# SURFACE PETROLEUM OPERATIONS

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## Contents





## Summary

The main objective of Surface Petroleum Operations, SPO, is the processing of reservoir fluids-exit the well-head- in order to produce marketable products; namely crude oil and natural gas. The proposed treatment of the subject matter of SPO follows a chronological sequence of field operations in transient. Each is described in terms of the unit operation concept when applicable as the oil-gas mixture moves from the well-head until the crude oil is separated, treated, and finally stored. Unit operation is a powerful tool that describes the physical changes involved in many chemical and petroleum industries.

The first step in crude oil processing takes place in the gas-oil separation plant (GOSP), where gases are separated from oil. When water exists in the stream produced from the well, the separators are used to separate the free water. Oil leaving does not generally meat the purchaser's specifications, because it may contain emulsified water. Salt present in emulsified water poses a serious problem in terms of corrosion and scaling during transportation and in refinery operations. Further treatment of crude oil takes place which involves emulsion treatment/dehydration and desalting. This brings the crude oil to a maximum of 1% BS&W (Basic Sediments & Water) and salt content of 15-20 PTB (Pounds per Thousand Barrel). Further processing of crude oil may be justified by a dual operation which involves both Stabilization and Sweetening when dealing with sour crude oils that contain more than 400 ppm of hydrogen sulfide gas.

## 1. Introduction

Crude oil-gas mixture, once produced from oil wells, moves through two main distinctive processing operations in order to obtain useful petroleum products. These are identified as:

1. Surface Petroleum Operations, where gases are separated from oil with further treatment of the separated fluids.
2. Refining operations, where crude oil is fractionated into cuts with further chemical conversion processes to produce different petroleum products.

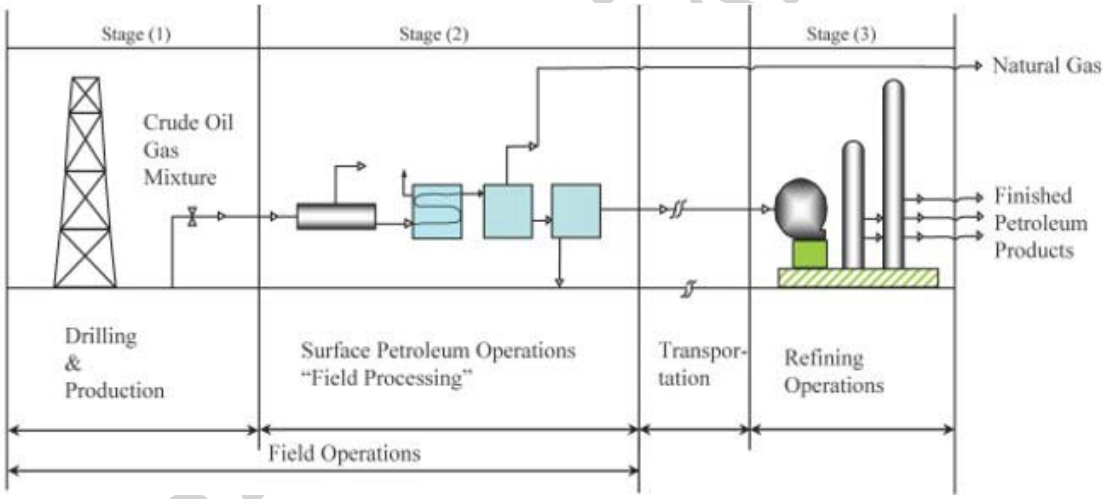


Figure 1. A Schematic Illustration of the Three Different Operations in the Oil Industry

Thus we go from oil production at one hand to oil refining on the other end via SPO, as sketched in Figure 1. SPO represents the 3rd stage in the series of oil stages as depicted in Figure 2.

