



Chapter 9

Produced Water Treatment



INTRODUCTION

- Production of water is usually associated with the production of crude oil and natural gas
- The produced water may be water that exists within the petroleum reservoir as connate water or bottom water.
- Water-flooding operations, water is injected into reservoir to enhance the recovery



Produced and treated water quality

- Produced water always has to be treated before it is disposed or injected into the reservoir.
- The purpose of the treatment is to remove enough oil from the water such that the remaining amount of oil in the water and the oil droplet size are appropriate for the disposal or injection of the water.



Equipment used

- The equipment used for water treatment serves the function of allowing the oil droplets to float to the surface of the water, where they are skimmed and removed



Water treatment equipment

- The main function of treating equipment is to separate the free oil droplets from the water; such equipments are:
 - Filters
 - Precipitators
 - Skim Tank and Vessels
 - Plate Coalescers
 - Serpentine-pipe Packs
 - Flotation units



Filters

- In this method, produced water is made to flow through a bed of porous medium, normally sand where the oil droplets are trapped in the filtering medium.



Precipitators

- In this method, the produced water is directed through a bed of porous material such as excelsior, placed inside a horizontal vessel that is similar in design to the three-phase separator to promote the coalescence of the oil droplets.



Skim Tanks and Vessels

- Used for primary treatment of produced water
- Pressure vessels are preferred over atmospheric tanks for the following reasons:
 - To avoid gas venting problems
 - To eliminate danger of over pressure
 - To eliminate the need of pumps



Skimmers

- Skimmers can be either horizontal (Figure 1) or vertical in configuration

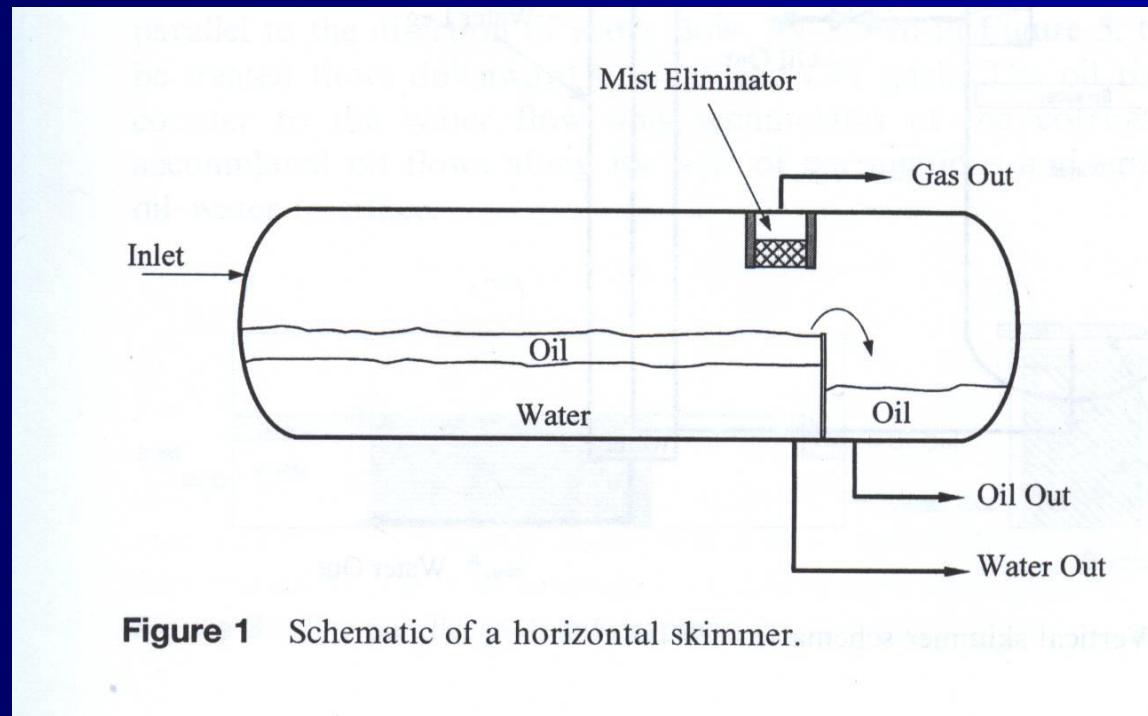


Figure 1 Schematic of a horizontal skimmer.



