



ESSO EXPLORATION AND PRODUCTION NORWAY INC.

[NORLANDSK AKSJESELSKAP]

P-0239

30 April 1980

T.I. Pedersen
Statoil
P.O. Box 300
4001 STAVANGER

FORTROLIG
I h.t. Beskyttelsesinstruksen,
jfr. offentlighetslovens
§ nr.

EPRCo Core Analysis
Well 34/10-3 Core

Dear Tor-Ivar,

As outlined in my letter to you on 10.3.80, EPRCo conducted a second waterflood test on a 34/10-3 composite core. This test was performed to determine if the relative permeability to brine measured in the previous tests was in error because the flood was conducted at too great of a rate. As discussed in the enclosed letter, reducing the flow velocity did indeed result in more creditable relative permeability data.

Very truly yours,

Tom Solak

T.A. Solak

10 MAR 1981

RECEIVED BY
OPERATIONAL DEPARTMENT

TAS/mv
cc: J. Hanstveit - Statoil
H. Hellman - EEPN
A.G. Spillette - EEPN

EXON PRODUCTION RESEARCH COMPANY
POST OFFICE BOX 2189 • HOUSTON, TEXAS 77001

RESERVOIR DIVISION
C. C. MATTAY
MANAGER

April 15, 1980

Mr. T. A. Solak
Esso Exploration and Production Norway Inc.
Postboks No. 560
4001 Stavanger, Norway

Dear Tom:

Attached are the results of a second waterflood conducted in the Norway 34/10-3 core composite at a flow velocity of 3.65 ft/day. The relative permeability to brine in this test started at a lower value and increased gradually during the flood. Final values were approximately the same in both this flood and the previous flood conducted at 34 ft/day.

We believe the faster flow rate in the first test resulted in an initial fingering action of the brine through the more permeable channels of the core. Values of relative permeability to brine were relatively high since the entire cross-section of the core was not available to flow. This situation was gradually corrected as the brine invaded the less permeable portions of the core as the test proceeded; thus the relative permeability values in the last part of the flood are accurate.

In the second test the flow velocity was 3.65 feet per day until just after water breakthrough, compared to about 34 feet per day in the initial flood. The slower rate permitted a more uniform advance of the flood front through the entire cross-section of the core, thus exhibiting lower values of relative permeability to brine early and gradually increasing values as the oil saturation decreased.

Following breakthrough, the injection rate was increased to the same value used in the first test (34 ft/day). Finally, after oil production had ceased, the rate was further increased to 78 feet per day. No further oil production occurred during a three pore-volume throughput at this rate.

Upon conclusion of the second flood, the flow was reversed and several values of specific permeability to brine (k_{br}) were obtained, as shown in the table below:


<u>Permeability to Brine 34/10-3 Composite, Reverse Flow</u>	
<u>Flow Rate, ft/day</u>	<u>k_{br}, md</u>
3.65	38.0
34	45.3
78	51.7

For comparison, the final values of specific permeability to brine at 34 ft/day during the first and second tests were 36.1 and 37.7 md., respectively. The higher values associated with the reversed flow may indicate slight plugging of the core during the floods.

