Introduction

- The fluid produced at the wellhead consists usually of gas, oil, free water and emulsified water.
- Before oil treatment, we must first remove the gas and free water from the well stream.
- This is essential in order to reduce the size of the oil-treating equipment.
- As presented in Chapters 4 and 5, the gas and most of the free water in the well stream are removed using separators.
- Gas, which leaves the separator, is known as "primary gas".
- Additional gas will be liberated during the oil treatment processes because of the reduction in pressure and application of heat.
- This gas known as "secondary gas" has to be removed.

Introduction

- The free water removed in separators is limited normally to water droplets of 500 μm and larger.
- The oil stream leaving the separator would normally contain free water droplets that are 500 μm and smaller in addition to water emulsified in the oil.
- This oil has yet to go through various treatment processes (dehydration, desalting, and stabilization) before it can be sent to refineries or shipping facilities.
- The objectives of dehydration process is first to remove free water and then break the oil emulsions to reduce the remaining emulsified water in the oil.

Introduction

Process Control & Safety

- Depending on the original water content of the oil as well as its salinity and the process of dehydration used, oil-field treatment can produce oil with a remnant water content of 1%.
- The remnant water is normally called the *bottom sediments and water* (B.S.&W.)
- The basic principles for the treating process are as follows:
  - Breaking the emulsion, which could be achieved by either any, or a combination of the addition of heat, the addition of chemical, or the application of electrostatic field.
  - Coalescence of smaller water droplets into larger droplets.
  - Settling, by gravity, and removal of free water.

Oil Emulsions

Process Control & Safety

- Rarely does oil production takes place without water accompanying the oil.
- Salt water is thus produced with oil in different forms as illustrated in Figure 1.
- Apart from free water, emulsified water (water-in-oil emulsion) is the one form that poses all of the concerns in the dehydration of crude oil.