Vertical Skimmers

- Vertical skimmers are preferred over horizontal vessels when treating water containing sand or other solids
- (Figure 2)

Produced Water Treatment



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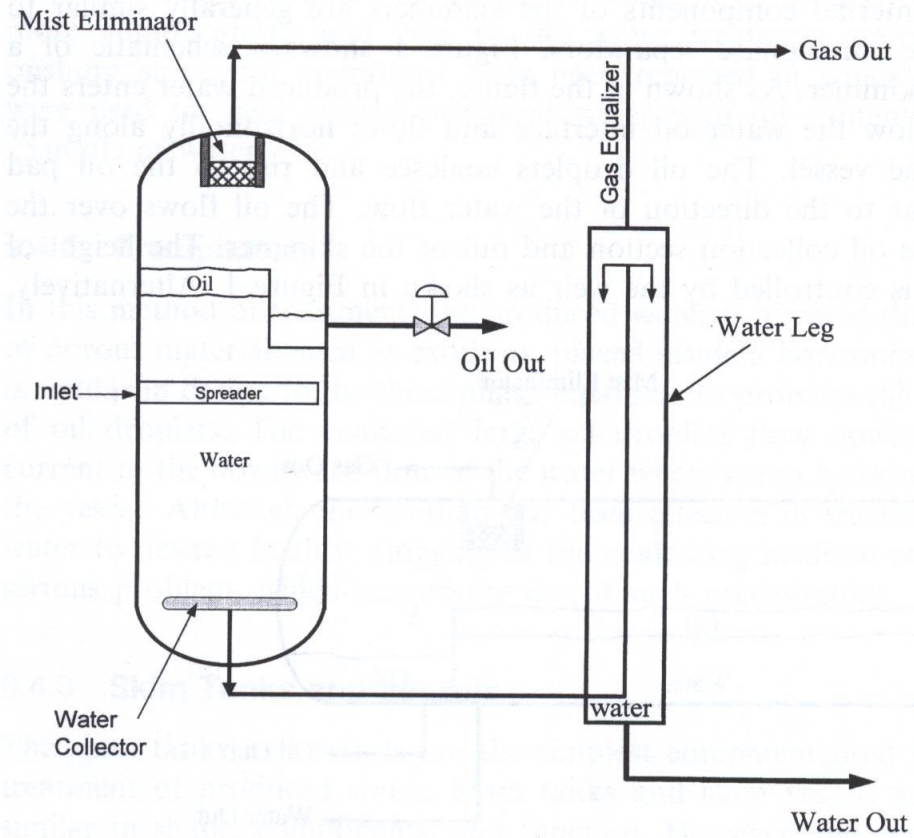


Figure 2 Vertical skimmer schematic.



Plate Coalescers

- Plate Coalescers consists of a set of parallel plates that are spaced a short distance apart and are inclined by an angle of 45 degree.
- Mainly there are two types
 - Parallel plate interceptors (PPI) (Fig. 3, 4)
 - Corrugated plate interceptors (CPI) (Fig. 5)



