Oil And Gas Separation And Its Application

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STAGE SEPARATION

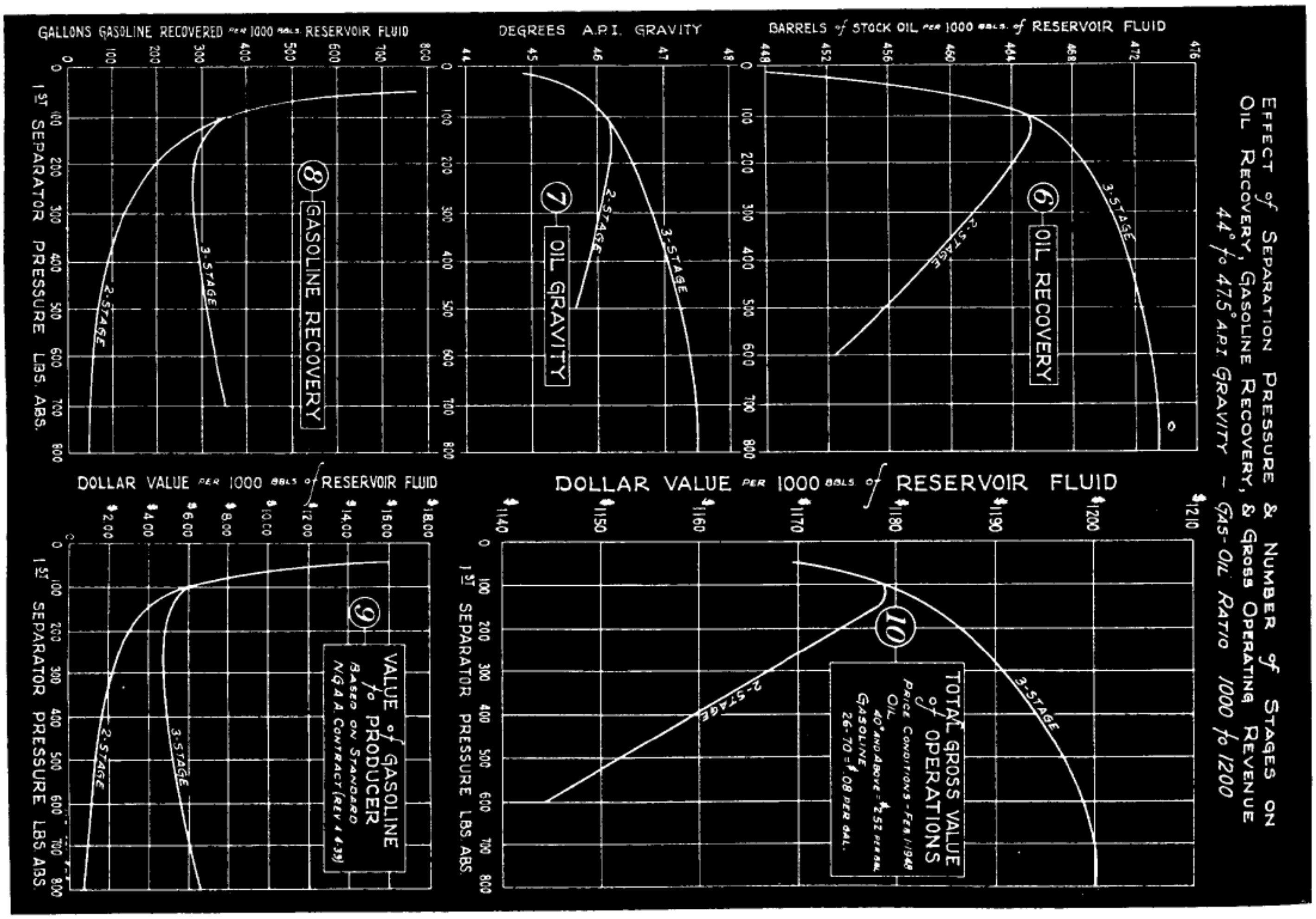
Stage separation, as applied to oil production, is a process in which the oil and gas mixtures, flowing from producing wells, are separated into liquid and vapor phases by two or more equilibrium flashes at consecutively lower pressures. The ideal method of separation, to retain the maximum amount of fluid flowing from an oil well, would be that of true differential liberation of the gas by a steady decrease in pressure from that existing at the well head to the atmospheric, or near atmospheric, pressure maintained in the storage tanks. With each differential decrease in pressure, the gas evolved would be immediately removed from the crude oil from which it is being separated. To carry out such a differential process would be impractical. A very close approach, however, towards differential liberation of gas can be accomplished by putting the mixture of oil and gas through several series connected separators, in each of which flash vaporization takes place. In this way the maximum economical amount of liquid flowing from the well can be retained in the stock tanks. The application of the process of stage separation, indeed, offers to the oil producer a means of increasing ultimate oil or distillate recovery, and also increasing revenue from property now in operation.

