APÉNDICE C

DESIGN AND SIZING CALCULATIONS

C.1 Sizing of Two-Phase Oil-Gas Separators. The following calculations are presented as a guide to the design and sizing of two-phase and three-phase separators. Sizing should be based on the maximum expected instantaneous rate.

C.1.1 Theory and Equations — Gas capacities of separators may be determined by a modification of Stokes' Law. When using Stokes' Law, the capacity is based on the principle of the minimum droplet size that will settle out of a moving gas stream at a given velocity. The maximum allowable superficial velocity of the gas at operating conditions is calculated by the following formula: (See Appendix D for separator sizing example calculation.)

$$V_a = K\sqrt{\frac{d_L - d_G}{d_G}} \qquad \text{Equation C.1.1}$$

Where: V_a = Maximum allowable superficial velocity in feet per second through the secondary separation section

d_L = Density of the liquid in pounds per cubic foot at operating conditions

d_G = Density of the gas in pounds per cubic foot at operating conditions

K = A constant depending upon design and operating conditions

TABLE C.1
K FACTORS FOR DETERMINING MAXIMUM ALLOWABLE SUPERFICIAL VELOCITY

Type Separator	Height or Length L (Feet)	Typical K Factor Range
Vertical	5	0.12 to 0.24
	10	0.18 to 0.35
Horizontal	10	0.40 to 0.50
	Other Lengths	$0.40 \text{ to } 0.50 \times (L/10)^{0.56}$
Spherical	All	0.2 to 0.35

C.1.2 The maximum allowable superficial velocity calculated from the above factors is for separators normally having a wire mesh mist extractor. This rate should allow all liquid droplets larger than 10 microns to settle out of the gas. The maximum allowable superficial velocity or other design criteria should be considered for other type mist extractors. Mist extractor manufacturer's recommended minimum distances upstream and downstream of the wire mesh between gas inlet and outlet nozzles should be provided for full utilization of the mist extractor.

C.1.3 The oil capacity of a separator is a function of retention time and gas-oil interface area. The basic requirement is to retain the oil long enough and provide sufficient interface area for entrained gas to break out of the oil. Separator liquid capacity is normally based on one minute retention time for non-foaming oils having a gravity of 35° API and above. A gravity lower than 35° API may require a greater retention time.

C.1.4 Foaming crudes offer a special problem in sizing separators. Foam is a mixture of gas dispersed in a liquid and having a density less than the liquid but greater than the gas. Greater interface area and longer retention time are needed to remove the gas from the liquid. Horizontal separators normally give the largest interface area. Retention times of as high as 15 minutes may be necessary. However, a retention time of 2 to 5 minutes is sufficient in most cases for the separators to handle foaming crudes. Where the well can be sampled in a test unit, a more accurate estimate of the required retention time can be determined. Defoaming separator designs often include a variety of proprietary internal configurations to improve capacity. These are beyond the scope of this specification.

C.1.5 In addition to the well stream properties, the gas capacity is influenced by the following:

a. Operating temperature being above the cloudpoint of oil

b. Operating temperature being above hydrate point of gas

c. Foaming tendency of liquid

d. Uniformity of flow

e. Defoaming chemicals; if used

C.1.6 The liquid capacity of a separator is primarily dependent upon the retention time of the liquid in the vessel. Good separation requires sufficient time to obtain an equilibrium condition between the liquid and gas phase at the temperature and pressure of separation. The liquid capacity of a separator or the settling volume required based on retention can be determined from the following equation:

$$W = \frac{1440\,(V)}{t} \text{ or } t = \frac{1440\,(V)}{W} \text{ or } V = \frac{W\,(t)}{1440}$$

Equation C.1.6

Where: W = Liquid capacity, bbl/day at flowing conditions

V = Liquid settling volume, bbl

t = Retention time, minutes

C.1.7 Basic design criteria for liquid retention time in two-phase separators are generally as follows:

Oil Gravities	Minutes (Typical)
Above 35° API	1
20 — 30° API	1 to 2
10 — 20° API	2 to 4

C.1.8 The settling volumes may be used in the above equations to determine the liquid capacity of a particular vessel. For proper sizing, both the liquid capacity and gas capacity should be determined. It may be noted that on most high pressure gas distillate wells, the gas-oil ratio is high and the gas capacity of a separator is usually the controlling factor. However, the reverse may be true for low pressure separators used on wellstreams with low gas-oil ratios. The liquid discharge or dump valve on the separator should be sized based upon the pressure drop available, the liquid flow rate, and the liquid viscosity.

C.2 Sizing of Three-Phase Gas-Oil-Water Separators — The basic principles of oil and gas separation have been covered under Sizing of Two-Phase Oil-Gas Separators. The following portion will cover the separation of free water and oil:

C.2.1 All of the basic separators (vertical, horizontal, spherical) may be used for three-phase separation. Regardless of shape, all three-phase vessels must meet the following requirements:

a. Liquid must be separated from gas in a primary separating section.

b. Gas velocity must be lowered to allow liquids to drop out.

c. Gas must be scrubbed through an efficient mist extractor.

d. Water and oil must be diverted to a turbulence-free section of the vessel.

e. Liquids must be retained in the vessel long enough to allow separation.

f. The water-oil interface must be maintained.

g. Water and oil must be removed from the vessel at their respective outlets.

C.2.2 Sizing a three-phase separator for water removal is mainly a function of retention time. Required retention time is related to the volume of the vessel, the amount of liquid to be handled, and the relative specific gravities of the water and oil. The effective retention volume in a vessel is that portion of the vessel in which the oil and water remain in contact with one another. As far as oil-water separation is concerned, once either substance leaves the primary liquid section, although it may remain in the vessel in a separate compartment, it cannot be considered as a part of the retention volume. There are two primary considerations in specifying retention time:

a. Oil settling time to allow adequate water removal from oil

b. Water settling time to allow adequate oil removal from water

The usual approach in design is to allow equal retention times for oil and water. This is accomplished with a wide range interface level controller or variable water weir. Basic design criteria for liquid retention time in three-phase separators are generally as follows:

Oil Gravities	Minutes (Typical)
Above 35° API	3 to 5
Below 35° API	
100+°F	5 to 10
80+°F	10 to 20
60+°F	20 to 30