Operation Of A Miscible Slug Injection Project

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ABSTRACT

Secondary Recovery was introduced to the oil field some years ago. One of the most advanced secondary recovery projects to date was "kicked off" by The Atlantic Refining Company on May 9, 1958, on the H. T. Boyd Lease in Slaughter Field, Texas.

This project consists of injecting propane, then gas, then water into the San Andres pay.

This paper will explain briefly the operation and problems encountered in this Miscible Slug Project.

INTRODUCTION

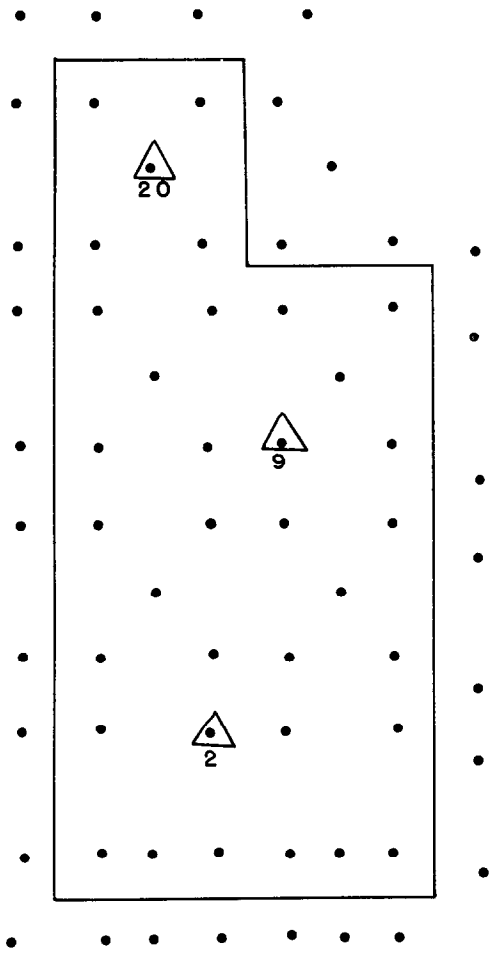
Miscibility is defined: "The ability of two or more substances to mix to form a single homogeneous phase." Under the proper reservoir conditions, propane and oil and gas and propane are miscible.

The Atlantic Refining Company's H. T. Boyd Lease Project in the Slaughter Field, Cochran County, Texas, was set up to inject propane ahead of natural gas. This will set up an intermediate zone of propane between the gas and the oil. At the front side the propane miscibly displaces oil and thereby pushes all of the oil ahead; and on the back side the gas miscibly displaces the slug of propane. On the back side of the gas the water fills the void space.

Due to the low bottom hole pressure (about 640 psi) in this area of the field, it will not be possible to completely sweep the lease by miscible displacement. The high pressures required would cause migration of oil to the surrounding leases. In order to prevent migration, it will be necessary to decrease the pressures on the H. T. Boyd Lease after we have miscibly swept only a portion of the lease.

FIGURE 1

HT BOYD LEASE
SLAUGHTER FIELD



OPERATIONS

Injection Wells

Three wells are being used for injection, Fig. #1. The injection lines from the manifold to the wells are 3 inch schedule 80 pipe. These lines are not coated internally.

The wells are equipped with 2-1/2 inch plastic coated tubing. They are also equipped with packers and back pressure valves. The back pressure valves are to keep the wells from "blowing wild" if there is a line break.

There was no remedial work done to these wells, such as acid or sand frac, prior to converting them to injecting wells. Tracer surveys were run on the injection wells prior to the injection of propane to assure that injection would be into the desired interval.

Propane Injection

The propane injection phase of this project began on May 9, 1958, into the three injection wells, Fig. #1.

The first problem encountered in this phase of the project was to find the 255,000 barrels of propane to be injected. The required volume of propane was finally rounded up at nine gasoline plants scattered over West Texas.

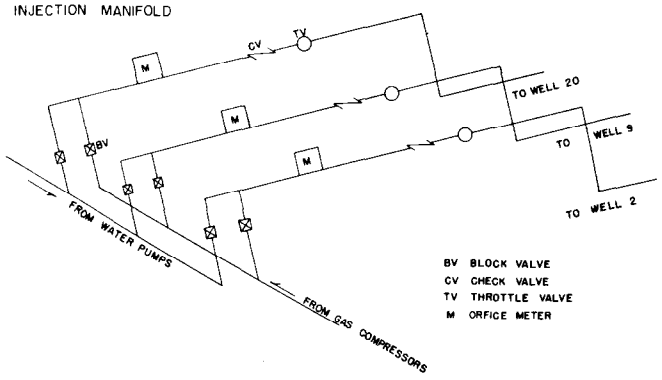
A second big problem was getting the propane to the lease as it was needed. It was desirable from an operational standpoint that propane injections be continuous. This was accomplished by hiring a trucking firm to haul the propane to the lease. The firm used 25 tank trucks, with an average capacity of about 170 barrels each, working 24 hours a day. About 27 per cent of the propane was brought to the lease by pipeline from the Slaughter Gasoline Plant.