Oil Emulsions

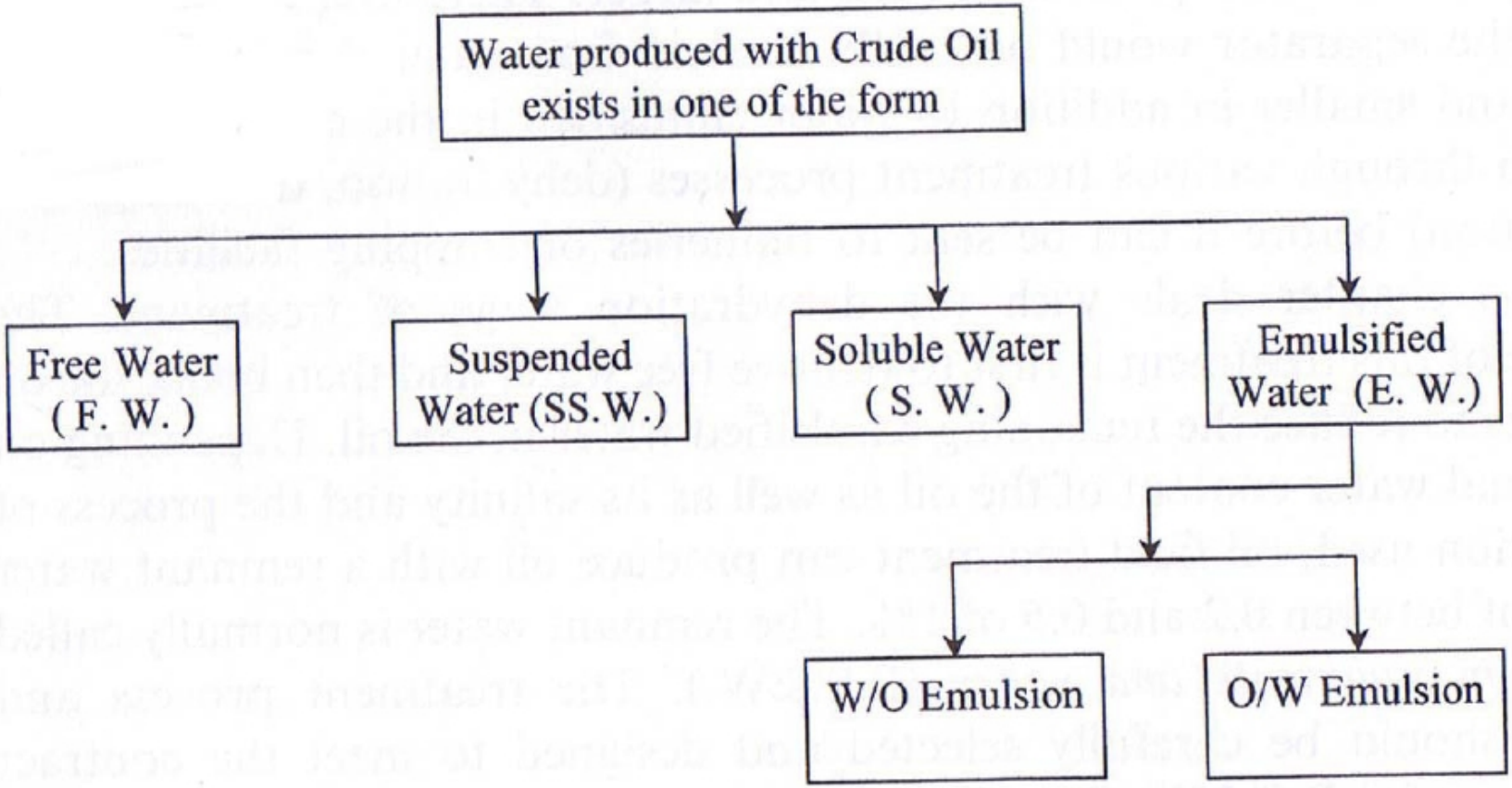


Figure 1 Forms of saline water produced with crude oil.

Oil Emulsions

Process Control & Safety

- Oil emulsions are mixtures of oil and water.
- In general, an emulsion can be defined as a mixture of two immiscible liquids, one of which is dispersed as droplets in the other, and is stabilized by an emulsifying agent.
- In the oil field, crude oil and water are encountered as the two immiscible phases together.
- They normally form water-in-oil emulsion (W/O emulsion), in which water is dispersed as fine droplets in the bulk of oil, as shown in Figure 2.

Oil Emulsions

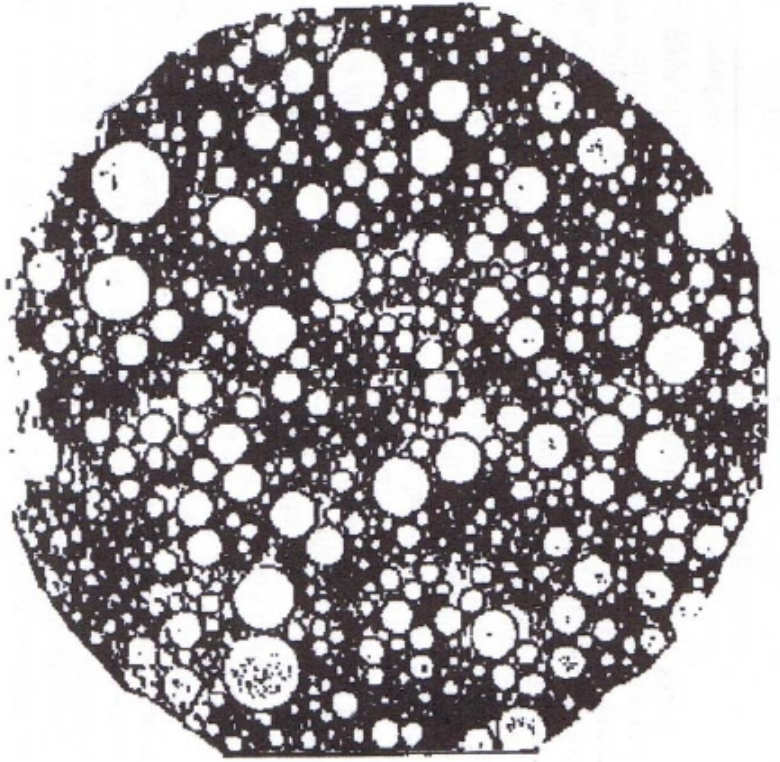


Figure 2 Photomicrograph of loose emulsion containing about 30% emulsified water in the form of droplets ranging in diameter from about 60 μm downward.

Dehydration/Treating Processes

Process Control & Safety

- The method of treating "wet" crude oil for the separation of water associated with it varies according to the form in which water is found with the crude.
- Free-water removal comes first in the treating process, followed by the separation of "combined" or emulsion water along with any foreign matter such as sand and other sediments.
- The basic approaches of handling "wet" crude oils are illustrated in Figure 3.