For purposes of clarification two-stage separation is defined as that type of operation obtained when one oil and gas separator is used in conjunction with storage tanks. Three-stage separation involves the use of two oil and gas separators and storage tanks. The storage tanks are classified as a stage of separation because oil and gas do separate in these vessels.

So that direct and quantitative comparisons can be made for various separation conditions the oil recovery, gasoline recovery, and value of operation curves have been plotted on a basis of the yield from 1,000 barrels of reservoir fluid. In explanation it should be noted that 1,000 barrels of reservoir fluid has been construed as being that quantity of free gas, solution gas, and oil which occupies void space in the reservoir equivalent to 1,000 barrels (5616 cu. ft.) under reservoir conditions.

Curves (6) through (10) have been prepared from data obtained on a study of crude oil production of 40 degrees to 47.5 degrees API gravity having a gas-oil ratio of 1,000 to 1200 cu. ft. per barrel.

As compared to the data presented



in the lower gravity crude (33 degrees to 36 degrees) it will be noticed that the data on this 44 degrees to 47.5 degrees API gravity crude involves higher first separator pressures. Generally speaking optimum separation conditions are reached at higher pressures for the high gravity crudes. The information presented in Curves (6) through (10) is plotted for separator pressures up to 800 pounds. The zone of greatest oil recovery as shown on Curve (6) occurs with three-stage separation with an initial separator of approximately 750 pounds per sq. in.

A condition of major importance in operating a separator or separators for the maximum benefit to the producer should be emphasized with reference to Curve (6). This involves the bad practice of operating one oil and gas separator at higher pressures than the optimum for two-stage separation. The optimum for two-stage operation occurs in the region of 125 pounds per sq. in. abs. for 44 degrees to 47.5 degrees API gravity crude with a gas-oil ratio of 1,000 to 1200. A great many times when it develops that there is a sale or usage of high pressure gas, it is a practice to install a high pressure separator and operate it without the benefit of a low pressure separator for staging the liquid to the storage tanks. A reference to Curve (6) readily indicates the fallacy of such a practice. For instance if one oil and gas separator is operated at a pressure of 500 pounds per sq. in. abs. and the liquid discharged directly to the storage tanks, the oil recovery amounts to approximately 455.5 barrels per 1,000 barrels of reserve fluid. fluid. On the other hand, if three-stage operation is utilized and the liquid is staged to the stock tanks, the oil recovery resulting amounts to 472.5 barrels per 1,000 barrels of reserve fluid. This means an increase, for the stipulated conditions, of 17 barrels of stock tank oil without increasing the withdrawal of fluid from the reservoir.

Curve (7) indicates the influence of separator pressure and the number of stages on the gravity of the oil in the stock tanks. Since this type production yields oil above 40 gravity for all operations and no price increases result from gravity increase, the information has minor importance.

Curves (8) and (9) indicate the influence of separation pressure and the number of stages on the natural gasoline recovery and the value of that gasoline to the producer.

The total gross value of the oil and the gasoline recovered per 1,000 barrels of reservoir fluid as influenced by separation pressure and the number of stages is indicated in Curve (10). Under current price conditions, an operation involving two-stage separation with the oil and gas separator operating at 50 pounds abs. would give a total gross value of approximately $1,170.00 per 1,000 barrels of reservoir fluid. By employing three-stage operation and an initial separator pressure of 750 pounds abs., the gross value of operations would be increased to $1,200.00 per 1,000 barrels of reservoir fluid.