The tank trucks unloaded the propane into surge tanks on the lease. Four high pressure pumps, which were temporarily installed to handle the propane, took the product from the tanks and discharged it at approximately 1200 psi into a header, Fig. #2, and then into the high pressure distribution system to the injection wells.

The volumes injected into the injection wells and the average pressures encountered were as follows:

FIG. 2

INJECTION MANIFOLD



Well	Propane Volume	Average Injection Pressure
#2	99,760 barrels	950 psi
#9	118,027 barrels	1200 psi
#20	37,629 barrels	140 psi

Gas Injection

Gas injection commenced immediately following the propane injection. The same three injection wells were used for gas as for propane.

The gas is being obtained for the project from a transmission line about one mile east of our compressor site. It is being compressed from 630 psi suction pressure to a maximum of 2200 psi by two 175 H. P. compressors. Two compressors were installed to insure that gas injection would be continuous. Some minor interruptions of gas injection could be tolerated, but the shutdown of gas injection for a prolonged period would cause the loss of miscibility.

These compressors discharge into the same header and distribution system that was used for the propane phase, Fig. #2.

The anticipated volume of gas to be injected into the three wells is 2.63 billion cu. ft. The distribution of this gas to the individual wells is as follows: Well #2 - 1.025 MMMCF; Well #9 - 1.220 MMMCF: Well #20 - 0.380 MMMCF.

As of January 1, 1960, the wells had received the following per cent of their total volumes: Well #2 - 89 per cent; Well #9 - 77 per cent; Well #20 - 100 per cent.

Water Injection

The #20 injection well completed its gas phase in February, 1959. The water phase was begun immediately.

The water for injection is being supplied by the H. T. Boyd Water Supply Well #1. This well is completed in the Santa Rosa formation. A 150 H. P., 40 stage submersible centrifugal pump is used in this well on 5-1/2 inch casing. A capacity test run in August, 1958, produced 8300 barrels of water per day. The limiting factor was the pump and not the formation.

Physical and chemical tests run on samples of the Santa Rosa water indicated the water was exceptionally clean and needed no filtration. It was also determined from these tests that the Santa Rosa water was incompatible with San Andres water. It might be mentioned here that as of January 1, 1960, no adverse conditions have been noticed because of this incompatibility.

Since no water treating was necessary for injecting Santa Rosa water, only one 750 barrel galvanized, bolted steel tank was installed for water storage and pump suction. This tank contains the automatic start and stop controls for the water supply pump and also the stop controls for the injection pumps.

The complete water system is air free. This is done by maintaining a gas blanket on the storage tank.

There are four triplex pumps being used for injection. Their total capacity is 9800 BWPD. These triplexes are tied into the same manifold system as used for propane and gas, Fig. #2. One of the triplexes is tied in so that it will inject into the #20 well alone. This triplex and well will be used for salt water disposal when the need arises.

Because of reasons that will be brought out later in this paper, water and gas are being intermittently injected into the #2 and #9 wells until the required volume of gas has been injected. Injection of water was begun in well #2 on July 1, 1959, and into #9 on July 29, 1959. The volumes of water injected as of January 1, 1960, are as follows:

Well #2	265,088 barrels of water
Well #9	322,795 barrels of water
Well #20	827,528 barrels of water

It is anticipated that gas injections will be completed by the end of 1960 and only water will be injected thereafter. Water injection should continue for the next 30 to 40 years.

PROBLEMS

The problems encountered on this project have been relatively minor. Aside from the few mechanical problems that have already been mentioned there has been only one major reservoir problem.

In the absence of necessary core data and logs to determine detailed analysis of stratification, the calculations of volumes, rates and procedure were based on a reservoir having an average stratification factor. Shortly after gas injection began it was determined that the San Andres, under our H. T. Boyd Lease, had only a moderate amount of stratification, but that some localized areas had enough stratification to be troublesome. Some thin, highly permeable stringers acted as thief zones. This was determined by propane break-through and increased GOR's on some of the producing wells.

First step taken to reduce these highly permeable zones was to start injecting water and gas intermittently in the #2 and #9 injection wells. That is, a certain volume of gas was injected followed by a predetermined volume of water. This procedure will be followed until the total required volume of gas has been injected into these two wells. After this gas volume has been reached, these wells will receive only water. The purpose of this procedure is to lower the mobility of the material behind the miscible front.

The lower mobility reduces the amount of material entering the most permeable layers in comparison to that entering the less permeable layers. This reduces the unfavorable effect of the permeability stratification. Thus far, the results of this procedure have been good. We have found very little propane in our produced gas and our ratios have decreased considerably.

The only problem encountered in this intermittent injection procedure is following the water with gas. The surface pressure on gas is limited to 2200 psi by the compressors and this pressure will not overcome the resistance of the formation created by the water phase. The only way that has been found thus far to start the gas injection is to allow the injection well to build down.

PRODUCTION

The allowable on the lease before any injection began was 910 barrels of oil per producing day. This was essentially lease capacity. The lease was producing about 500 barrels oil per calendar day. The present producing capacity is about 2000 barrels per day. The allowable is 1400 barrels per day. According to all indications the project is successful.