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**MASTER**

Contract No. DE-FC03-79SF10761  
 FIELD DEMONSTRATION OF THE CONVENTIONAL STEAM-DRIVE PROCESS  
 WITH ANCILLARY MATERIALS

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FC03-79SF10761

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OBJECTIVE

The objective of this contract is to field test the potential of chemical blocking foams to increase the efficiency of steam drive operations, particularly in shallow, heavy oil reservoirs. The contract will be conducted in four phases:

Phase 1: Preparation, Laboratory Work, and Pre-testing

During this phase laboratory work on foam development and two pilot test will be conducted.

Phase 2: Field Test

This phase consists of two field tests of various alternatives of the foam blocking process.

Phase 3: Verification Field Test

The third phase consists of a verification field test incorporating the experience gained during the first two phases.

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## SUMMARY OF TECHNICAL PROGRESS

The initial work under the contract has consisted of laboratory work to test foaming materials. The state-of-the art was surveyed through a review of current work and through meetings held with university and industry laboratories. Discussed was equipment, data, and agents in the generation and evaluation of foams.

Testing during the first quarter was conducted at room temperature and atmospheric pressure to screen the foaming agent. These tests were conducted in distilled water, saline water, and water with crude oil added, as described in detail in the appendix. The preliminary results, also included in the appendix, indicate that several chemicals appear promising.

Two distinct types of steam drive operations have been selected for the first two pilot tests.

The first steam drive operation is representative of a mature drive near the end of its economic life. In these operations the reservoir has been extremely depleted. Early break-through of the steam did not occur, but at the current stage the oil-steam ratio is approaching the technical limit.

The second steam drive operation is representative of highly heterogeneous and thick reservoirs that are difficult to produce conventionally. Channeling occurs virtually from the inception of the steam drive and steam break-through is exacerbated by thick oil sand intervals.

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Phase 4: Data Collection and Analysis

Data collection, evaluation of the pattern geology and past production and the analysis of the results will be performed on an on-going basis.

## APPENDIX

### SURFACTANT SCREENING BY A STATIC FOAM TEST

#### OBJECTIVE

A rapid and reproducible test was utilized to select surfactants with good foaming potential, and screen out those with poor foaming ability. The method used for static foam testing was patterned after the Chevron High Speed Stirrer Test (CHSST) which is a convenient procedure for evaluating the foaming action of surfactants at ambient temperature. Maximum foam volume attained and foam "half-Life" were the evaluation parameters used; "half-life" being the time necessary for half the initial liquid to drain from the foam.

#### METHODS

The surfactants submitted for testing were made up in 0.5 and 1.0 volume percent solutions using a 3 cc syringe in distilled water. Since some of the surfactants were solids at room temperature, these were solubilized in distilled water on a weight percent basis. Some of these surfactants required several hours to dissolve.

A Hamilton Beach Scovill Blender was used to create the foam. The blender was connected to a Variac, so that the blending speed could be varied continuously. One hundred milliliters of surfactant solution were added to a one liter Griffin Type Beaker and agitated at 75°F by the Variac-Controlled Blender until a maximum foam volume was attained. Usually, this required twenty to thirty seconds. The blender was then immediately shut off, a stop watch started,

Appendix  
Surfactant Screening by a Static Foam Test  
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and the maximum foam volume recorded. As the foam began to break down and drain, the "half-life" was measured using the stop watch. When fifty milliliters had drained the time was recorded, and then the solution was immediately refoamed and the refoamed volume and "half-life" again measured and recorded in Table I.

These steps were repeated following the addition of twenty-five milliliters of a one percent (w/v) solution of sodium chloride, Table II. These same procedures were again repeated after adding an additional twenty five milliliters of crude oil. For the initial testing, twenty nine gravity crude oil from the Ventura Field was used.

The relatively poor performance of several surfactants under what should have been ideal foaming conditions caused these surfactants to be eliminated from further consideration.