Dehydration/Treating Processes

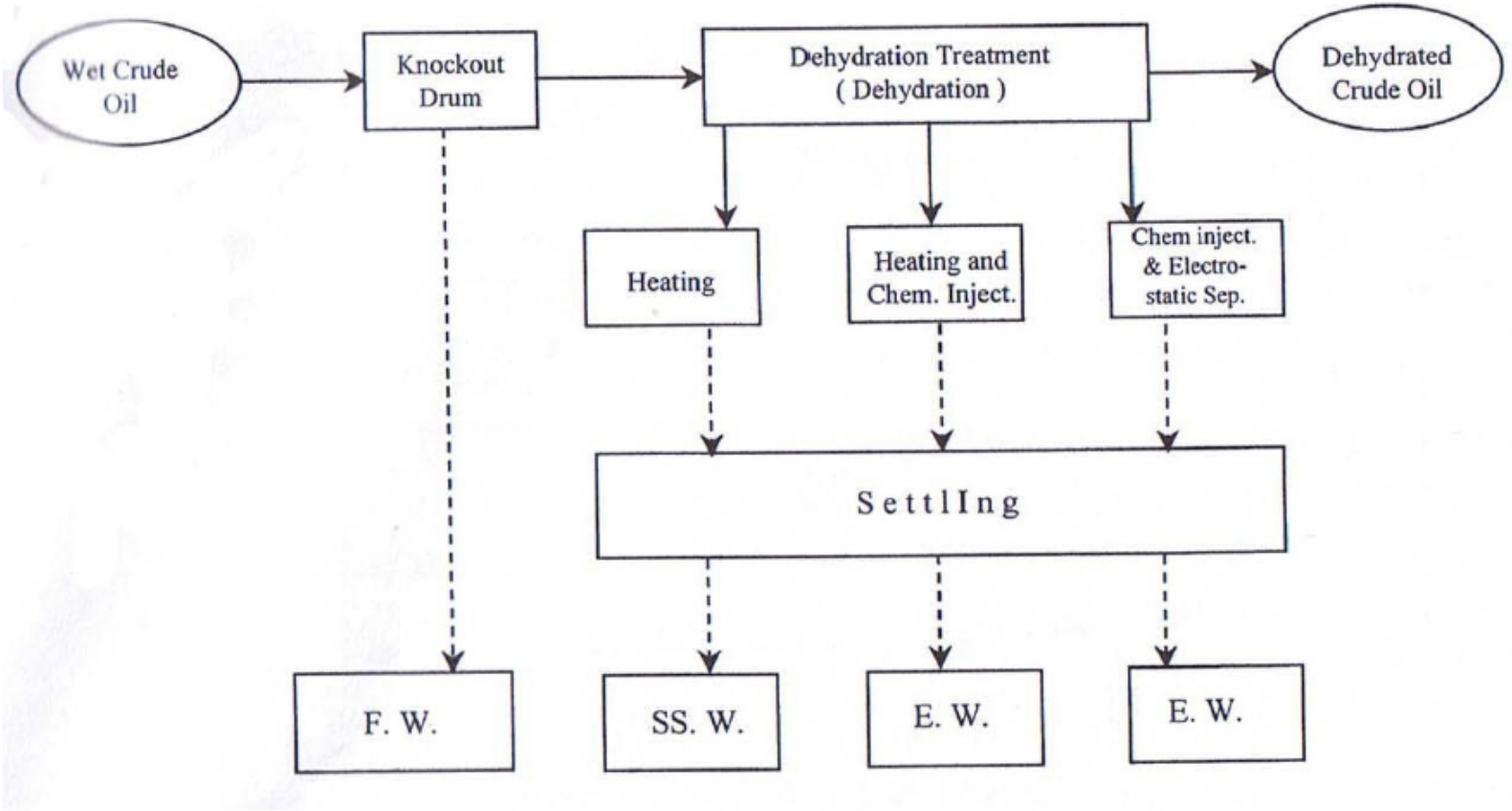


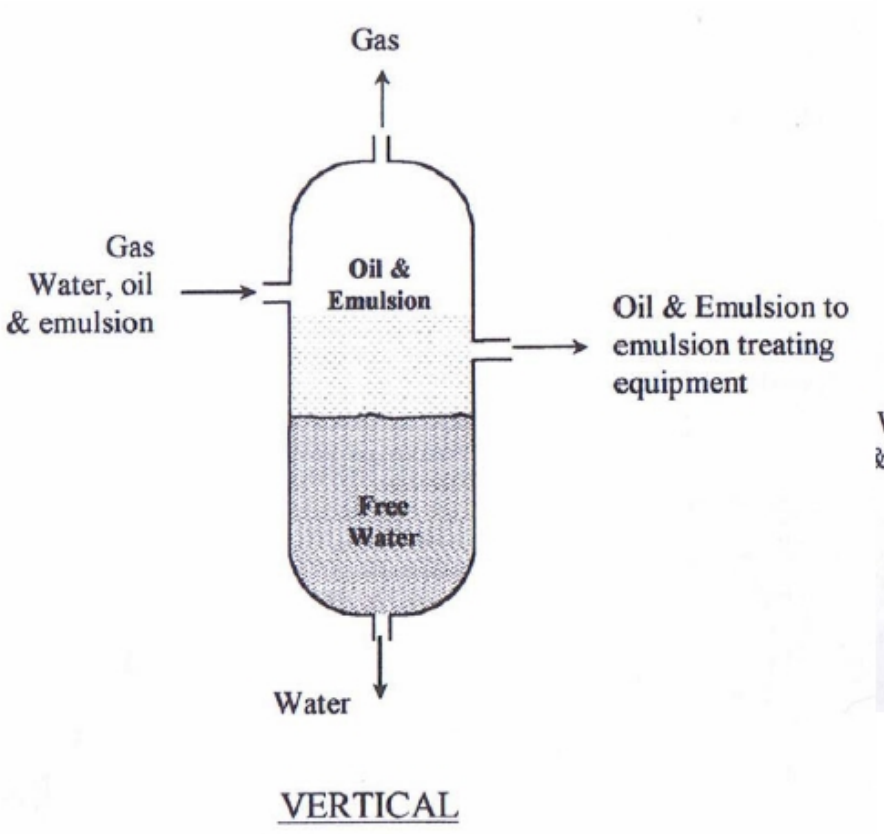
Figure 3 Basic approach of handling wet crude oil.

Removal of Free Water

Process Control & Safety

- Free water is simply defined as that water produced with crude oil and will settle out of the oil phase if given little time.
- There are several good reasons for separating the free water first:
  - Reduction of the size of flow pipes and treating equipment.
  - Reduction of heat input when heating the emulsion (water takes about twice as much heat as oil).
