation after the initial separation the more light components will be stabilized into the liquid phase. This can be understood qualitatively by realizing that in a stage separation process the light hydrocarbon molecules that flash are removed at relatively high pressure, keeping the partial pressure of the intermediate hydrocarbons lower at each stage. As the number of stages approaches infinity, the lighter molecules are removed as soon as they are formed and the partial pressure of the intermediate components is maximized at each stage. The compressor horsepower required is also reduced by stage separation as some of the gas is captured at a higher pressure than would otherwise have occurred. This is demonstrated by the example presented in Table 1.

Case	Separation Stages psia	Liquid Produced bopd	Compressor Horsepower Required
I	1215, 65	8,400	861
II	1215, 515, 65	8,496	497
III	1215, 515, 190, 65	8,530	399

Table 1. Effect of separation pressure for a rich condensate stream

3. Exercises

(1) Refer to the given 1-stage separation Hysys file, construct a 3-stage separation process with Hysys. (The inlet condition of crude oil and the outlet condition of export gas are same as 1-stage file.)

(2) Compare the composition and flow rates of the 1-stage product and the newly constructed 3-stage product.

(3) Compare the economic value of the product with the recent appropriate oil price.