Field Operation And The Natural Gasoline Plant

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Production of natural gasoline and other liquified petroleum gases from casinghead or oil well separator gas and gas distillate is the primary function of a natural gasoline plant. In this role, it demonstrates just another step taken by our industry toward achieving maximum utilization and deriving maximum benefit from one of our country's important resources, natural gas.

The importance of these plants, in relation to the production and refining phases of the petroleum industry, is apparent if we examine production and refinery statistics in the U. S. for the past year. Domestic crude oil processed in refineries during 1955 averaged 7,473,000 barrels daily. During this same period natural gasoline plant production was 720,500 barrels per day or approximately 10 percent of the volume of crude oil processed. In Texas the comparison is even more striking, for with a crude oil processing rate of 2,089,000 barrels per day, natural gas liquids average 391,700 barrels daily or about 19 percent.

The natural gasoline plant's contribution is significant not only from the volume of its products but also because of the wide application found for them. Natural gasoline has for many years been an essential ingredient for blending of motor grade gasolines made by refineries. It provides the volatility needed and improves the octane or performance factor of these gasolines. Other pure natural gas liquids such as iso-butane and iso-pentane are used widely, either to produce aviation alkylate or directly in blending of high octane aviation gasoline. This gasoline is in great demand for use as commercial or military aviation engine fuels. Blends of such hydrocarbons as ethane, propane, and butanes, find a multitude of usess including domestic or industrial fuels, automobile and truck fuels, gas manufacturing, synthetic rubber manufacture and many other petrochemical manufacturing applications.

Discussion of the operation of a natural gasoline plant can be simplified and more easily understood, if first we look at the various hydrocarbons occurring in natural gas and crude oil that are encountered. The following table shows these materials in order of the volatility or normal boiling temperatures.

Components In Natural Gas

	State at S. C.	Normal Boiling Point degrees F
Hydrogen Sulfide	Gas	—76.5
Carbon Dioxide	Gas	—109.3
Nitrogen	Gas	—320.4
Water	Liquid	212.0
Methane	Gas	—258.7
Ethane	Gas	—127.5
Propane	Gas	—43.8
Iso-butane	Gas	10.9
Nor-butane	Gas	31.1
Iso-pentane	Liquid	82.1
Nor-pentane	Liquid	96.9
Hexane	Liquid	155.7
Heptane	Liquid	209.1
Octane	Liquid	258.1
Crude Oil	Liquid	——

With the exception of hydrogen sulfide, carbon dioxide, nitrogen and water at the top of the table, we have what the chemist calls a homologous series of hydrocarbons. This simply means that as we move downward through the list, each successive hydrocarbon becomes heavier, having additional carbon atoms in the molecule and a higher normal boiling point. Although this list contains by no means all of the hydrocarbons found in oil and gas reservoirs, it does give the more common materials with which we must deal.

In essence our problem is to separate certain of these hydrocarbons from the others and place them in storage tanks from which they may be dispensed to the ultimate user. A typical casinghead gas available to a natural gasoline plant for processing will have the following composition.

	Gas Volume Percent	Liquid Gals. MCF
Inerts	2.40	
Methane	70.83	
Ethane	16.69	
Propane	7.23	1.99
Iso-butane	.71	.23
Nor-butane	1.49	.47
Iso-pentane	.21	.08
Nor-pentane	.21	.08
Hexanes Plus	.23	.11
Total	100.00	2.96

Gas from a distillate reservoir is similar to casinghead gas except that the quantities of propane and heavier hydrocarbons are greater. Thus the quantity of liquids which can be recovered are much larger.

From these gases, we strive to recover as much of the propane and heavier components as possible. After processing, the residue gas consisting predominantly of methane, ethane, and some propane is suitable for delivery into a gas pipeline or in certain cases returned to the producing reservoir to assist in maintaining reservoir pressure.

