

ROBERTSON RESEARCH INTERNATIONAL LIMITED

REPORT NO. RRLS/6

**SPECIAL CORE ANALYSIS STUDY FOR
STATOIL DEN NORSKE STATS OLJESELSKAP a.s.
WELL: 34/10 - 16, GULLFAKS FIELD
NORWEGIAN SECTOR, NORTH SEA.**

VOLUME 1

by

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November, 1984

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RESEARCH**

INTRODUCTION

This report comprises the results of Special Core Analysis tests performed on a suite of samples from Well 34/10-16 of the Gullfaks field situated in the Norwegian sector of the North Sea.

The request and specifications for the study were originally outlined in a telex from Mr. Jon Ringen of Statoil, ref. telex ZCZC 091001 dated 20/9/83. These test requirements were later modified in a letter from Mr. Kora Sørheim of Statoil, ref. letter THE/BF dated 2/11/83.

The results of the analyses have been presented in three volumes. Volume 1 comprises the results of the initial Klinkenberg permeabilities, the residual gas determinations and gas-oil relative permeability tests. Volume 2 comprises the results of the high rate waterflood tests and Volume 3 includes the results from the low rate waterfloods with the accompanying high rate 'bump floods'.

Exact details of the organisation of each volume are presented on the contents pages which like the introduction are also included in each volume to ensure their individual clarity.

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1.2 PERMEABILITY AND POROSITY SUMMARY CHART

SAMPLE NUMBER	DEPTH (metres)	FORMATION	AIR PERMEABILITY*	POROSITY(ϕ)**
			Ka (mD)	(per cent)
7.1	3171.85	ZONE 1	1013	26.2
† 7.1	3171.85	ZONE 1	1015	24.7
57.1	3190.00	ZONE 1	36	21.9
† 57.1	3190.00	ZONE 1	34	21.7
81.1	3200.00	ZONE 1	195	24.5
† 81.1	3200.00	ZONE 1	198	23.1
93.1	3204.15	ZONE 1	485	25.8
† 93.1	3204.15	ZONE 1	456	24.5
135.1	3219.00	ZONE 2	37	22.3
†135.1	3219.00	ZONE 2	35	22.0
316.1	3284.25	ZONE 2	80	19.6
†316.1	3284.25	ZONE 2	75	19.0
408.1	3325.15	ZONE 2	8.9	20.5
†408.1	3325.15	ZONE 2	8.8	19.9
471.1	3347.50	ZONE 2	2316	22.8
†471.1	3347.50	ZONE 2	2210	22.0
487.1	3359.15	ZONE 2	511	21.1
†487.1	3359.15	ZONE 2	470	20.3
586.1	3396.00	ZONE 3	27	18.0
†586.1	3396.00	ZONE 3	27	17.7
604.1	3401.65	ZONE 3	6.3	15.4
†604.1	3401.65	ZONE 3	6.5	14.3
623.1	3407.50	ZONE 3	128	19.5
†623.1	3407.50	ZONE 3	128	19.2
657.1	3419.10	ZONE 4	2.00	13.3
†657.1	3419.10	ZONE 4	1.90	12.5
666.1	3422.10	ZONE 4	17.8	18.4
†666.1	3422.10	ZONE 4	18.0	18.4
700.1	3433.70	ZONE 4	0.76	14.0

* Extrapolated value from Klinkenberg permeability results.

** Helium Porosity, calculated using a bulk volume determined by immersion in brine.

† Parameters re-determined after second cleaning cycle.

1.3 SAMPLE PREPARATION AND BASE PERMEABILITY MEASUREMENTS

1.3.1 Test and Calculation Procedures

1.3 SAMPLE PREPARATION AND BASE PERMEABILITY MEASUREMENTS

1.3.1 Test and Calculation Procedures

The test suite for this study comprised 15 plug samples of one and one half inches diameter. The samples had been drilled and trimmed into right cylinders prior to transportation to Robertson Research. Upon receipt an examination of the samples confirmed that there had been no damage to the samples during transit and that the samples appeared suitable for the requested test programme.

Sample Cleaning

All of the samples were cleaned of residual mobile reservoir and drilling fluids by solvent extraction. This was achieved by Soxhlet retorting the samples in a low boiling point azeotrope of methanol and toluene. The samples were deemed clean when the refluxing solvent showed no discolouration and tests for salt proved negative. The samples were then dried in a humidity controlled oven at 60°C and 40 per cent relative humidity.

Air Permeability and Porosity Measurement Techniques

In order to derive air permeability and Klinkenberg correction, the gas permeability of each sample was determined at four mean pressures. The measurements were made by flowing nitrogen gas through the samples after they had been loaded in Hassler core holders with a net overburden stress of 200 psi applied. Differential pressure across the sample was measured by manometer and back pressure was monitored by either manometer or electronic pressure transducer.