The need for field processing of crude oil-gas mixture is justified for four main reasons:-

- These mixtures are very difficult to handle, meter, or transport.
- It is unsafe and uneconomical to ship or transport such two-phase mixtures over-seas to refineries and gas plants.

- Oil producers have to abide with the specifications set for shipping and refining.
- Environmental constraints established for the safe handling of hydrocarbons and the disposal of produced salt water.

In its broadest meaning, SPO may cover the processing of all three streams from well head as indicated in Figure3. However, this chapter is limited to the handling and processing of crude oil only.

Examples of some unit operations that are used in SPO are given:-

| **Unit Operation** | **Application in SPO** |
|---|---|
| Equilibrium Flash Separation | Gas-Oil Separation |
| Distillation/Stripping | Stabilizers/Sweetening |
| Absorption | Treatment of Natural Gas |
| Fluid Flow | All Operations |
| Heat transfer | Most Operations |

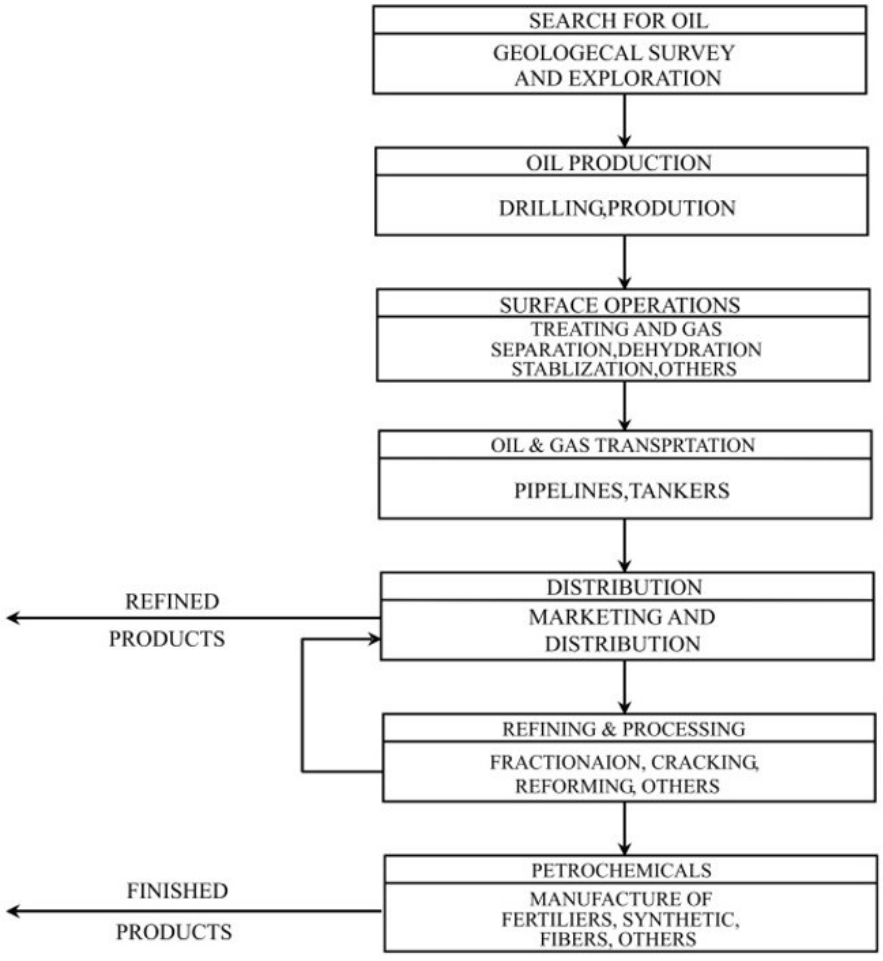


Figure 2 Stages in the Oil Industry

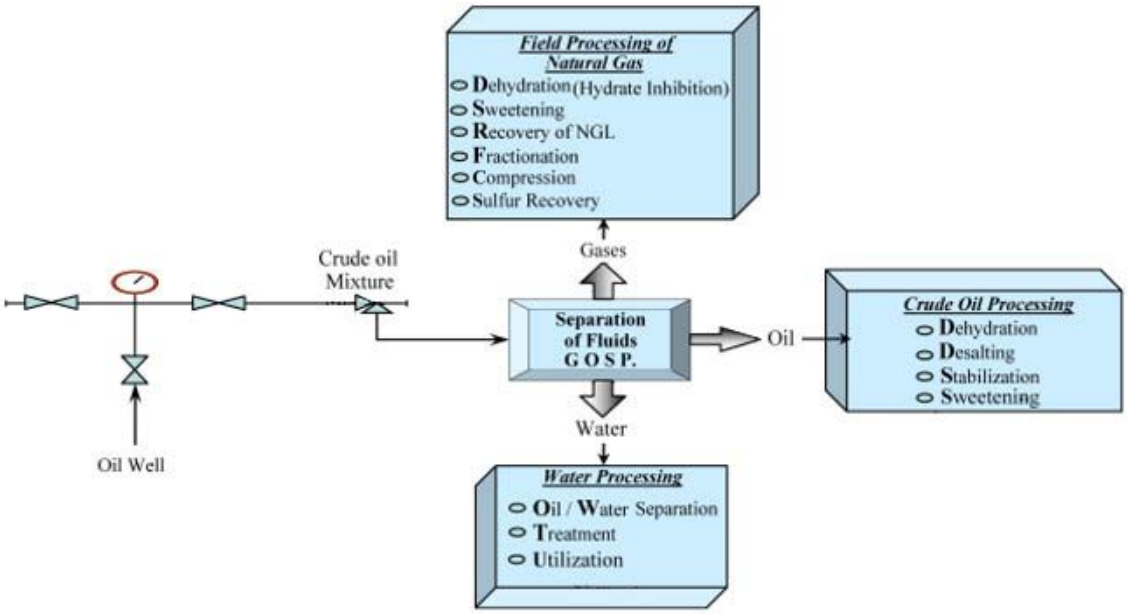


Figure 3. An Outline of the Processing Surface Field Operations

## 2. Gas-Oil Separation

### 2.1. Background

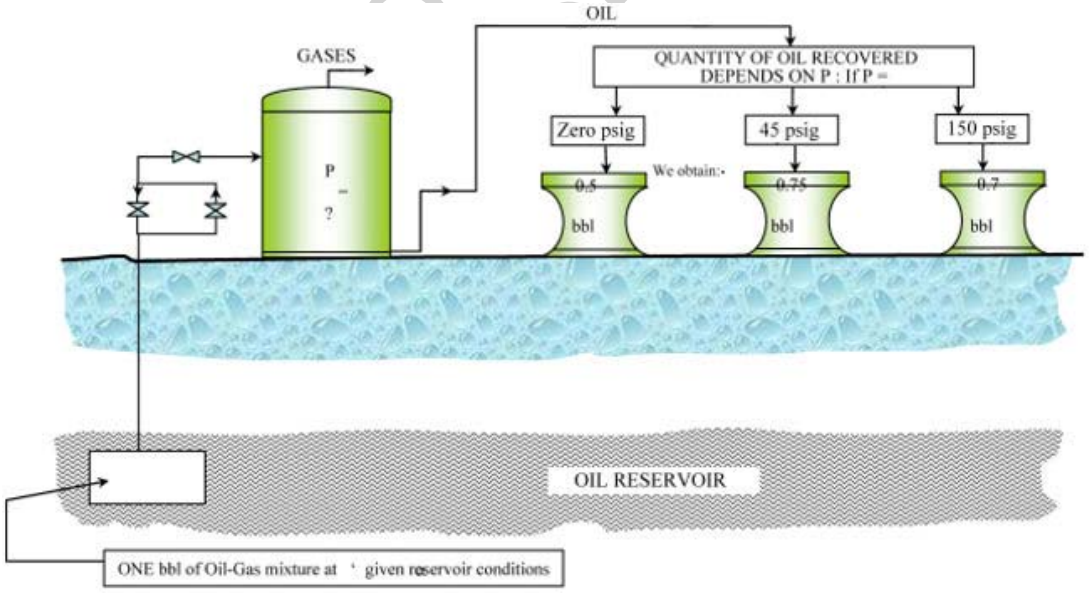


Figure 4. Effect of Operating Pressure on Separation

Well effluents flowing from producing wells are usually identified as turbulent, high velocity mixtures of gases, oil and salt water. As these streams flow reaching the surface, they undergo continuous reduction in temperature and pressure forming a two-phase fluid flow: gas and liquid. The fluid emerges as a mixture of crude oil and gas