  - Minimization of corrosion because free water comes into direct contact with the metal surfaces, whereas emulsified water does not.
- Free water removal takes place using a knockout vessel, which could be an individual piece of equipment or incorporated in a flow treater.
- Figures 4 and 5 show some of the common types of two-phase and three-phase free-water knockout drums, respectively.

Removal of Free Water



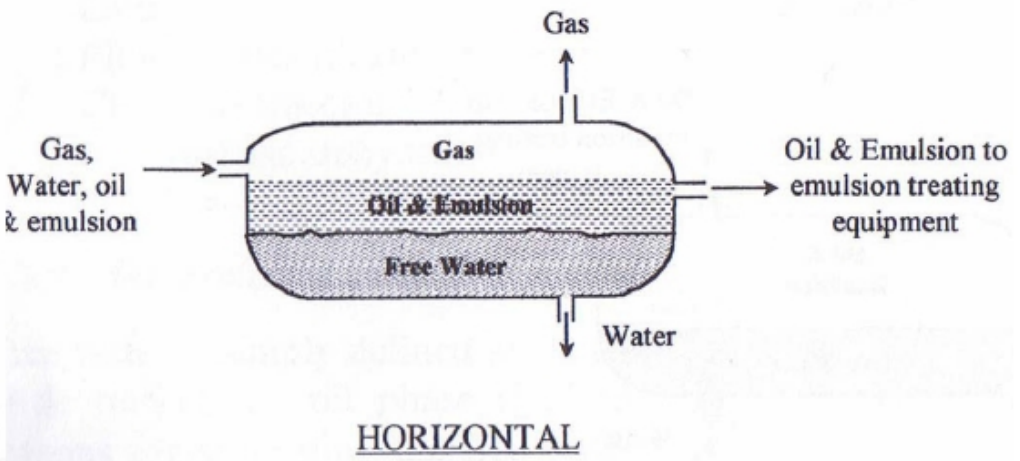


Figure 5 Three-phase free-water knockouts.