The curves entitled "Total Gross Value of Operations" have been prepared especially to illustrate pictorially the importance of employing proper surface production practices to effect the maximum conservation and revenue from existing reservoirs. To those whose attention is concentrated toward effecting the conservation of their crude oil reservoirs the use of higher separator pressures and/or stage separation, cannot be questioned. This is especially true in a case where facilities for recovering the natural gasoline from the separation vent gases are not present.

To those who are economists and

FIGURE NO. 1 — FIELD DATA SHOWING INCREASED LIQUID HYDROCARBON RECOVERY WITH LOW TEMPERATURE SEPARATION COMPARED TO CONVENTIONAL METHODS

		OPERATING CONDITIONS						
		Well Head H.P. Separator		Low Temp. Separator		Condensate Recovery Bbls/MMCF of Sales Gas Low Temp. Separator	Increase in Condensate by Low Temp. Separation Bbls/MMCF of Sales Gas	Additional Yearly Rev. Per MMCF of Sales Gas. Value of Condensate $2.65/bbl.
Unit Number	Location	Press.	Temp. degrees F.	Press.	Temp. degrees F.			
1	Oklahoma	2625	82	450	--8	17	6	$5,803.50
2	Oklahoma	3150	85	380	0	44	7	6,770.75
3	West Texas	2500	78	875	32	15	4	3,869.00
4	Southwest Texas	1800	75	365	22	24	5	4,836.25
5	North Louisiana	2670	90	950	50	105	15	14,508.75
6	East Texas	2350	94	830	42	14	4	3,869.00
7	Soutm Texas	2800	82	840	14	16	5	4,836.25
8	North Louisiana	1680	80	500	42	223	12	11,607.00
9	South Louisiana	2750	86	600	16	48	15	14,508.75
10	South Louisiana	2900	85	600	10	52	17	16,443.25
11	South Louisiana	2830	82	805	20	50	13	12,574.25
12	South Missiissippi	2960	85	465	10	90	14	13,541.50
13	South Louisiana	2350	80	650	24	21	5	4,836.25
14	South Texas	2750	82	530	0	12	5	4,836.25

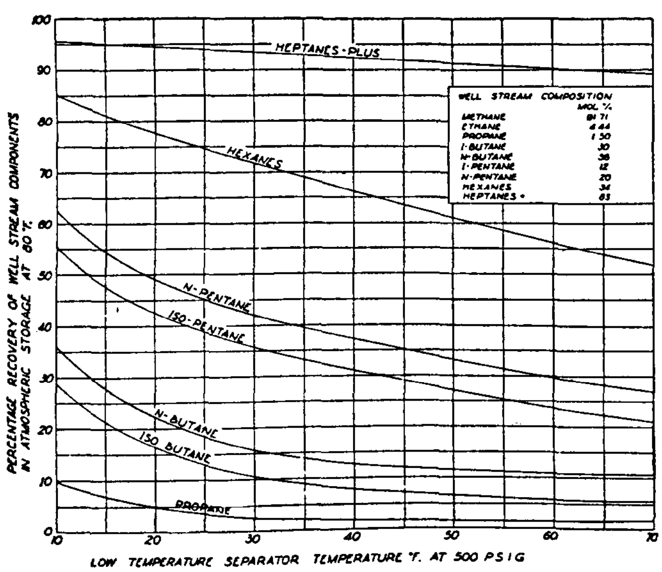


Fig. 2—Per cent recovery of well-stream hydrocarbon components.