Very truly yours,

C. C. MATTAX

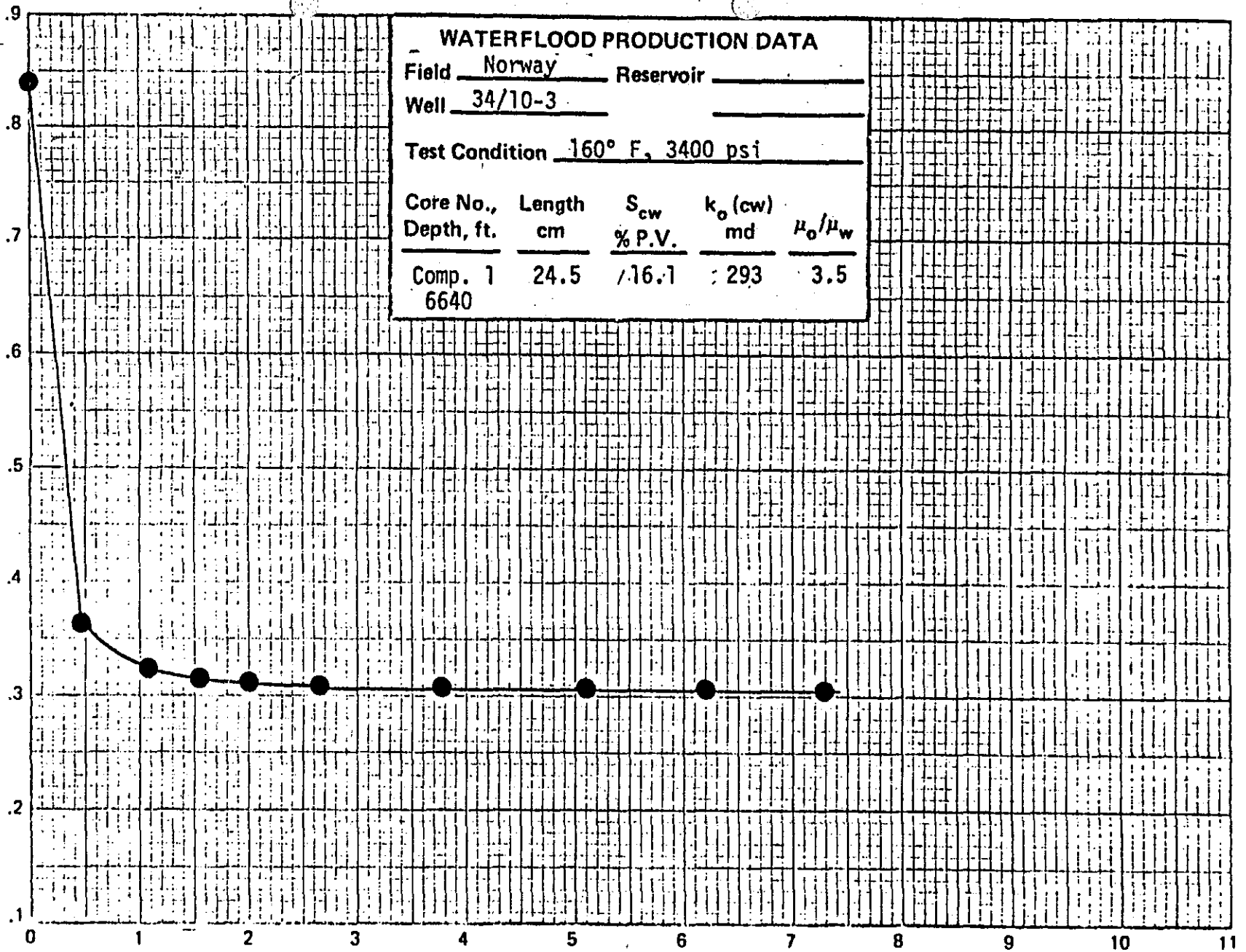
By


Clay Gruesbeck

LHJ:lfj
Attachment

cc: J. G. Richardson

OIL SATURATION - PORE VOLUME



CUMULATIVE WATER INJECTED - PORE VOLUMES

FIGURE _____

OIL-WATER RELATIVE PERMEABILITY BY WATERFLOOD

Field Norway Reservoir _____
 Well 34/10-3 _____

Core Composite 1
 Depth, ft. 6640
 Permeability, k_o (cw), md 293
 Connate Water, % P.V. 16.1