Removal of Free Water

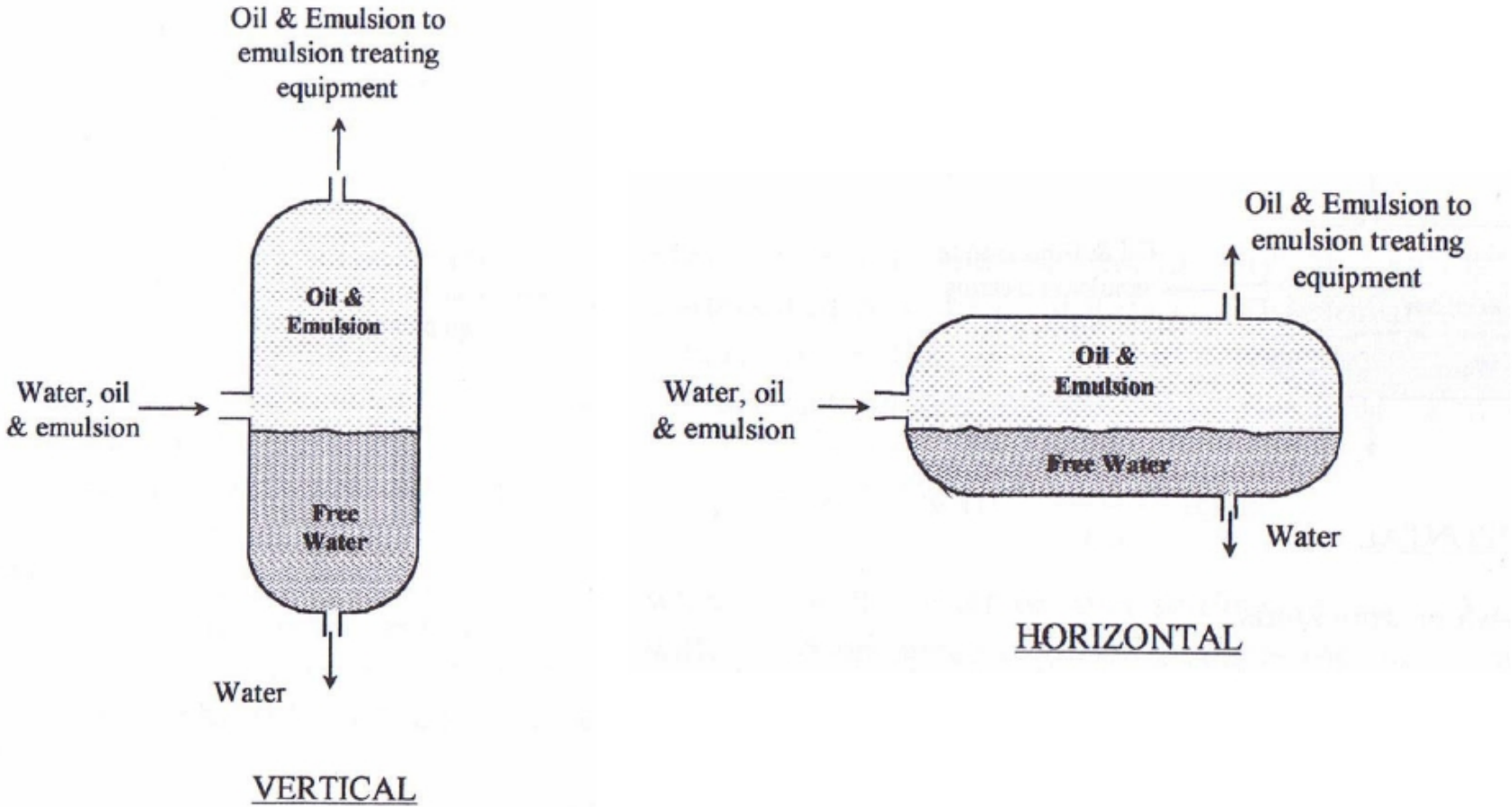


Figure 4 Two-phase free-water knockouts.

Resolution of Emulsified Oil

Process Control & Safety

- This is the heart of the dehydration process, which consists of three consecutive steps:
  1. *Breaking the emulsion:* This requires weakening and rupturing the stabilizing film surrounding the dispersed water droplets. This is destabilization process and is affected by using what is called an "aid", such as chemicals and heat.
  2. *Coalescence:* This involves the combination of water particles that became free water after breaking the emulsion, forming larger drops.
  3. *Gravitational settling and separation of water drops:* The larger water droplets resulting from the coalescence step will settle out of the oil by gravity and be collected and removed.

