Dollarhide Queen

Secondary Recovery Study

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I. Object:

This study was made by the Dollarhide Queen Engineering Sub-Committee for the following purposes:

1. To determine the feasibility of a waterflood project in the subject pool.

2. To outline a program for secondary recovery by waterflooding.

3. To determine participation parameters applicable to the proposed unit.

4. To design a waterflood project for the proposed unit.

II. Conclusions

1. The subject pool is a feasible waterflood project, and a full scale flood is indicated as soon as possible.

2. Ultimate primary depletion will recover 3.14 million barrels of oil.

3. Secondary recovery resulting from water injection will yield an additional 1.6 million barrels of oil.

4. The flood program as outlined is expected to result in top allowable unit oil production of 42 barrels per day per unitized well, or 2688 barrels per day.

5. The participation formula herein described is presented as the most equitable method of allocating secondary production from the unitized reservoir. The proposed formula was agreed upon, after extensive investigation of a variety of types and combinations of parameters. It is believed to be the most reasonable division of interests for a reservoir with the characteristics and performance history of the Dollarhide Queen. The participation formula, which includes 72% cumulative to 1-1-60; 23% ~~productive~~ acres; and 5% gross pay, has been approved by the working interest owners.

III. Recommendations:

1. The subject area should be unitized to promote effective secondary recovery of oil from the Queen reservoir.

2. A full-scale water injection program as proposed should be instituted at the earliest possible date.

IV. Discussion:

A. History

Initial discovery of the Dollarhide Queen pool was the completion of Skelly Oil Company's Mexico "O" Well No. 1 in Sec. 6, T-25-S, R-38-E, Lea County, New Mexico. Subsequent development of the field has been effected by various operators. The following are presently operating leases within the proposed unit:

Culbertson & Irwin
Elliott & Hall
J. P. Gibbins
Gulf Oil Corp.
Pan American Petroleum Corp.
Sinclair Oil & Gas Co.
Skelly Oil Co.
Texaco, Inc.

Within the horizontal limits of the proposed unit area, a total of 64 Queen producers on regular 40-acre spacings have been completed. Of this number, 58 wells continue to produce a limited amount of oil from the depleted reservoir. The proposed unit with the Queen completions enclosed by its boundaries is outlined on the accompanying Unit Area Map, Figure 1.

B. General Reservoir and Fluid Properties

The Dollarhide Queen reservoir, as shown on the structure map, Figure 2, is represented as an elongated northwest-southeast trending anticline. Structural dip on the south and west sides is 300 feet per mile, and on the north is 150 feet per mile. The Queen formation, a member of the Whitehorse Group, Permian Age, is found at an average depth of 3600 feet in the Dollarhide area. A typical section of the Queen formation is illustrated by the included log of Skelly's Mexico L #24, Figure 3.

Productive limits of the Queen reservoir in this area are defined by a water-oil contact at 585 feet, subsea elevation, on the north and west and by insufficient porosity on the south and east.

The water-oil contact is shown by the core analysis of Skelly's Mexico "J" Well No. 4, Fig. 4. Determination of the water-oil contact at -585 feet is further supported by the water locator log run on Texaco's McGhee No. 5, Fig. 5. An additional indication of the presence of a water-oil contact at -585 is the performance of Texaco's United Royalty Well No. 1. Originally completed at a PBTD of 3715 feet (a subsea elevation of -546'; TD was 3717'), the well's initial potential was 132 barrels oil and no water. After three years, oil production had declined and a slight amount of water was being produced. The well was deepened to approximately one foot above the water-oil contact, resulting in a marked

increase in water production.

Absence of porosity is evidenced by the low capacity wells and dry holes on the south and east flanks of the reservoir, and is illustrated on the Gross Isopach map, Fig. 6, and on logs of the Pan American's State "Y" wells numbered 13, 15, and 1 on cross-section A-A', Fig. 7. The porosity limit was established on the basis of well surveys and results of drill stem tests.

C. Primary Recovery

The oil originally in place was determined volumetrically, applying a core determined net to gross factor as shown in the attached calculations. Assuming a recovery efficiency of 15 per cent, ultimate primary recovery was estimated at 3.14 million barrels. This estimate is in accord with extrapolated decline curves, and is equivalent to a per well primary ultimate of 49,000 barrels.

D. Secondary Recovery

1. Waterflooding

The geometry of the reservoir is such that no single flood pattern will affect a maximum portion of the reservoir in a reasonable period of time without additional drilling. The engineering committee has agreed upon use of a combination of two patterns; the 80-acre five-spot and peripheral. This combination will make possible the utilization of existing wells, and is expected to fulfill flooding requirements for the Queen reservoir. The injection pattern is illustrated on Fig. 8. Employment of this pattern is believed the most effective approach toward secondary recovery from this reservoir, and should afford adequate protection against drainage by non-unitized properties.

Based upon an injection rate of 500 barrels/day/well, a response is expected approximately 14.5 months after the proposed flood is initiated.

Secondary recovery was calculated by the Stiles method to be 1.6 million barrels, employing a water-oil ratio of 50:1 as the economic limit. Secondary production will bring to 4.74 million barrels the estimated ultimate recovery.