Porosity, % B.V. 30.3
 Oil Viscosity, cp 1.5
 Brine Viscosity, cp 0.43

● Oil ○ Water

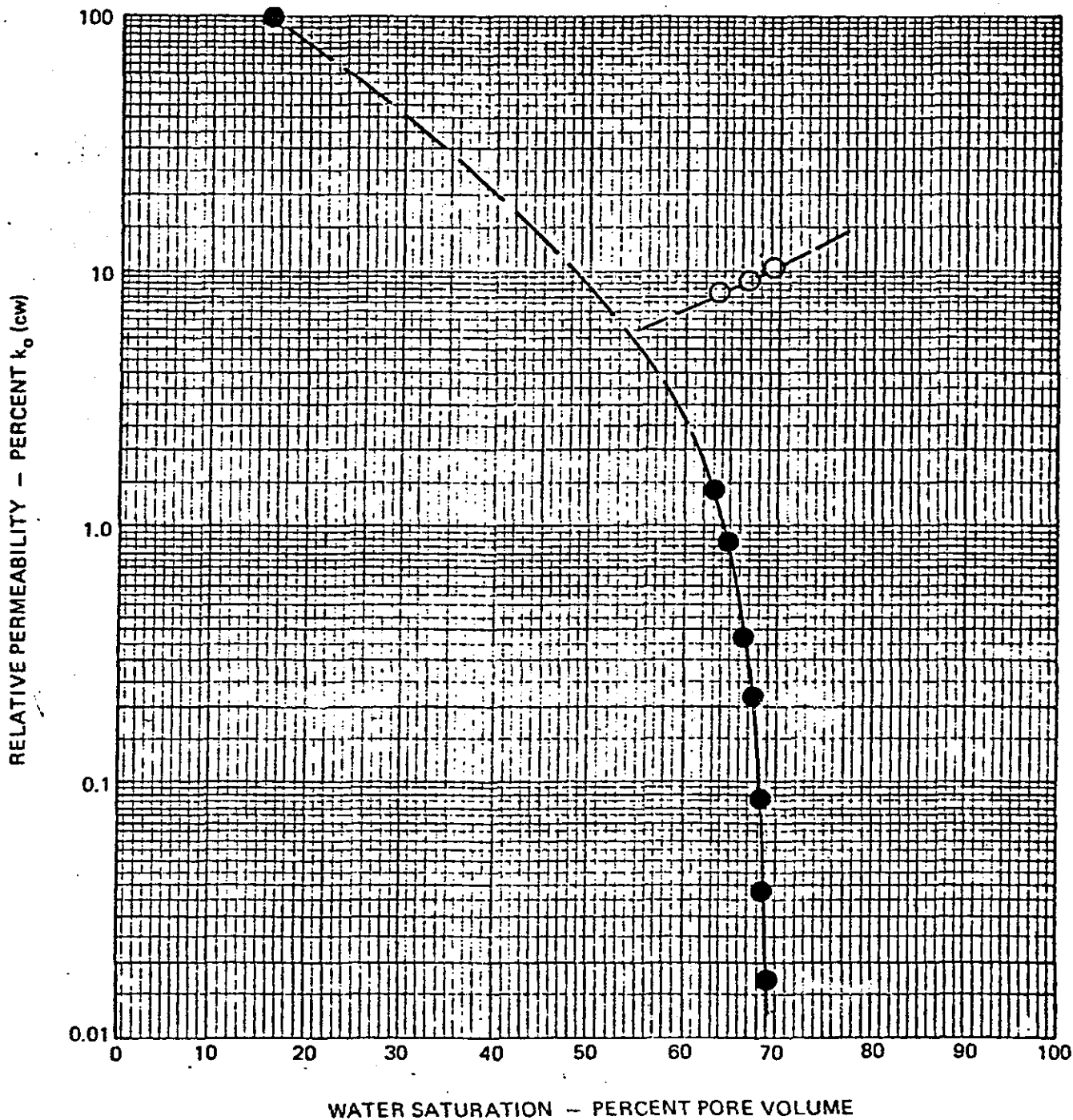
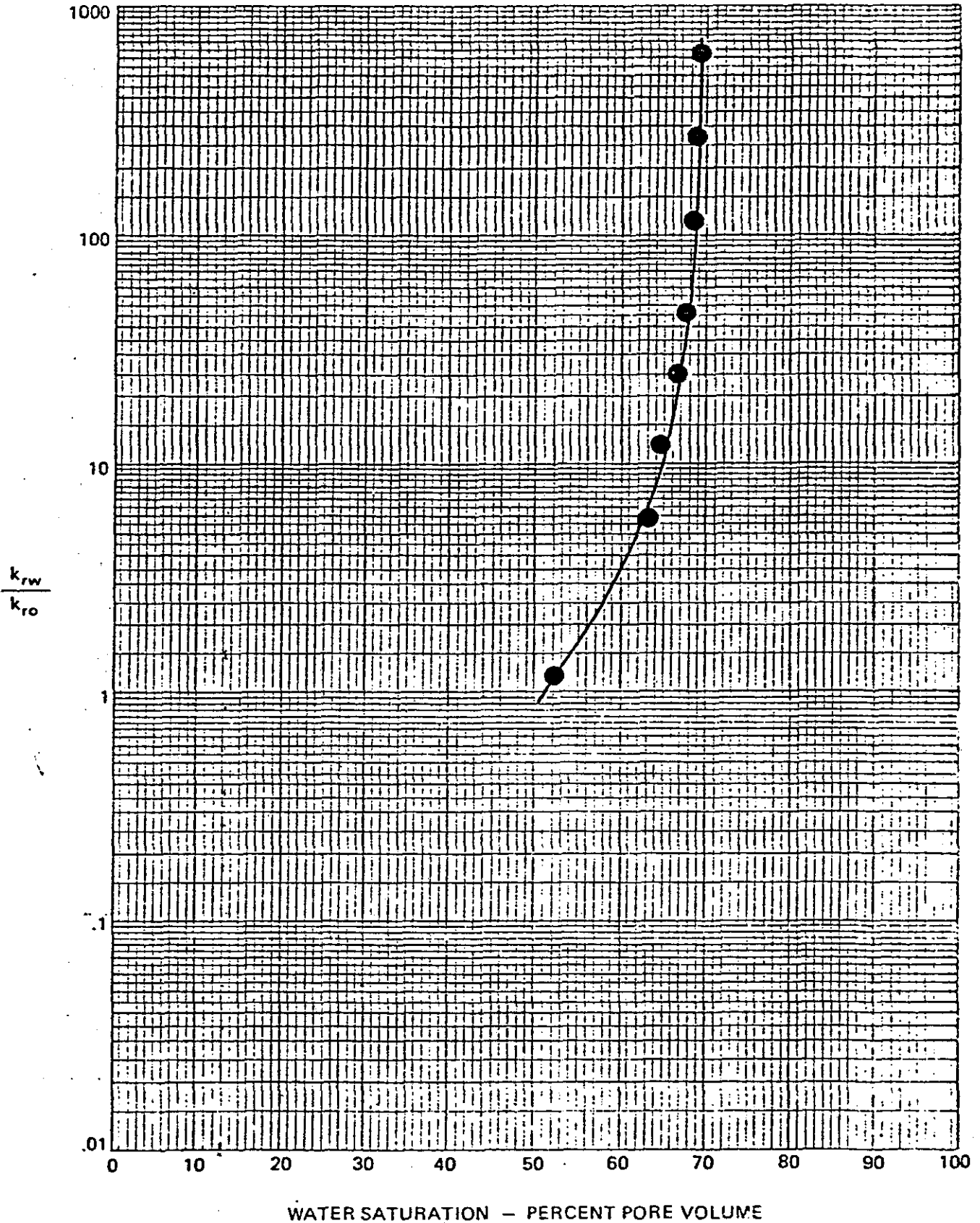