Variation in field or lease operation methods and techniques and the effect produced upon the natural gasoline plant may not be readily apparent without a prior knowledge of just how a gasoline plant functions. Today, there are basically two types of plants, each named for the process used to. achieve primary separation of liquids from the gas processed. The compression-refrigeration plant, just as the name implies, employs gas compression to raise the gas pressure, followed by refrigeration to lower its temperature and promote condensation of liquids. This process is rather inefficient on casinghead gas having the composition mentioned above, but where the recoverable butanes and heavier content of the gas is five gallons per thousand standard cubic feet or higher and compression to 500 psig or more is feasible, it becomes an efficient method. Under such favorable circumstances the compression-refrigeration plant can be the most economical one to construct and to operate.

The most common plant found today by far, however, is the oil absorption type. An absorption plant has advantages not offered by other types. It will give much more selective primary separation of the various hydrocarbons, which simplifies their further purification. It will efficiently operate on much leaner gas than will the compression-refrigeration plant.

To further illustrate just how these natural gas liquids are recovered, refer to Figure 1 which is a simplified diagram of a typical oil absorption natural gasoline plant.

At the left is the absorber, and it is here that the absorption oil and gas are brought into intimate contact. A typical absorption oil is a 38 to 40 degree API kerosene or naptha. In this vessel the oil absorbs some portion of each of the hydrocarbons present. The percentage of the heavier hydrocarbons, which are absorbed, is much greater than is the percentage of the lighter hydrocarbons absorbed. This is the first step in concentration of the hydrocarbons which will be recovered. The rich oil now contains the absorbed hydrocarbons and flows to the next step in the process which is the still or distillation system. Here, by means of heat and steam, the absorbed hydrocarbons are literally boiled out of the oil. After cooling, these vapors condense as a liquid and are ready for the final separation steps. This raw charge liquid, which is a mixture of our final products, is pumped to a battery of three or more fractionating towers where final separation is accomplished. The final products are taken from these towers in order of their decreasing volatility. Separation of a product from each tower is accomplished by proper selection of operating pressure and temperature so that the desired material can be driven out as a vapor and then cooled, condensed, and delivered into the storage tank.

The primary difference between this and a compression-refrigeration plant is that the gas compressors and refrigeration coolers replace the absorber and still. The fractionation equipment for products separation would be the same.

Practically all vessels in use today for separation of hydrocarbons by the distillation or absorption process employ the bubble cap tray column. Such vessels may contain as many as 100 bubble cap trays. Figure 2 illustrates the basic principal behind the bubble caps operation. As liquid flows downward through a column it is contacted counter-currently by vapor or gas which is rising upward through the column. By this means the vapors tend to carry the lower boiling materials toward the top of the column, whereas, the liquid carries the higher boiling materials to the base. In this way, separation of mixtures of hyrocarbons can be accomplished.

Before the gas produced on a lease can be processed, it must be gathered and delivered to the plant. Gathering systems are operated at various pressures depending upon the type of oil or distillate reservoir from which the gas is produced and the methods of production employed. The very high pressure systems in the 1,000 to 2,000 psig range, and the sub-atmospheric pressure or vacuum systems found in some of the older plants, create the most problems. In high pressure systems the stoppage of gas flow by the formation of hydrate plugs is quite common. Many methods have been devised and used to combat this problem such as the use of heaters, glycol and alcohol injection or dehydration of the gas. Heaters are effective providing they are spaced in such a manner that line temperatures are kept above the hydrate formation point. This can become a rather difficult feat in the winter time since hydrates will form under these high pressures at temperatures as high as 60 to possibly 70 degrees F. Glycol and alcohol injection into the gas lines may also help to some extent, but is not entirely effective at the higher pressures and can become quite expensive when used over extended periods of time. Dehydration to actually remove water from the gas is the most effective but is prohibitively expensive except where other methods cannot be used.

Gathering systems operated at sub-atmospheric pressures have a problem which is peculiar to them alone. The problem is difficult to overcome and it is perhaps fortunate that vacuum systems are becoming rather rare today, being found in only a few areas such as the Ranger Field in West Central Texas. This problem is the leakage of air into the lines from the atmosphere. This leakage is undesirable for at least two reasons. Gas containing even small amounts of hydrogen sulfide, carbon dioxide and water vapor is corrosive to varying degrees, but when oxygen from the air is also added to this gas, the corrosion proceeds at greatly increased rates and pipelines transporting such a gas have short life. To combate this problem it has proven necessary in some areas to remove the hydrogen sulfide and carbon dioxide from the gas by means of treaters.