Parallel plate interceptor

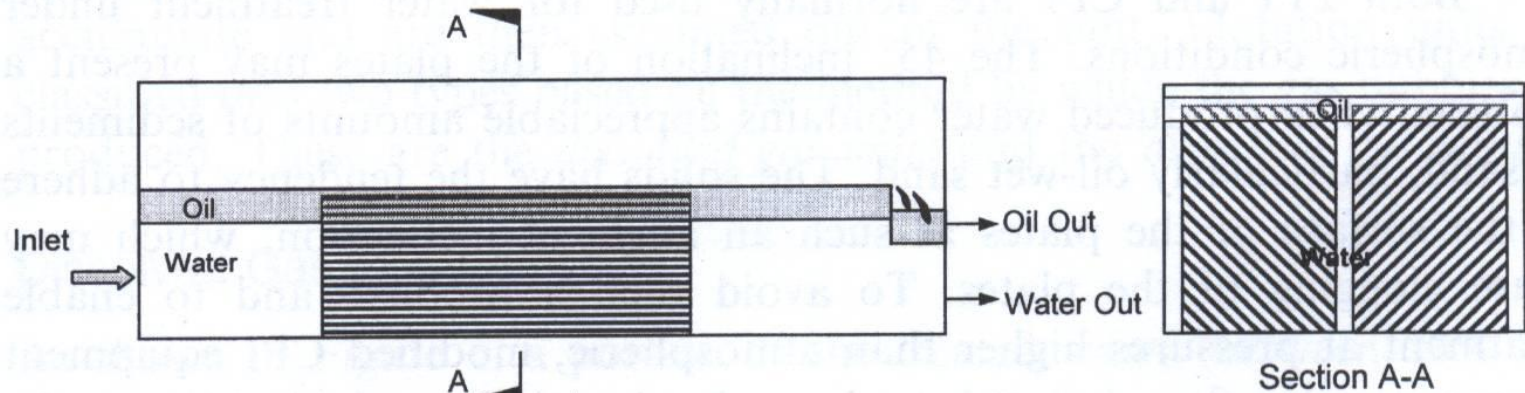


Figure 3 The parallel plate interceptor.



Inclined Parallel Plate Interceptors

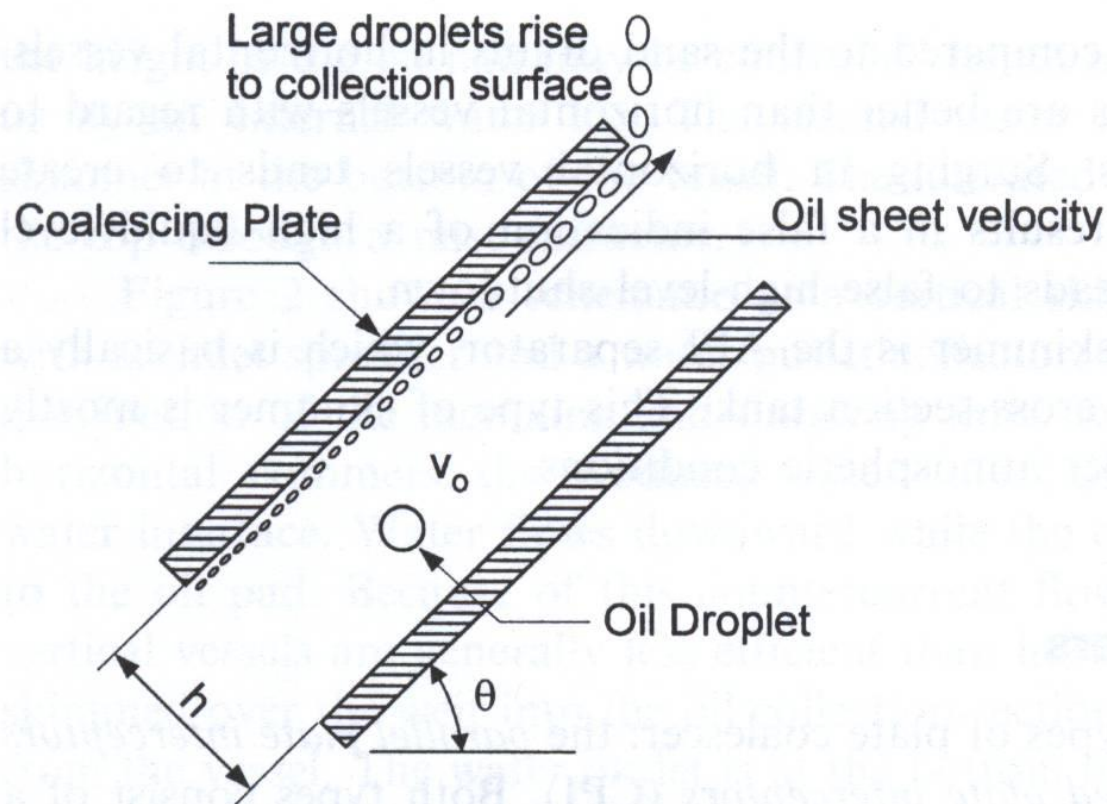


Figure 4 Oil droplets rise between two consecutive plates in the PPI.