FIGURE _____
OIL-WATER RELATIVE PERMEABILITY RATIO

Field Norway Reservoir _____
Well 34/10-3 _____

Symbol	Core No., Depth, ft.	Permeability k_o (cw), md	Connate Water % P.V.
	Comp. 1 6640	293	16.1



EPRCO WATERFLOOD CALCULATION, SAMPLE COMP.

CONDITION - PRESERVED

DATE 3-26-80

COMPANY	RESERVOIR	WELL NO.	DEPTH FT.	SAMPLE NO.	WATERFLOOD NUMBER	TOT. TIME INCREMENTS IN FLOOD
EXPRO NORWAY		34/10-3	6640.000	COMP.	2	13
CORE LENGTH, CM				24.500		
CROSS-SECTIONAL AREA OF CORE, SQ CM				10.860		
BULK VOLUME, CC				266.070		
PORE VOLUME OF CORE, CC				80.500		
HYDROCARBON VOLUME, CC				67.500		
OIL VISCOSITY IN TEST, CP				1.500		
FLOODING BRINE VISCOSITY IN TEST, CP				0.430		
VISCOSITY RATIO				3.488		
POROSITY, PCT. BULK VOLUME				30.255		
SCALING FACTOR, LVMUB				2.313		
KOCW, PREDETERMINED PERMEABILITY TO OIL IN PRESENCE OF CONNATE WATER, MD				293.000		
KBRD, BRINE PERMEABILITY AT RESIDUAL OIL SATURATION				38.059		
FLOW VELOCITY IN CORE, INCHES/DAY				411.344		
TIME CONVERSION FACTOR, UNITS/MINUTE				0.133		
TIME UNITS AT FLOOD START				0.0		
PRESSURE CONVERSION FACTOR, UNITS/PSI				4.000		
PRESSURE UNITS AT ZERO PRESSURE				0.0		
TEMPERATURE OF CORE DURING FLOOD, DEG F				160.000		
CORE OUTFLOW FACE PRESSURE, PSIG				3520.000		
INITIAL OIL IN PLACE, PCT. PV				83.851		
CONNATE WATER, INITIAL WATER IN PLACE, PCT. PV				16.149		
OIL DISPLACED DURING FLOOD, PCT. PV				53.341		

RELATIVE PERMEABILITY CALCULATION METHOD - SMOOTHED (5 POINT, LEAST SQUARES, BOSSLER)

COMMENTS

- RESERVOIR CONDITIONS WATERFLOOD-SLOW RATE UNTIL BREAKTHROUGH-STEP 3
 INLET 2023.99, 2024.15, 2024.08, 2024.01 OUTLET

EPRCO WATERFLOOD CALCULATION, SAMPLE COMP.