that is partly free and partly in solution. Crude oil has to be processed to separate the oil from gases and from water as well. This is usually done by admitting the well fluid into a GOSP through which pressure of the flowing mixture is successively reduced to atmospheric pressure using few stages. As can be observed from Figure 4, the volume of one barrel of the gas mixture, at a given reservoir conditions would shrink to a value dependant on the operating pressure in the gas-oil separator.

### 2.2 Mechanism of Separation

The process involved in a gas-oil separator encompasses two main stages in order to free oil from gas. These are recognized as: flash separation of the gas-oil mixture followed by oil recovery.

#### 2.2.1. Flash Separation

In order to understand the theory underlying the separation of well-effluents of hydrocarbon mixtures, it is assumed that such mixtures contain essentially three main groups of hydrocarbons:-

- Light group which consists of methane($CH_4$) and ethane($C_2H_6$)
- Intermediate group which consists of two subgroups: propane ($C_3H_8$)/butane ($C_4H_{10}$) and pentane ($C_5H_{10}$)/hexane ($C_6H_{12}$)
- Heavy group which is the bulk of crude oil and is identified as $C_{7}H_{14+}$

Basically our objective in separating the gas-oil mixture is a dual function:-

(a) To get rid of all $C_1$ and $C_2$, i.e. light gases
(b) Save the heavy-group components as our liquid product