Thus eight of the fourteen surfactants originally submitted were selected from the results in Table I for further screening tests. These secondary evaluations were run in the same manner as the initial tests with the following changes:

- (1) 2% (w/v) potassium chloride (KCL) was substituted for distilled water as the primary medium.
- (2) The effects of calcium were investigated.
- (3) The 29° API crude oil was dropped in favor of an oil-in-water suspension obtained from the Fellows Field in California

CONCLUSIONS: CHSST TESTING

(A) Initial Screening Tests

- (1) Nine of the fourteen surfactants tested foamed satisfactorily in 2% (w/v) potassium chloride.
- (2) Introduction of 1% NaCl did not adversely affect foam volume in eight of the nine satisfactory foaming agents.
- (3) Introduction of crude oil in the presence of NaCl did adversely affect foam volume in each case and also "half-life" in all but two cases.

Thus eight of the fourteen surfactants originally submitted were selected from the results in Table I for further screening tests.

(B) Secondary Screening Tests

- (1) 2% (w.v) potassium chloride (KCl) was substituted for distilled water as the primary medium.
- (2) The effects of calcium were investigated.
- (3) The 29° API crude oil was dropped in favor on an oil-in-water suspension obtained from the Fellows Field in California.

The conclusions of these tests are:

- (1) Seven of the eight surfactants tested foamed satisfactorily in 2% (w/v) potassium chloride.
- (2) Although the addition of 400 ppm calcium had only a small effect of foam volume, in three cases the "half-life" was

very much affected.

- (3) Three of the eight surfactants were severely affected by the addition of the Fellows Field produced water.

TABLE I. FOAMING AGENTS IN DISTILLED WATER.

Foaming Agent Company Description	Concentration %	Initial foaming		Second foaming		ADDED CONTAMINANTS			
		Foam volume (ml)	Half-life (sec)	Foam volume (ml)	Half-life (sec)	25 ml of 1% NaCl		25 ml of 29° crude oil	
						Foam volume (ml)	Half life (sec)	Foam volume (ml)	Half life (sec)
Dresser/ Magco Foamer 77 11/15/79	0.5(v/v)	625	200	650	200	700	150	275	15
Armax (trimethyl chloride)	ARQUAD T-50 11/15/79	1000	280	1000	320	1000	165	200	0
	Itallowammonium chloride 1.0(v/v)	1100	310	1100+	300	1000	185	225	0
Armax	ARQUAD T 27W Lot 19,8003	625	270	1000	250	575	165	-	-
	1.0(v/v)	250	230	950	210	300	140	-	-
Suntech Group	Sulfonate Run #768533 BTF+C15 OLEFIN Sample Code VII	150	0	150	0	175	0	200	0
Suntech Group	Sulfonate Run #768547 Solvent Lube Extract 661°F to 904°F @ 760mm Sample Code X	250	40	300	55	250	10	200	0
Suntech Group	Sulfonate Run #768551 Solvent Lube Extract 661°F to 804°F @ 760 mm Sample Code XI	-	-	No Foaming Observed - - -					
Suntech Group	Sulfonate Run #768553	450	120	425	120	275	30	200	0
	1.0(w/v) Solvent Lube Extract 830° to 858°F @ 760 mm Sample Code XII	375	95	375	120	400	20	225	0

TABLE I. FOAMING AGENTS IN DISTILLED WATER.

Foaming Agent Company Description	Concentration %	Initial foaming		Second foaming		Added contaminants 25 ml of 290 crude oil			
		Foam volume (ml)	Half- life (sec)	Foam volume (ml)	Half- life (sec)	25 ml of 1% NaCl Foam volume Half life (ml) (sec)		Foam volume (ml)	Half life (sec)
Milchem Ampli-Foam	0.5 (v/v)	550	260	550	220	675	210	200	0
	1.0 (v/v)	750	290	700	270	850	240	300	5
Textilana Deriphat EC #792603 11/6/79	0.5 (v/v)	800	210	675	180	775	155	250	5
	1.0 (v/v)	1075	330	1175	300	950	180	325	10
FarBest Thermofoam EW-D 8/14/79	0.5 (v/v)	1025	375	1200	390	1200	290	500	60
	1.0 (v/v)	1200	380	1200	390	1200	340	625	65
FarBest Thermofoam EW-D 7/20/79	0.5 (v/v)	1000	310	1100+	340	1100+	245	-	-
Lakeway 301-10 Lot #3838	0.5 (w/v)	1000	400	1100	360	1100	315	700	320
Lakeway 301-10F Lot #3135 (Sodium Alpha Olefin Sulfonate)	0.5 (w/v)	850	310	875	320	900	280	750	220

TABLE 1. FOAMING AGENTS IN DISTILLED WATER.