Corrugated Plate Interceptor (CPI)

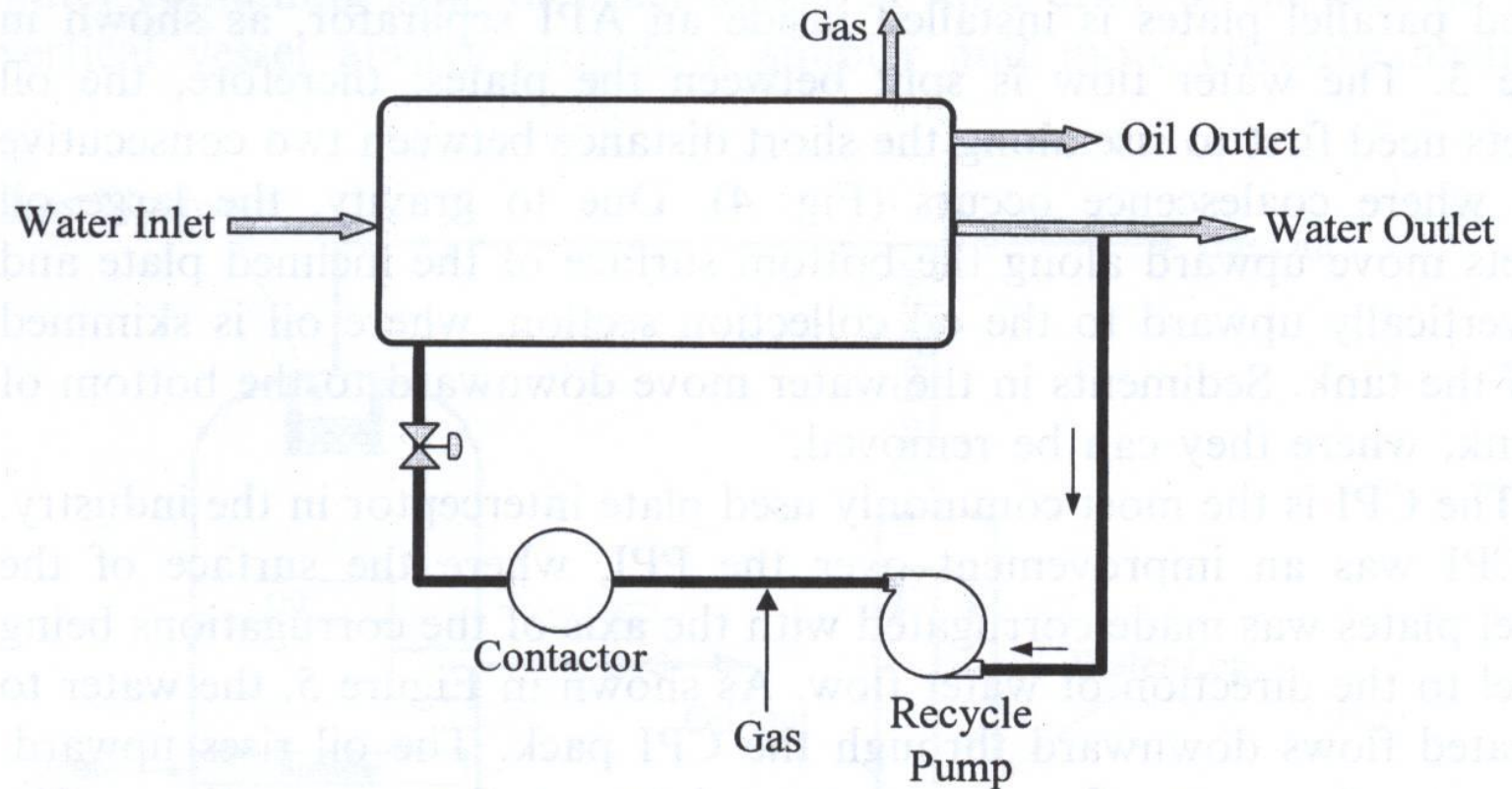


Figure 5 The corrugated plate interceptor.



Serpentine-pipe Packs

- A device used to promote coalescence of the oil droplets and thus facilitates their separation by gravity
- Water is forced to flow through a serpentine path that is properly sized to create turbulence that is sufficient to cause coalescence without causing shearing of oil droplets below a specified size



Floatation units

- The basic principles of operation this device is that, large number of small gas bubbles are produced within the water. As the gas bubbles rise upward, they carry the oil droplet to the surface, where they accumulate and then skimmed out of the unit:
 - Dissolved Gas floatation unit
 - Dispersed gas flotation units



