

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

Cooperative Agreement Number: DE-FC22-94BC14991

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OBJECTIVE

The first objective is to utilize reservoir characterization and advanced technologies to optimize the design of a carbon dioxide (CO₂) 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. All work this quarter falls within the demonstration project.

SUMMARY OF TECHNICAL PROGRESS

BUDGET PHASE II

TASK V FIELD DEMONSTRATION

Drill Production Well No. 6-29

SCU Well 6-29 was drilled to a total depth of 4808' during September, 1997, with a plugback depth at approximately 4755', as a replacement well for SCU Well No. 6-01, which was deemed to have irreparable casing damage. The casing program consisted of 8-5/8" surface casing set at 1699' and 5-1/2" production casing to 4805' total depth (TD). The completion is scheduled for early fourth quarter.

Drill two vertical WAG injectors along South Cowden Unit boundary - approved under Amendment No. A007 to the Cooperative Agreement for inclusion in Phase II funding

Vertical water alternating gas (WAG) injection Wells 6-26W and 6-27W were placed on water injection during January, 1997. Injection profile logs were run while the wells were on water injection during February, 1997.

The injection profile survey on Well 6-26W indicated communication with an uphole water sand and a deeper reservoir interval. A workover was performed during April, 1997, to conventionally squeeze the lower thief zone (4709'-4726') below a retainer at 4701' and then squeeze cement the upper perforations at 4568'-4582'. A subsequent water injection profile survey was run during June, 1997, which indicated that the upward channel had been successfully plugged; however, all of the injected water was then going out the bottom of the well.

During late June, 1997, a foamed cement job was then performed to stop the out-of-zone injection, and the well was reperfored across only the E and upper F zones (4618'-4638'). The job appeared to have been successful as planned. On September 19, 1997, a follow-up injection profile was obtained on the well, at a reported injection rate of 424 barrels of water per day (BWPD) at 400 pounds per square inch gauge (psig) surface injection pressure. The velocity calculations indicated that eighty-three percent (83%) of the fluid was going into the new perforations at 4618'-4638'; however, eighteen percent (18%) of the fluid was exiting the old perforations at 4631'-4637'. No

flow was detected inside the pipe past 4642'.

The temperature logs indicated channeling up to 4580' and a channel down below 4648', with approximately 70% of the fluids leaving in the new perforations at 4618'-4628'. Although the profile was not perfect, the foamed cement job was deemed a success and CO₂ injection commenced.

Convert Two wells for Water Injection

During third quarter, 1997, SCU Wells Nos. 6-18 and 8-03 were converted to water injection. The results are summarized below:

	-----BEFORE-----	-----AFTER-----
SCU 6-18	Shut-in	Injecting @ 248 BWPD and 480 psig
SCU 8-03	Shut-in	Injecting @ 300 BWPD and 680 psig.

Plug and Abandon Three Shut-in Wells (not included in DOE funding)

During third quarter 1997, SCU Wells Nos. 2-16W, 6-01 and 6-12W were plugged and abandoned due to regulatory requirements (bad casing):

Workover or Recondition Existing Wells

During third quarter 1997, fourteen wells were acid stimulated. The results follow:

Well	-----BEFORE-----			-----AFTER-----			Comments
	BOPD	BWPD	MCFD	BOPD	BWPD	MCFD	
SCU 2-01	20	107	0	41	217	7	
SCU 2-02	3	41	0	12	188	1	
SCU 2-08	3	38	0	13	147	3	
SCU 2-22	8	141	5	24	253	29	
SCU 2-25	30	167	5	30	207	6	
SCU 5-07	8	87	1	25	225	49	
SCU 6-02	12	105	1	9	150	47	
SCU 6-22	47	97	25	0	151	32	
SCU 7-02	2	43	0	11	70	28	
SCU 7-08	28	910	340	20	477	123	
SCU 7-09	3	55	0	5	220	0	
SCU 7-12	1	8	0	0	285	0	
SCU 7-13	14	30	0	9	1	5	
SCU 7-15	6	30	0	13	96	0	

Production for the project area was increased by approximately 75 barrels of oil per day (BOPD) and 1500 BWPD as a result of the total clean-out program, including Wells Nos. 7-01, 7-05, and 7-10, stimulated during second quarter.

Purchase CO₂ and Operation of Recycle Compression Facilities

The CO₂ recycle compression facilities were in operation throughout the third quarter. CO₂ injection volumes were necessarily curtailed during August and September as a result of pipeline maintenance being done by Amoco. Horizontal Well No. 7C-11H was switched back to water injection during this time period.

The total volumes injected in all four injection wells for the third quarter were:

GAS INJECTION - MCF

	Jul 97	Aug 97	Sep 97
Monthly	252,308	208,448	132,748
Daily Average	8,139	6,724	4,425
Cumulative	2,859,131	3,067,579	3,200,327

Unit Production

By late September, oil production had increased approximately 150 BOPD total, with 75 BOPD as a result of the CO₂ injection in the near vicinity of the horizontal injection wells, and the remaining 75 BOPD as a result of the stimulation program. A summary of quarterly average production and injection follows:

Qtr	-----PRODUCTION-----			-----INJECTION-----		
	BOPD	BWPD	MCFD	BWIPD	MSCFPD	CO ₂
1st 1996	375	3861	88	4520	0	
2nd 1996	356	3526	89	4208	0	
3rd 1996	337	4301	91		4144	3623
4th 1996	375	4907	105	4900	8674	
1st 1997	442	5837	611	5837	8111	
2nd 1997	425	6462	929	5931	8293	
3rd 1997	445	6408	1110	6335	6451	

TASK VI TECHNOLOGY TRANSFER

Kimberly B. Dollens participated as a panelist and presented a paper entitled “Application of Horizontal Injection wells in the South Cowden Unit CO₂ Flood,” at the 1997 Society of Petroleum Engineers (SPE) Horizontal Well Conference held in Midland, Texas, September 17 and 18, 1997.