Foaming Company	Agent Description	Concentration %	Initial foaming		Second foaming		Added contaminants			
			Foam volume (ml)	Half- life (sec)	Foam volume (ml)	Half- life (sec)	25 ml of 1% NaCl		25 ml of 290 crude oil	
							Foam volume (ml)	Half life (sec)	Foam volume (ml)	Half life (sec)
Suntech Group	Sulfonate Run #768549 C15+BTF+mixed Xylenes Sample Code XIII	0.5(w/v)	130	0	130	0	175	0	200	0

TABLE II. FOAMING AGENTS IN 2% POTASSIUM CHLORIDE SOLUTION

FOAMING AGENT		Concentration (%)	INITIAL FOAMING		SECOND FOAMING		ADDED CONTAMINANTS				
Company	Description		Foam Vol. (ml)	Half Life (sec)	Foam Vol. (ml)	Half Life (sec)	25 ml of hard water (400 ppm Ca)		25 ml produced water* containing approx. 1% crude oil in suspension		
						Foam Vol.	Half Life	Foam Vol.	Half Life	Foam Vol.	Half Life
Milchem	Ampli foam	0.5 (v/v)	425	170	400	165	500	120	275	0	
		1.0 (v/v)	675	195	825	240	800	180	350	20	
Textilana	Deriphat BC	0.5 (v/v)	850	155	850	245	1000	140	525	40	
		1.0 (v/v)	950	190	1100	270	1075	160	825	140	
Farbest	Thermophoam BW-D	0.5 (v/v)	750	155	350	245	900	225	500	75	
		1.0 (v/v)	1000	190	1100	270	1200	255	850	190	
Lakeway	301-10 Lot #3838	0.5 (v/v)	675	235	650	230	925	230	425	40	
		1.0 (v/v)	925	260	1000	280	1100	270	700	175	
Lakeway	301-10F Lot #3135	0.5 (v/v)	1100	230	1100+	315	1100+	280	1050	200	
	sodium alpha olefin sulfonate)	1.0 (v/v)	1200	263	1200	365	1200	300	1200	240	
Dresser/ Magco-bar	Magco Foamer 77 11/15/79	0.5 (v/v)	600	310	550	165	725	155	575	65	
		1.0 (v/v)	950	360	925	180	975	165	900	160	
Armak (trimethyltallowammonium chloride)	ARQUAD T-50 Lot 1918003	0.5 (v/v)	750	160	700	160	950	145	300	10	
		1.0 (v/v)	975	165	925	165	1050	170	375	20	
Armark	ARQUAD T27W Lot 1808701	0.5 (v/v)	400	110	400	115	450	55	225	15	
		1.0 (v/v)	400	105	400	110	500	105	275	10	

\*Notes: Produced water was obtained from Santa Fe Energy Co., Fellows, California, Well #60-22

TABLE II. FOAMING AGENTS IN 2% POTASSIUM CHLORIDE SOLUTION

FOAMING AGENT		Concentration (%)	INITIAL FOAMING		SECOND FOAMING		ADDED CONTAMINANTS				
Company	Description		Foam Vol. (ml)	Half Life (sec)	Foam Vol. (ml)	Half Life (sec)	25 ml of hard water (400 ppm Ca)		25 ml produced water* containing approx. 1% crude oil in suspension		
						Foam Vol.	Half Life	Foam Vol.	Half Life	Foam Vol.	Half Life
Stepan Chemical Co.	Lathalol LAL Flake Control #79929 8/13/79	0.5 (w/v) 1.0 (w/v)	Sample was not soluble in solution under 62° C-----								
Stepan Chemical Co.	BIO Soft D-40 Control # 79939 8/27/79	0.5 (v/v) 1.0 (v/v)	400 725	80 190	575 825	130 180	525 725	120 175		400	10
Stepan Chemical Co.	BIO Terge AS-40 Control # 79979 10/22/79	0.5 (v/v) 1.0 (v/v)	650 1050	230 270	850 1100+	255 285	1000 1200+	245 270		800	200

\* Notes: Produced water was obtained from Santa Fe Energy Co. Fellows, California, Well #60-22