Treating the Emulsion

Process Control & Safety

- As explained earlier, using chemicals followed by settling can break some emulsions.
- Other emulsions require heating and allowing the water to settle out of the bulk of oil.
- More difficult (tight) emulsions require, however, both chemicals and heat, followed by coalescence and gravitational settling.
- Basically, a dehydration process that utilizes any or a combination of two or more of the treatment aids mentioned earlier (heating, adding chemicals) is used to resolve water-oil emulsions.

Heating

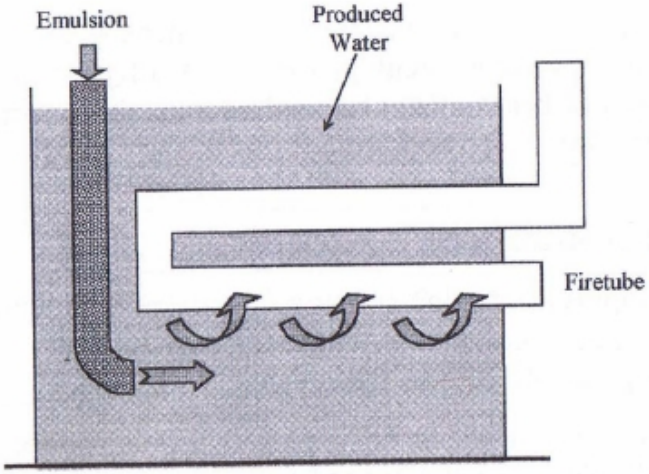
- Heating is the most common way of treating water-oil emulsions.
- The most significant effect is the reduction of oil viscosity with temperature.
- The viscosity of all types of crude oil drops rapidly with temperature, resulting in increasing the water droplet settling velocity and, thus, speeds and promotes the separation of water from the oil.

Methods of Heating Oil Emulsions

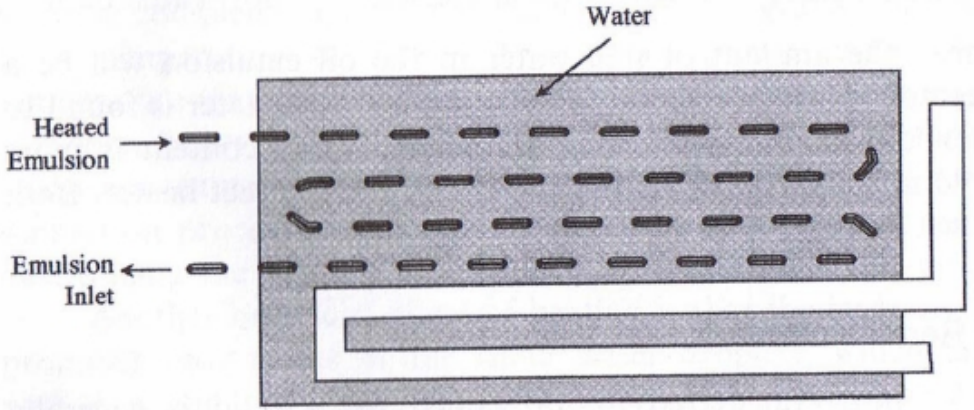
Process Control & Safety

- The fuel used to supply heat in oil-treating operations is practically natural gas. Under some special conditions, crude oil may be used.
- Heaters are generally of two basic types:
  1. *Direct heaters*, in which oil is passed through a coil exposed to the hot flue gases of the burned fuel or to introduce the emulsion into a vessel heated using a fire tube heater.
  2. *Indirect heaters*, in which heat is transferred from the hot flue gases to the emulsion via water as a transfer medium. The emulsion passes through tubes immersed in a hot water bath.
- In general, the amount of free water in the oil emulsion will be a factor in determining which method is to be used.
- If free water is found to be 1-2%, then use an indirect heater.
- If the free water content is more enough to hold a level around the fire tube, then use a direct heater.

Methods of Heating Oil Emulsions



Direct Heating



Indirect Heating

Figure 5 Methods of heating the emulsion.

Chemical Treatment

Process Control & Safety

- As mentioned earlier, some oil emulsions will readily break upon heating with no chemicals added.
- Others will respond to chemical treatment without heat.
- A combination of both "aids" will certainly expedite the emulsion-breaking process.
- Chemical additives, recognized as the second "aid" are special surface-active agents comprising relatively high-molecular-weight polymers.
- A deemulsifier, as it reaches to oil-water interface, function in the following pattern: flocculation, then film rupture, followed by coalescence.
- The faster the deemulsifier reaches the oil-water interface, the better job it achieves.