BC/14991-10

DESIGN AND IMPLEMENTATION OF A CO2 FLOOD UTILIZING ADVANCED RESERVOIR CHARACTERIZATION AND HORIZONTAL INJECTION WELLS IN A SHALLOW SHELF CARBONATE APPROACHING WATERFLOOD DEPLETION

DOE/BC/14991--10

Cooperative Agreement Number:	**DE-FC22-94BC14991**
Contractor Name and Address:	**Phillips Petroleum Company** **4001 Penbrook Street** **Odessa, Texas 79762**
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Project Director:	**John S. Chimahusky**
DOE Project Officer:	**Jerry F. Casteel**
Reporting Period:	**July 1, 1996 - September 30, 1996**

DISCLAIMER

OBJECTIVE

The first objective is to utilize reservoir characterization and advanced technologies to optimize the design of a carbon dioxide (CO_2) project for the South Cowden Unit (SCU) located in Ector County, Texas. The SCU is a mature, relatively small, shallow shelf carbonate unit nearing waterflood depletion. The second objective is to demonstrate the performance and economic viability of the project in the field. This report includes work on the reservoir characterization and project design objective and the demonstration project objective.

SUMMARY OF TECHNICAL PROGRESS

BUDGET PHASE II

TASK V FIELD DEMONSTRATION

Drill, Re-Activate, and Convert Wells

Testing of reservoir characterization Well RC-3 (6-24)

A step-rate test was run on reservoir characterization Well RC-3 during mid-July to determine the reservoir fracture pressure in the vicinity of the two horizontal injection wells. The results of this step-rate test were used to establish the maximum injection pressure for the horizontal injectors.

Testing of Horizontal Injection Wells Nos. 6C25H (H-1) and 7C11H (H-2)

Prior to being placed on CO_2 injection, injection profile surveys and falloff tests were conducted under water injection to verify that we had obtained an acceptable distribution of injection along the lateral section and to determine the mechanical condition and completion efficiency in the horizontal wells.

The injection profile work for the first horizontal well, Well No. 6C25H, was done by Cardinal Surveys Company. This consisted of a continuous flowmeter, quartz pressure sensor, temperature survys, capacitance and gamma ray probe conveyed on 1.25" coiled tubing. Good results were obtained even though the survey was done at relatively low injection rates under a very small pressure differential into the formation. The survey showed the injection water was entering the formation along most of the length of the lateral section.

Injection pressure measurements and a pressure falloff test were run during the water injection period in Well No. 6C25H. High-quality falloff data were obtained. Initial pressures matched closely with the simulation model predictions along the horizontal traverse and permeability data derived from radial flow periods matched well with the history-matched permeabilities in the model. The length of the effective intervals taking fluid derived from model verification matching agreed with the injection profile survey results. The pressure falloff results indicated a good acid stimulation had been obtained from the coiled tubing acid wash completion in the horizontal section. Based on the favorable results in the injection profile and falloff data, the well was placed on CO_2 injection during early July and slowly brought up to capacity injection at a bottomhole injection pressure slightly below the calculated formation parting pressure (from step-rate results on RC-3). The injection rate stabilized very close to the expected rate forecast in the model.

The injection profile survey on the second horizontal well, Well No. 7C11H, was conducted by Halliburton using a different procedure. They opted to run a logging and injection program wherein coiled tubing and wireline were run in the injection well simultaneously with a Y-block and coiled tubing side-entry assembly attached to the coiled tubing below the spot valve. The tool consisted of positive and negative gamma-ray and temperature tool. A slug of more than one gallon of radioactive gel with 50 micron sand was used rather than the standard injection procedure of 1 cc per station. A flowing temperature log and velocity shots were used to determine fluid entry. Results of the second injection profile survey were somewhat ambiguous and difficult to interpret. Halliburton's interpretation indicated injection fluid movement throughout all but the last 150 feet near the toe of the horizontal interval. In-house interpretation of the results, however, indicated that a good portion of the injected water could be entering the reservoir near the toe of the well.

A pressure falloff test was also run in Well No. 7C11H. This test did not show the same behavior as demonstrated in the first well. The test showed early linear flow behavior rather than early radial flow as in the first horizontal well. This second well was drilled approximately normal to the preferential parting direction indicated in earlier micro-frac tests conducted in two reservoir characterization wells. A step rate test was also conducted on the well, which showed a shift toward linear flow behavior and possible fracture extension above 2600 psi bottomhole injection pressure.

Low-volume injection of CO_2 in the horizontal injection wells commenced in early July, following the pressure and injection profile testing. Higher-volume CO_2 injection into Wells Nos. 6-25H and 7-11H commenced August 14, and August 29, 1996, respectively.