Dissolved Gas Flotation Units

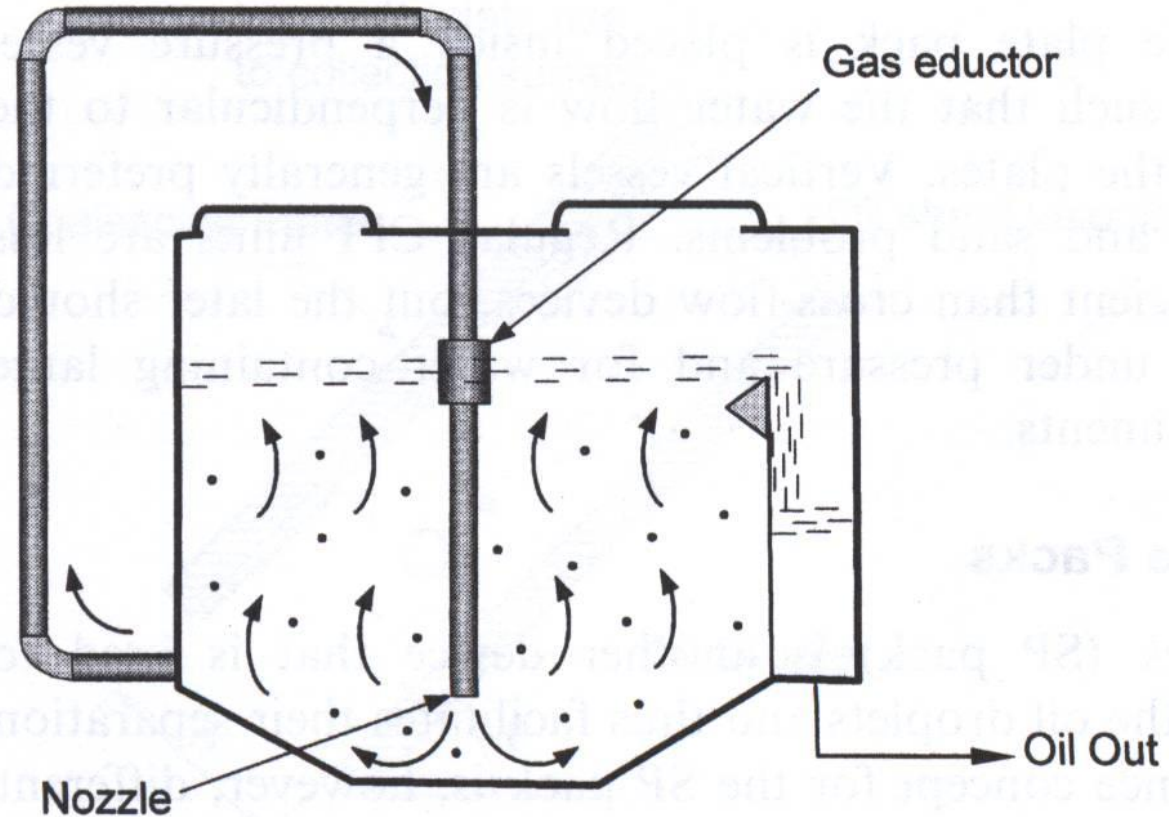


Figure 6 Dispersed gas flotation unit with eduction.



Dispersed Gas Flotation Units

- Gas bubbles are created, introduced, and dispersed into the bulk of the water to be treated, this basically done by two methods:
 - Gas bubbles are created and dispersed in the water by inducing a vortex using a mechanical rotor driven by an electric motor (Figure 7)
 - Creating and dispersing the gas bubbles utilizes an inductor device (Figure 9)