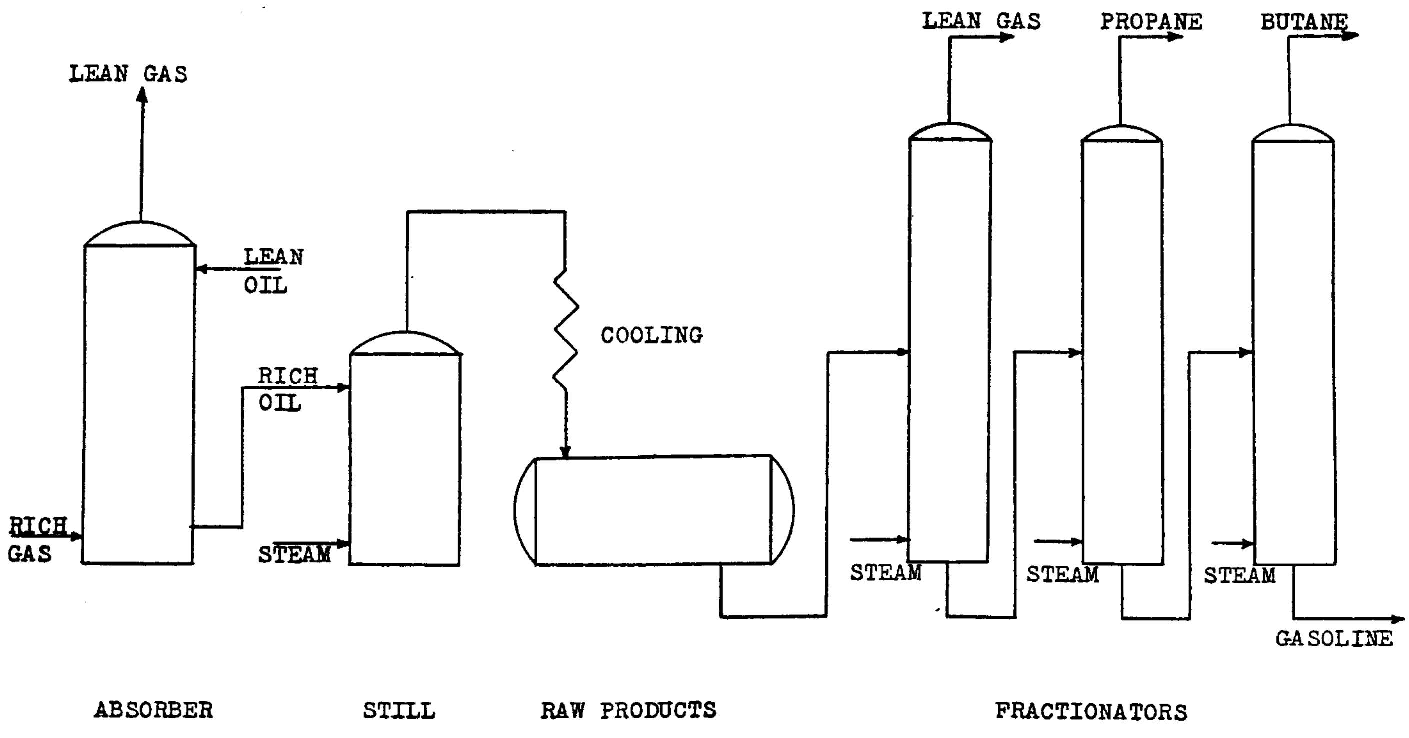
Air leakage into gas destined for sale to transmission and distribution companies reduce the heating value of the gas and in some cases will severely restrict the extent to which the gasoline plant may remove the high heating value propane and butanes and still meet its 1,000 BTU per cubic foot residue gas heating value requirement.