Injection in Vertical Wag Injection Wells Nos. 2-26W and 2-27W

Water injection commenced in vertical WAG injection Wells Nos. 2-26W and 2-27W in early July. Bottom-hole pressure surveys were run in both these vertical injection wells during early August,

immediately prior to commencing CO_2 injection. CO_2 injection began July 19, 1996 in Well No. 2-26W, at an initial wellhead pressure of 890 psig, and on July 22, 1996 in Well No. 2-27W.

Drill multiple producing wells

Two new producing wells were proposed for drilling during fourth quarter, Wells Nos. 7-13 and 7-15. Well No. 7-13 will be drilled as a replacement well for plugged and abandoned production Well No. 7-06. Well 7-15 will be drilled to improve the spacing in the northern portion of Section 18. This work was originally scheduled for 1997.

Convert Five Wells for Water Injection

Wells Nos. 5-02 and 8-18 were converted for use as water injection wells and are waiting on injection line tie-in.

Reactivate Wells for Production

Wells Nos. 7-02, 7-05 and 6-02 were reactivated for production.

Construct, Modify, and Upgrade Facilities for Injection and Production

Purchase Land, Install Perimeter Fence and H_2S Monitors

All of the required private lots in Section 17 of the South Cowden Unit have been purchased. The sixth lot could not be purchased for a reasonable price; hence, the lot will not be purchased. Extra precautionary monitors and alarms will be installed along the lot line to protect the owner. This has been discussed and agreed with the Texas Railroad Commission (TRRC) to meet Rule 36 requirements.

The main 250-acre tract of land where CO_2 flood facilities are located is currently being leased. Purchase of the land is anticipated in November.

Twenty of twenty-one hydrogen sulfide (H_2S) premised monitors have been installed and are operational. An additional H_2S monitor along the perimeter fence behind the private lot that could not be purchased will be added. If H_2S is detected by any of the monitors, an alarm is sent via radio to the Phillips Petroleum Odessa office South Cowden Unit (SCU) Supervisory Control and Data Acquisition (SCADA) computer, which in-turn sends a message to an operator on-call who will have an alpha-numeric pager. If the operator on-call cannot be reached, a list of people will be called until someone acknowledges the alarm.

The perimeter fence is approximately 95% complete. This fence is being constructed to prevent public entrance into the project area, provide protection from exposure to H_2S and protect against vandalism. The fence will be completed now that all the private lots have been purchased.

Construct Injection Facilities

Installation of injection runs to all four of the CO_2 WAG injection wells is completed. Installation to the water injection wells is complete for Wells Nos. 5-02 and 8-18. Tie-in of additional wells will be ongoing as wells are prepared for injection.

Installation is complete.

Construction and installation of the H_2O and CO_2 (WAG) manifold is completed. Since completion of the manifold with the CO_2/water meters, the meters have been modified to improve $_2CO$ measurement. The work is now complete.

Replacement of the old water injection system is essentially complete except for the lateral to injection well No. 5-02.

Modify or Upgrade Production Facilities

Construction of the new Tract 6 Satellite facility is approximately 90% complete. The Satellite facility will be ready within the next thirty (30) days. However, the Satellite facility will not be put into operation until the Unit experiences significant CO_2 production.

Construct Compression Facilities

Production Operators, Inc. (POI) completed construction of their re-injection facility on June 21, 1996. The facility will continue to be idle until CO_2 production increases enough to justify operating the compressors.

Install Cathodic Protection

No additional field work has been completed this quarter. Evaluation of the collected data from the well logs is ongoing and redesign of the system utilizing the new data continues. A decision to install the field wide cathodic protection will be made during fourth quarter 1996.

Install Supervisory Control and Data Acquisition (SCADA) Equipment

The SCADA system has been installed and is operating. Installation of producing well pump-off controllers is 95% complete.

Purchase CO_2 and Operation of Recycle Compression

The total volumes purchased for injection in all the wells for the quarter were:

	MSCF CO_2
July	10,446
August	90,687
September	232,190
Total	333,323

The recycle compression facilities are currently not in use.

TASK VI TECHNOLOGY TRANSFER

During the last quarter, a paper entitled "Reservoir Characterization of an Upper Permain Platform Carbonate in Preparation for a Horizontal-Well CO_2 Flood, South Cowden Unit, West Texas," was written and submitted to the Oklahoma Geological Survey by Craig D. Caldwell. This paper was previously presented as a poster session at the March, 1996, meeting "Platform Carbonates of the Southern Midcontinent" sponsored by the OGS. The OGS is planning on publishing 1000 copies of the proceedings from this meeting.

An abstract for SPE Paper 37470, "The Evaluation of Two Different Methods of Obtaining Injection Profiles in CO_2 WAG Horizontal Injection Wells," was submitted by Kimberly B. Dollens, James C. Shoumaker, Burl W. Wylie, and Phil Rice, for presentation at the 1997 SPE Production Operations Symposium, March 9-11, 1997, in Oklahoma City, Oklahoma.