Dispersing vortex gas bubbles

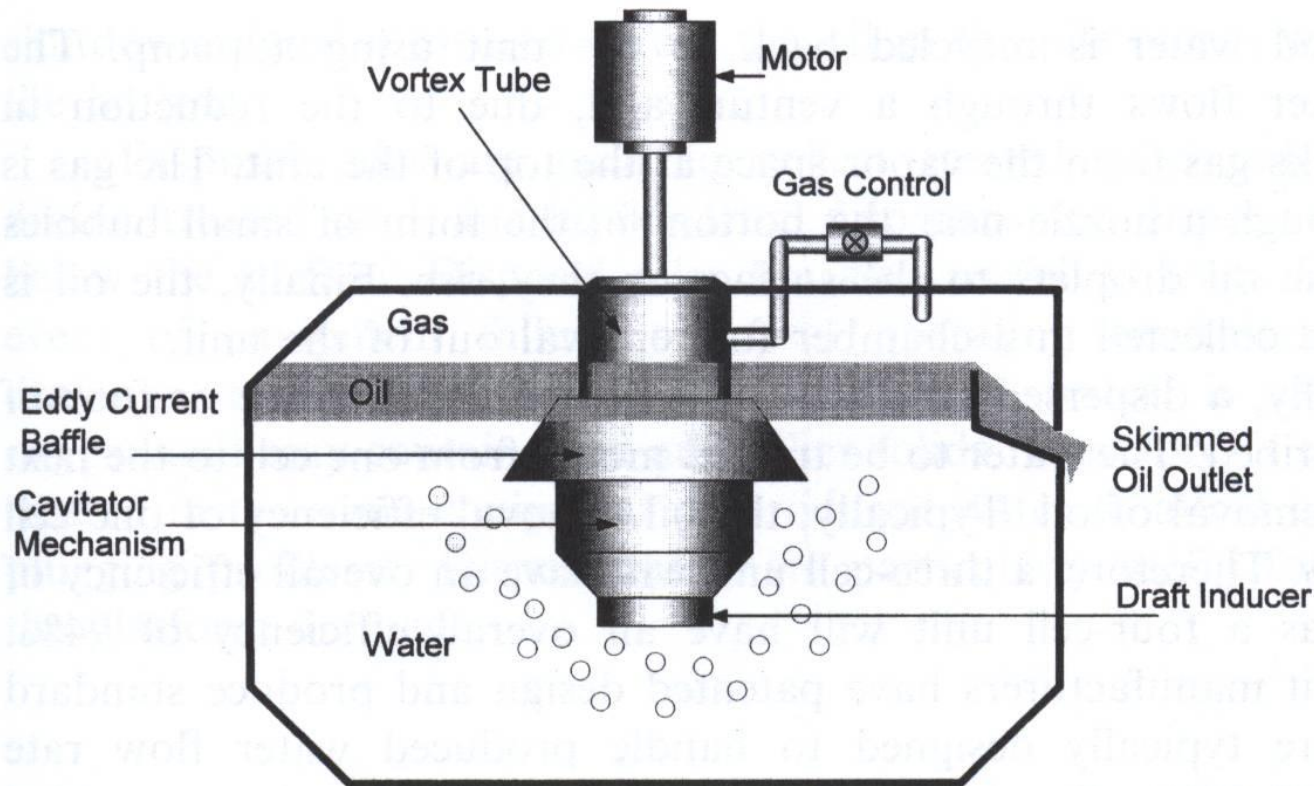


Figure 7 Unit utilizing the method of creating gas bubbles and dispersing them in the water by inducing a vortex.



Using inductor device

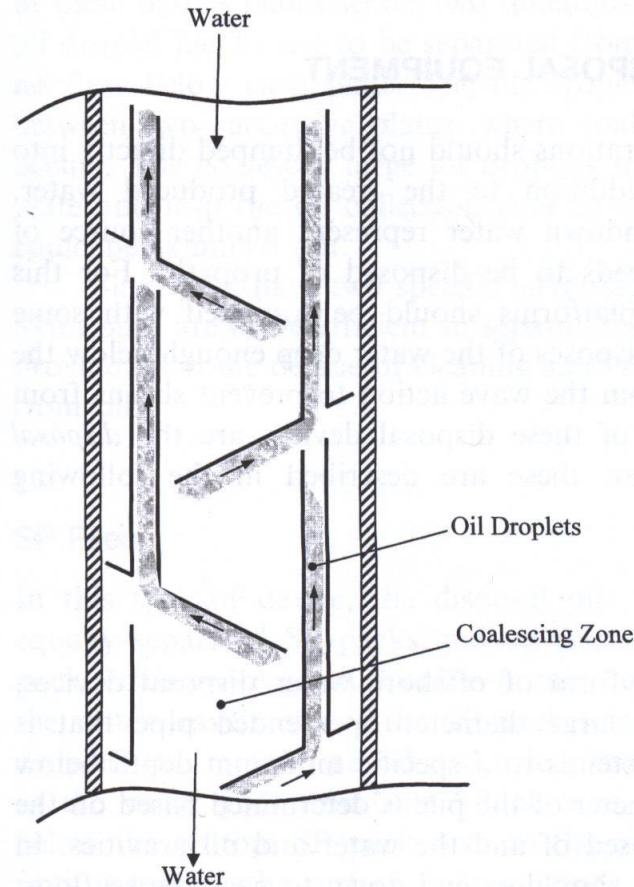


Figure 8 Unit utilizing the method of creating and dispersing gas bubbles using an inductor device.