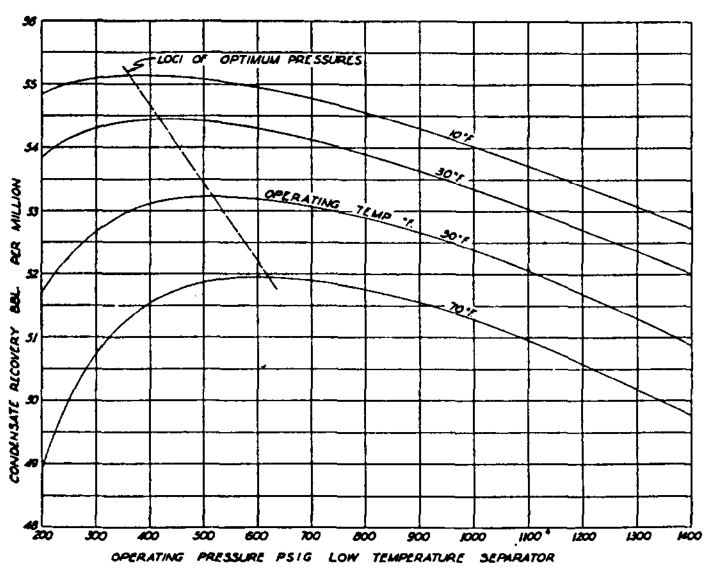


Fig. 3—Condensate recovery as a function of pressure and temperature.

must examine or analyze the application of stage separation from the stand-point of current gains and deferred gains, the lines of demarcation are not nearly so clear. The gains established from an increase in the selling price of crude as a result of an increase in gravity can most certainly be classed as a current gain. On the other hand the gain in the volume of oil recovered per unit of reservoir fluid should be classed as a deferred gain when the production involved is under regulatory proration. The value of this deferred gain is of a controversial character and each individual application must be studied in order to establish the value of the deferred gain. It should suffice here to say that such practices are true conservation and further that if all operators producing from a reservoir would employ the best separation practices that the benefits will be greater than if the best separation practices are employed by only a part of the producers from the reservoir.

Low Temperature Separation

The advantages of processing natural gas for pipe-line delivery as it leaves the producing wells has been a contributing factor toward involving gas producers in processing operations which were previously carried out in large processing plants.

Low-temperature separation is one of the gas producer's tools which finds application in the high-pressure gas fields usually referred to as "vapor phase" reservoirs. In this process the low temperatures obtainable from the expansion of these high pressure gas streams is utilized to a profitable advantage. A more efficient recovery of the hydrocarbon condensate and a greater degree of dehydration of the gas as compared to the conventional stage separation process are the two major advantages of low-temperature separation. As in the case of stage separation there are several variables that influence the efficiency of low-temperature separation, such as well stream composition, reservoir stability, flowing temperature and pressure, liquid composition and rates of flow.

From an operating standpoint the producer not only obtains a water dew point depression from cold separation but also a hydro-carbon dew point depression of the gas. This is important especially in long transmission lines as it eliminates liquid accumulation and thereby increases the transmission efficiency.

Removing these hydrocarbons at the well is actually where the producer realizes his greatest benefit. Many installations pay out a total investment of surface equipment in a matter of a few months by increased distillate production over standard separation methods. To show the value of this increase in production Fig. No. 1 has been prepared from actual field data.

Fig. No. 2 has been prepared to show where such an increase comes from and Fig. No. 3 to show how the recovery varies with the pressure and temperature. The additional hydrocarbon recovered from this process shows the calculated percent recovery of each wellstream component at a constant pressure of 500 pounds per sq. in. and a temperature range of 70 degrees to 10 degrees F. The recovery calculations were based on the final flash conditions to storage tanks of 14.7 pounds per sq. in. and a flash temperature of 80 degrees F. With this in view the calculated recoveries are based upon a liquid having stability characteristics equivalent to one having a true vapor pressure of 14.7 psia at a temperature of 80 degrees F.

This means that the recovery calculations for each temperature condition were based on stock tank liquid of equal stability. On first examination the foregoing statement may provoke concern, particularly in view of the increased recovery of the volatile fractions, butane and propane, at the lower temperature conditions. However, when one considers the very marked increase of the heavier or lower vapor-pressure components, hexanes and pentanes, one realizes how the recovery of the butane and propane fraction can likewise be increased without affecting the stock tank liquid stability. The increase in the recovery efficiency of (1) the hexanes from 52 percent at 70 degrees to 85 percent at 10 degrees (2) the normal pentanes from 27 to 62.5 percent, and (3) the isopentanes from 21 to 55 percent serves as a good indication of the source of the higher liquid recoveries experienced by operators of low-temperature separation.