Primary performance and the projected secondary performance are shown on Figures 9a, 9b, and 9c.

2. Unitization and Participation

Secondary development of an area having the size and conformation of the proposed Dollarhide Queen Unit is generally considered most practical and economical if undertaken by a single operator. Skelly Oil Company has been named operator for the proposed unit.

Participation parameters were developed on the following basis:

A. Primary Participation Formula. Each tract's percentage of the total production from Unit Area during the year 1959.

B. Secondary Participation Formula. 72% each tract's percentage of the total Unit Area's Cumulative Production as of January 1, 1960,

Plus

23% of each tract's percentage of total ~~Productive~~ Developed Acres in the Unit Area,

Plus

5% of each tract's percentage of Gross Pay under the Unit Area.

The primary participation parameter will be used as the basis for allocating production among working interest owners up to the time when all primary oil has been produced. Primary oil is described as that portion of the estimated primary (3.14 million barrels) remaining after deducting therefrom all oil produced from said Queen formation and run to the pipeline (as determined by Working Interest Owners from the Commissions monthly reports, Form C-115) from the beginning of production to the effective date of the Unit.

When ultimate primary recovery is complete, the secondary participation parameter will become the basis of allocation.

The cost of installation will be distributed among the working interest owners on the basis of the secondary participation percentage of each.

3. Plan of Waterflood

Thirty-six producing wells and twenty-eight injection wells employed in a combination 5-spot and peripheral pattern as shown on Figure 8, are planned for the secondary recovery project. An injection rate of 500 barrels/day/well is intended. The nine Santa Rosa water wells proposed on Figure 10 will be used as the injection water source.

A water test drilled through the Santa Rosa on Skelly's Mexico "O" lease produced 1800 barrels water per day from the interval between 590 feet and 766 feet. Nine wells should adequately supply the 14,000 barrels water per day required to sustain the injection rate. Water rights have been obtained in the pool and an analysis of the water is attached, Fig. 11. Santa Rosa water is being used successfully in a Drinkard and Devonian flood a few miles east in Texas. No treating problems are anticipated.

On Figure 12 is shown the flow of injection water from supply well to injection well. Installation of a filtering system will be determined by filter tests of water from the Santa Rosa formation.

Injection wells will be equipped with retrievable packers to isolate the casing-tubing annulus, and for control of the media injected.

Although Ellenburger and Fusselman waters are present in the Queen area the supply is limited, and availability as a primary injection source cannot be assured due to instability of supply from these oil-producing formations. The cost of treating the produced water for injection would be high, and due to the expected marginal flood is not recommended for use.

A single injection plant, shown in the distribution system on Figure 13, will be constructed in Unit L Sec. 32-T24S-R38E. The system, including 4½" O.D., 3½" O.D., and 2-3/8" O.D., injection lines, will be installed for implementation of full scale secondary recovery operations when unitization becomes effective.

Initial installation of 200 hydraulic horsepower is planned to implement the flood at the proposed injection rate. Ultimate power requirements of 600 hydraulic horsepower is anticipated to sustain the injection rate at an expected peak well-head pressure requirement of 2,000 psi. Power requirements will be determined by the injection rate, and additions or deletions of power will be governed by pressure and volumetric conditions as observed when the flood is instituted.

Dollarhide Queen
Volumetric Calculations

Volumetric formula: $N = \frac{7758 \times A \times H \times \phi \times So}{Bo}$

Where:
N = Oil originally in place, Bbls.
7758 = Conversion factor, Bbls./acre - feet
A = area included, acres
H = Thickness of formation, feet
ϕ = Porosity
So = Oil saturation
Bo = Oil formation volume factor

Factors used to determine Primary Oil:
Ah = 222,796.3 gross acre-feet (from gross pay isopach map)
$Ah_{effective} = \frac{222,796.3}{5} = 44,559.26$ acre-feet (employing a net-to-gross factor of 1:5, estimated from logs and cores)
ϕ = 14% (estimated using logs and cores)
So = (1-Sw); Sw = 48% (estimated using cores)
Bo = 1.2 RBO/STBO (estimated, based on area)

Primary recovery efficiency = 15% (estimated, based on area)

$$N_{primary} = \frac{44,559.26 \times 7758 \times .14 \times 0.52 \times 0.15}{1.2}$$

$N_{primary} = 3.14 \times 10^6$ Bbls.

$\frac{\text{Acre-Feet} \times \text{Bbls/acre-feet}}{\text{Bbls/bbl.}}$ = Bbls.

V. Maps, Reports and Graphical Data

Figure 1 - Unit Area
Figure 2 - Structure Map
Figure 3 - Typical Section
Figure 4 - Core Analysis
Figure 5 - Water Locater Log
Figure 6 - Gross Isopach Map
Figure 7 - Cross-Section A-A'
Figure 8 - Injection Pattern
Figures 9a, 9b, 9c - Performance Curves
Figure 10 - Distribution System
Figure 11 - Analysis of Santa Rosa Water
Figure 12 - Schematic Diagram of Water Injection