Offshore water disposal equipment

- Produced water in offshore operation should not be dumped directly into the sea after treatment
- Offshore production platforms should be equipped with some form of a disposal device that disposes of the water deep enough below the surface of the sea and away from the wave action to prevent sheens from occurring



Disposable Devices

- The most common of these disposal devices are:
 - Disposal Piles
 - Skim Piles
 - SP Piles



Disposal Piles

- Disposal piles are the simplest form of offshore water disposal devices
- The disposal pile is simply a large diameter open-ended pipe that is attached to the platform and extends to a specific minimum depth below the surface of the sea
- Disposal piles are used to collect treated produced water, deck drains, treated sand, and liquid from drip pans and dispose of them deep below the surface



Skim Piles

- The skim pile is basically a disposal pile equipped with a series of inclined baffle plates and oil collection risers (Figure 9)
- Skim piles have two specific advantages over standard disposal piles
 - Skim piles are more efficient than disposal piles
 - More efficient in separating oil from water
 - Provide cleaning sand that may be present



Skim Piles

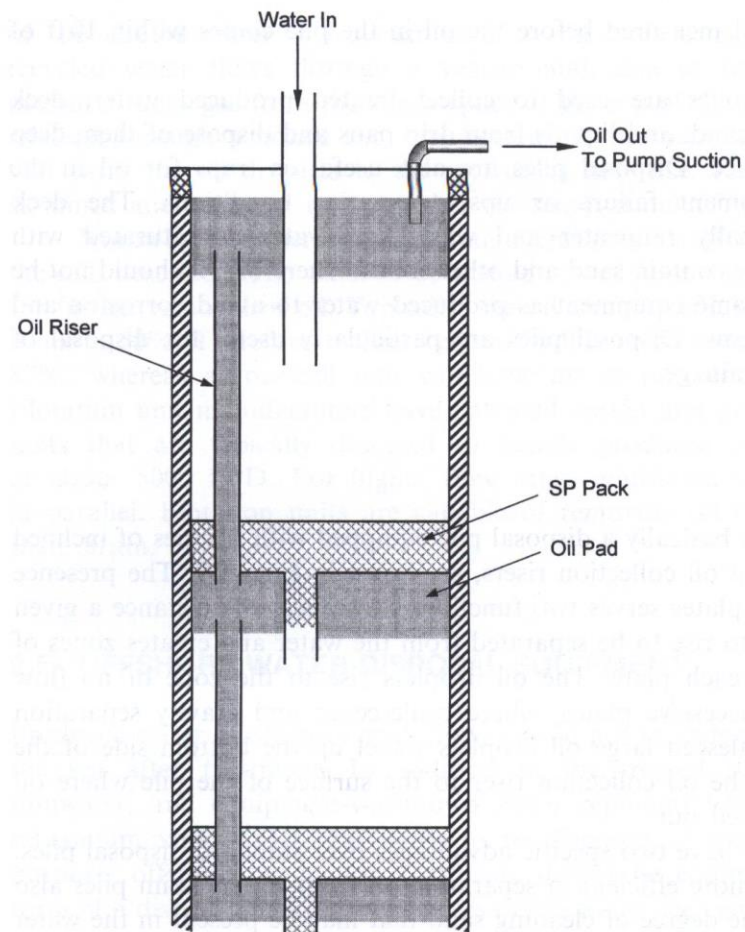


Figure 9 Schematic of a skin pile.



SP Piles

- Disposal pile is equipped with a number of equally separated SP packs and oil risers
- As water flow through a SP pack, coalescence of oil droplets occurs due to the induced turbulence.
- As the water travels out the SP pack to the next SP pack, the larger oil droplets rise to form an oil pad below the upper SP pack
- The SP pack is designed to develop oil droplets to maximum size of 750 micro m
- The number of SP packs needed is determined from the desired overall efficiency of oil removal and the calculated efficiency of oil removal and the calculated efficiency of a single pack will be explained later