CONDITION - PRESERVED

DATE 3-26-80

CONTINUOUS CHART TYPE FLOOD
DISPLACED OIL RECORDED FROM SEPARATOR TRANSDUCER OUTPUT

INPUT DATA

READING OF OIL RECOVERY SYSTEM AT FLOOD START, UNITS	10.0000
OIL RECOVERY VOLUME FACTOR, CC/UNIT	1.3770
BRINE HOLDUP, CC. (VOLUME OF SYSTEM BETWEEN CURLE OUTLET AND OIL COLLECTOR)	1.0000
OIL HOLDUP, CC. (VOLUME OF OIL IN INLET AND OUTLET LINES OF CORE HOLDER, NOT PART OF HV)	1.4000
BRINE INJECTION RATE, CC/MIN	2.3840
COMPUTED TIME TO PRODUCE OIL PLUS WATER HOLDUP, MIN	1.0067

STEP NO.	CUMULATED TIME FROM START OF FLOOD TIME UNITS	PRESSURE DROP ACROSS CORE PRESSURE UNITS	PRODUCED OIL READING CHART UNITS
1	0.8260	67.8000	20.0000
2	1.6950	78.5000	31.3000
3	2.2920	83.6000	38.9000
4	3.0760	81.0000	39.8000
5	4.0760	79.2000	40.9000
6	5.0760	76.4000	41.2000
7	7.0760	73.4000	41.6000
8	9.0760	72.0000	41.9000
9	12.0760	69.0000	42.0000
10	17.0760	65.4000	42.1000
11	23.0760	62.2000	42.1000
12	28.0760	60.2000	42.2000
13	33.0760	58.9000	42.2000

CHECK VOLUMES AT STEP 2.

EPRCO WATERFLOOD) CALCULATION. SAMPLE COMP.

CONDITION - PRESERVED

DATE 3-26-80

STEP NO.	AVG. DIL SAT. PERCENT PV	OIL DISPLACED PERCENT PV	OIL DISPLACED PERCENT HV	VOLUME BRINE INJECTED, PV	VOLUME OIL PRODUCED, CC	TOTAL FLUID PRODUCED, CC
1	68.4845	15.3664	18.3259	0.1537	12.3700	12.3726
2	49.1552	34.6957	41.3779	0.3468	27.9301	27.9142
3	36.1550	47.6959	56.8818	0.4794	38.3953	78.5912
4	34.6155	49.2354	58.7178	0.6536	39.6346	52.6126
5	32.7339	51.1171	60.9619	0.8757	41.1493	70.4971
6	32.2207	51.6302	61.5739	1.0979	41.5624	88.3816
7	31.5365	52.3144	62.3898	1.5422	42.1132	124.1505
8	31.0233	52.8276	63.0018	1.9866	42.5263	159.9195
9	30.8522	52.9987	63.2059	2.6531	42.6640	213.5729
10	30.6812	53.1697	63.4098	3.7639	42.8017	302.9949
11	30.6812	53.1697	63.4098	5.0969	42.8017	410.3018
12	30.5101	53.3408	63.6138	6.2078	42.9394	499.7241
13	30.5101	53.3408	63.6138	7.3186	42.9394	589.1465