Gathering lines operating at medium to low pressures of from five to several hundred psig are confronted primarily with the problems of effective liquid removal by means of drips to maintain good line efficiencies and combatting corrosion in areas where the gas contains hydrogen sulfide and carbon dioxide. Corrosion can be controlled by dehydration to remove water, amine treaters to remove the acid gases, and use of corrosion inhibitors or use of plastic wall or plastic lined pipe.

One of the most important factors for obtaining maximum efficiency in gasoline plant operation is that of securing delivery of gas to the plant at a uniform rate from day to day and from month to month. The plant is designed to operate with maximum efficiency at a definite rate of gas flow. Whenever the gas rate varies either above or below this design value, loss of efficiency results. A uniform rate of gas production can be achieved only through cooperation between the lease and plant operators. We all recognize that for the lease operator to satisfy the boss, he must get the oil produced. When the separation gas is being processed by a gasoline plant, his company is also participating in the revenue from the natural gas liquids. To insure maximum return from plant liquids, a uniform rate of gas production is essential.

Good separation of crude oil and gas on the lease is also important to insure maximum gasoline plant recoveries. Crude oil carried over from lease separators accumulates in gathering lines and drips, reducing line efficiency, and a portion of it will invariably get into the gasoline plant absorbers, mixing with and contaminating the absorption oil. Absorption oil is selected for its ability to absorb hydrocarbons. Crude oil contamination reduces materially its capacity to quantities of paraffin or other undeabsorb. Where the crude contains sirable heavy materials, fouling of bubble trays, heat exchangers and other plant process equipment occurs which necessitates frequent shutdown for cleaning. Special absorption oil

FIGURE I



SIMPLE GASOLINE PLANT

conditioning equipment is provided in most plants to maintain the absorptive capacity of the oil at a maximum.

A gasoline plant can recover only the natural gas liquids contained in the gas delivered to it. The revenue to the lease is based upon the liquids actually recovered. Operation of lease separators at low pressures and at reasonably high temperatures tend to increase the content of the separator gas. The question often arises as to why the lease separator pressure should be lowered or the temperature raised just to increase the content of the gas going to the plant. Why not just leave things as they are and put that extra liquid into the oil stock tanks? The answer is, of course, that this extra liquid is composed predominantly of propane, butane, and pentanes and it is not possible to retain more than a very small portion of it in the oil stored in atmospheric pressure tanks. The vapors so often seen venting from oil stock tanks are these components. When vented to the air no one receives benefit from them. By choosing separator pressures and temperature conditions which hold this venting to a minimum, these liquids will go out in the separator gas and be recovered by the gasoline plant. In this way a loss becomes a gain both to the lease operator and to the plant.

In looking out for his company's best interests, the field production man should know something of the contractual agreement under which the lease gas is processed through a gasoline plant. The usual form of contract in this area is the casinghead gas type processing agreement.

A typical casinghead gas contract contains, in part, the following general provisions.

PLACE OF DELIVERY:

Gas is delivered from the lease separator into the plant gathering system on each lease. Title to the gas is transferred at this point.

FLUSH PRODUCTION:

Because the plant's gathering system is limited in capacity, during periods of abnormally high rates of production, the plant agrees to take gas ratably from all leases up to the capacity of this gathering system. Disposing of excess gas becomes the lease operator's responsibility.

LEAN GAS:

Plant is usually not required to take gas from a lease if it becomes unprofitable to do so. For example, if the content of the gas falls below a specified minimum figure, the plant may refuse to take gas from that lease.

RESIDUE GAS:

Lease operator is entitled to use sufficient gas for operation of lease. All other gas remaining after processing may be sold and the net proceeds are divided equally between lease operator and plant.

RIGHT OF WAY:

Lease operator grants right of way for plant gathering lines and right of free entry incidental to operation of these lines.

SETTLEMENT TESTS:

Periodic compression or charcoal adsorption tests are made on each lease to determine the recoverable liquids contained in the separator gas. These tests serve as a basis for determining the lease's share of liquids produced by the plant.