In order to accomplish these objectives, we unavoidably loose part of the intermediate group in the gas stream, whose heavier components ($C_5$ /$C_6$) would belong definitely belong to the oil product. The problem of separating gases in general from crude oil in the well-fluid effluents breaks down to the well-known problem of flashing a feed mixture into two streams: vapor and liquid. This takes place using a flashing column (a vessel without trays). Gases liberated from the oil are kept in intimate contact. As a result, thermodynamic equilibrium is established between the two phases .This is the basis of flash calculations which is carried out to make material balance calculations for the flashing streams.

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## Biographical Sketch

**Hussein K. Abdel-Aal** born in Egypt, 1935. He has B.S. Ch E, Alexandria University, 1956, M.S. & Ph.D. Ch E, Texas A.& M., TX, USA, 1962, 1965.Major field of study: chemical engineering.

He has more than 50 years of industrial experience, academic research and university teaching. He was a faculty member at NRC, Cairo, Egypt, 1965-70, Post-Doctoral fellow at UMIST, England, 1970-71, Visiting Prof., Texas A & M., College Station, TX 1980-81, Prof. at KFUPM, Dhahran, Saudi Arabia 1971-98. Currently, he is Emeritus Prof., NRC, Cairo, Egypt. He is the author of more than 50 publications and two books: Petroleum Economics & Engineering, Marcel Dekker Inc., New York 1992, Petroleum & Gas Field Processing, Marcel Dekker Inc., New York, 2003.

Prof. Abdel-Aal is a founding member of the International Association of Hydrogen Energy, FL, USA, member of the editorial board of the International Journal of Hydrogen Energy, member, AICHE, member, Egyptian Syndicate of engineering at Cairo.