RELATIVE PERMEABILITIES

STEP NO.	CALC. OIL SAT. AT OUTLET CORE FACE PCT. HV	CALC. OIL SAT. AT OUTLET CORE FACE PCT. PV	CALC. WATER SAT. AT OUTLET CORE FACE PCT. PV	RELATIVE PERMEABILITY TO BRINE PCT.	RELATIVE PERMEABILITY TO OIL PCT.	RELATIVE PERMEABILITY RATIO
1	*****	90.2299	9.7701	-4.9849	59.3081	-0.00405
2	84.5556	70.9007	29.0993	4.4810	26.2875	0.17046
3	69.0516	57.9004	42.0996	6.5659	19.0145	0.34531
4	56.9779	47.7765	52.2235	7.6566	6.7345	1.13691
5	43.8957	36.8070	63.1930	8.3524	1.4213	5.87678
6	42.0020	35.2191	64.7809	8.7605	0.8580	10.21006
7	39.7139	33.3005	66.6995	9.0994	0.3673	24.77534
8	38.4825	32.2679	67.7321	9.4987	0.2089	45.46887
9	37.5843	31.5148	68.4852	9.8181	0.0858	114.49602
10	37.0745	31.0873	68.9127	9.9510	0.0375	265.38757
11	36.9925	31.0186	68.9814	10.3051	0.0238	432.80640
12	36.7885	30.8475	69.1525	10.3063	0.0195	527.19653
13	36.7885	30.8475	69.1525	10.3072	0.0166	621.58667

RELATIVE INJECTIVITY

STEP NO.	BRINE INJECTED. PV	RELATIVE INJECTIVITY
1	0.1537	0.3980
2	0.3468	0.3437
3	0.4794	0.3228
4	0.6536	0.3331
5	0.8757	0.3407
6	1.0979	0.3532
7	1.5422	0.3676
8	1.9866	0.3748
9	2.6531	0.3911
10	3.7639	0.4126
11	5.0969	0.4338
12	6.2078	0.4482
13	7.3186	0.4581



TAS

ESSO EXPLORATION AND PRODUCTION NORWAY INC.

[NORLANDSE AKSJESELSKAP]

P-0147

10 March 1980

T.I. Pedersen
Statoil
P.O. Box 300

4001 STAVANGER

EPRCo Core Analysis Program
Well 34/10-3

Dear Tor-Ivar,

Enclosed are five copies of the Exxon Production Research Co. final report on the special core analysis performed for well 34/10-3.

As agreed by Statoil, EPPCo will conduct a second waterflood test on the composite core at a cost of \$ 4 k to determine the effect of rate variations on relative permeability results. The flood-front movement for the existing test was 34 feet per day while the revised test will be conducted at 4 feet per day. Results are expected to be available by the end of March.

Yours very truly,

T.A. Solak

DRP/mv
cc: J. Hanstveit - Statoil
Attachments

LPRCO WATERFLOOD CALCULATION, SAMPLE COMPOSITE

CONDITION - PRESERVED

DATE 11-16-79

RELATIVE PERMEABILITIES

STEP NO.	CALC. OIL SAT. AT OUTLET CORE FACE PCT. HV	CALC. OIL SAT. AT OUTLET CORE FACE PCT. PV	CALC. WATER SAT. AT OUTLET CORE FACE PCT. PV	RELATIVE PERMEABILITY TO BRINE PCT.	RELATIVE PERMEABILITY TO OIL PCT.	RELATIVE PERMEABILITY RATIO
1	*****	92.2422	7.7578	-4.3190	89.4483	-0.04828
2	79.9316	71.0945	28.9055	10.1309	39.0418	0.25949
3	63.3995	56.3901	43.6099	13.2792	28.0593	0.47325
4	49.8973	44.3807	55.6193	12.8945	5.9690	2.16003
5	40.5004	36.0228	63.9772	12.5781	0.9202	13.66950
6	38.7329	34.4506	65.5494	12.3313	0.3969	31.07161
7	38.1566	33.9360	66.0620	11.8219	0.2431	48.62354
8	37.4440	33.3042	66.6958	11.4287	0.1449	78.87831
9	36.7090	32.6505	67.3495	11.1306	0.0986	112.89719
10	36.1328	32.1380	67.8620	11.0132	0.0460	239.53292
11	35.5328	31.6043	68.3957	11.0027	0.0127	864.52441
12	35.5328	31.6043	68.3957	11.0033	0.0107	1027.36182
13	35.5328	31.6043	68.3957	11.0036	0.0097	1135.92065

FIGURE 2

OIL-WATER RELATIVE PERMEABILITY BY WATERFLOOD

Field Norway Reservoir _____
 Well 34/10-3 _____

Core	Composite	Porosity, % B.V.	30.3
Depth, ft.	6640	Oil Viscosity, cp	1.5
Permeability, k_o (cw), md	302	Brine Viscosity, cp	0.43
Connate Water, % P.V.	11.1		

● Oil ○ Water