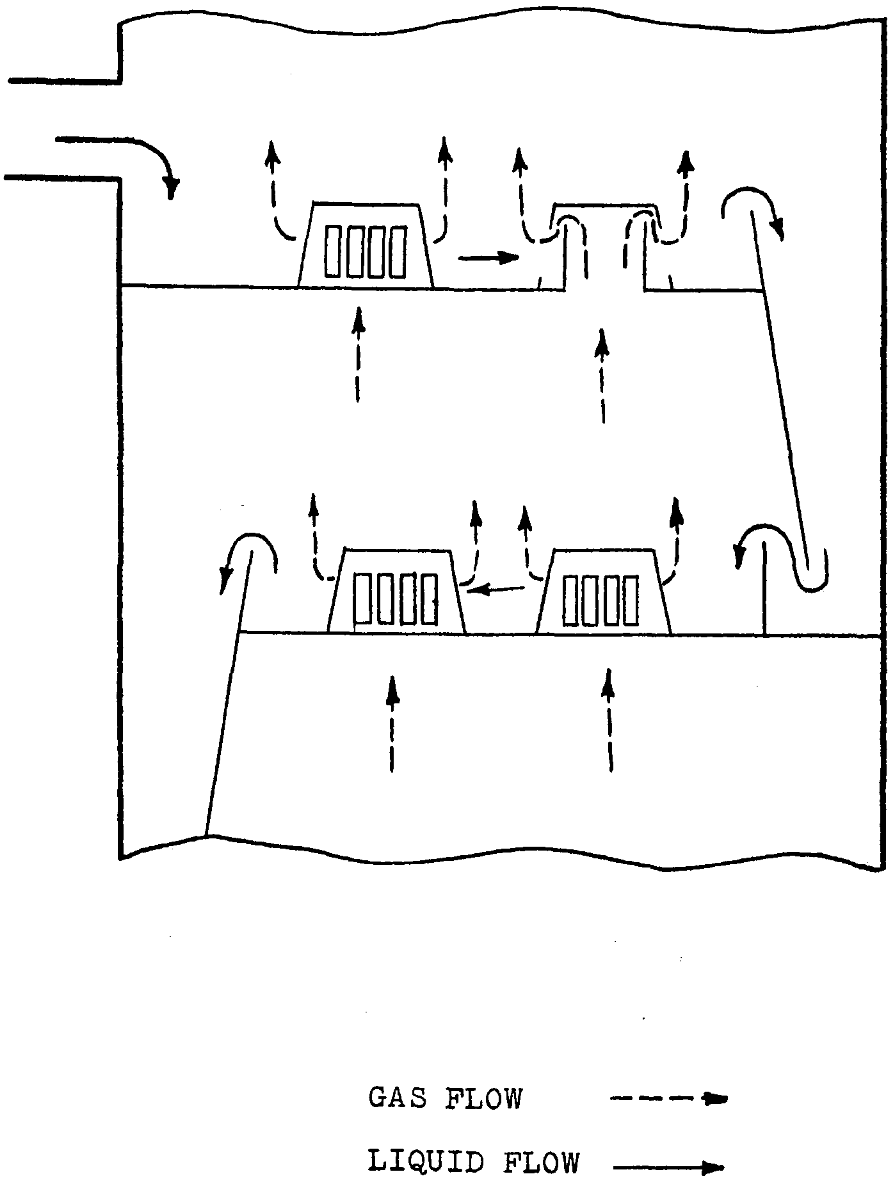
PAYMENTS FOR LIQUIDS:

Each lease receives payment for a percentage of the liquids produced from its separator gas depending upon the content of the gas and upon the price received for these liquids when sold.

Although all of the wording contained in these contracts requires many pages, the above general provisions are those having the most significance for the man on the lease.

This brief review of the various phases of natural gasoline plant operation gives the field production man some idea of our problems. Certainly it should be evident that without his interest and assistance, our situation would become much more difficult. The measure of success achieved in the operation of natural gasoline plants for many years is ample demonstration of the splendid cooperation they have received.

FIGURE II



BUBBLE TRAY OPERATION