From this data a graph of gas permeability versus the reciprocal of mean pressure was plotted for each sample and air permeability and Klinkenberg permeability were determined by extrapolation. A plot of Klinkenberg permeability versus porosity is presented in Figure 1.3.2.

Porosity values were determined indirectly. The grain volume of each sample was measured by the expansion of helium gas from standard volumes into the sample loaded in a Matrix cup. Pressures in the system were monitored by electronic transducer and the grain volume was calculated by applying Boyle's law to the data. Pore volume and subsequently porosity were calculated after saturating and immersing the samples in brine to derive the bulk volume.

Upon completion of the base air permeability and grain volume measurements the samples were saturated with simulated formation brine. Saturation was achieved in two stages. Firstly the samples were carefully positioned in an air-tight vessel and this vessel was then evacuated. De-aired simulated formation brine was then introduced and the system was pressured up to approximately 70 bars. This pressure was maintained overnight for approximately 16 hours.

The saturated pore volume of each sample was calculated by material balance and sample bulk volume was determined by immersing the samples in brine and applying Archimedes' principle. The helium pore volumes and the saturated pore volumes were compared and in all cases the levels of saturation were considered suitable for testing to continue.

The brine permeability of each sample was then determined. The measurements were performed by flowing brine at three different flowrates. A graph of flowrate versus brine permeability was plotted for each sample and the data was taken to be valid if a straight line could be drawn through the data points and the co-ordinate 0.00, 0.00.

All of the samples were then loaded onto a brine saturated porous plate and desaturated in a single desaturation stage using humidified air at 200 psi. The time taken to reach SW_{ir} was approximately seven days, the desaturation profile of the sample being monitored periodically throughout this stage. Once irreducible brine saturation had been attained gas permeability measurements were performed using the techniques previously described. Air permeability SW_{ir} and Klinkenberg Permeability SW_{ir} were then calculated from this data.

The gas permeabilities at SW_{ir} were later used as the base values for the Gas-Oil Relative Permeability calculations.

1.3 SAMPLE PREPARATION AND BASE PERMEABILITY MEASUREMENTS

1.3.2 Helium Porosity, Grain Density and Klinkenberg
Permeability Results

1.3.2 HELIUM POROSITY, GRAIN DENSITY AND KLINKENBERG PERMEABILITY RESULTS

SAMPLE NUMBER	DEPTH (metres)	FORMATION	HELIUM POROSITY (per cent)	GRAIN DENSITY (g/c.c.)	GAS PERMEABILITY (mD)	MEAN PRESSURE (bars)	KLINKENBERG PERMEABILITY K1 (mD)
7.1	3171.85	ZONE 1	26.2	2.64	1013 (Ka)		946
					999	1.28	
					984	1.81	
					978	2.07	
					970	2.32	
57.1	3190.00	ZONE 1	21.9	2.65	36 (Ka)		29
					33	1.80	
					32	2.49	
					31	3.17	
					30	4.60	
81.1	3200.00	ZONE 1	24.5	2.66	195 (Ka)		182
					191	1.39	
					189	1.74	
					188	2.10	
					187	2.44	
93.1	3204.15	ZONE 1	25.8	2.65	485 (Ka)		440
					476	1.27	
					470	1.56	
					465	1.80	
					460	2.36	
135.1	3219.00	ZONE 2	22.3	2.66	37 (Ka)		30
					34	1.80	
					33	2.53	
					32	3.21	
					32	4.71	

1.3.2 HELIUM POROSITY, GRAIN DENSITY AND KLINKENBERG PERMEABILITY RESULTS

SAMPLE NUMBER	DEPTH (metres)	FORMATION	HELIUM POROSITY (per cent)	GRAIN DENSITY (g/c.c.)	GAS PERMEABILITY (mD)	MEAN PRESSURE (bars)	KLINKENBERG PERMEABILITY K1 (mD)
316.1	3284.25	ZONE 2	19.6	2.69	80 (Ka)		72
					78	1.32	
					77	1.61	
					77	1.87	
					76	2.13	
408.1	3325.15	ZONE 2	20.5	2.67	8.9 (Ka)		6.5
					7.4	2.59	
					7.1	3.89	
					7.0	5.07	
					6.8	6.75	
471.1	3347.50	ZONE 2	22.8	2.65	2316 (Ka)		2223
					2299	1.22	
					2289	1.44	
					2272	1.87	
					2269	2.11	
487.1	3359.15	ZONE 2	21.1	2.65	511 (Ka)		465
					502	1.27	
					491	1.80	
					488	2.09	
					485	2.32	
586.1	3396.00	ZONE 3	18.0	2.65	27 (Ka)		21
					25	1.77	
					24	2.14	
					23	2.98	
					23	4.05	

1.3.2 HELIUM POROSITY, GRAIN DENSITY AND KLINKENBERG PERMEABILITY RESULTS

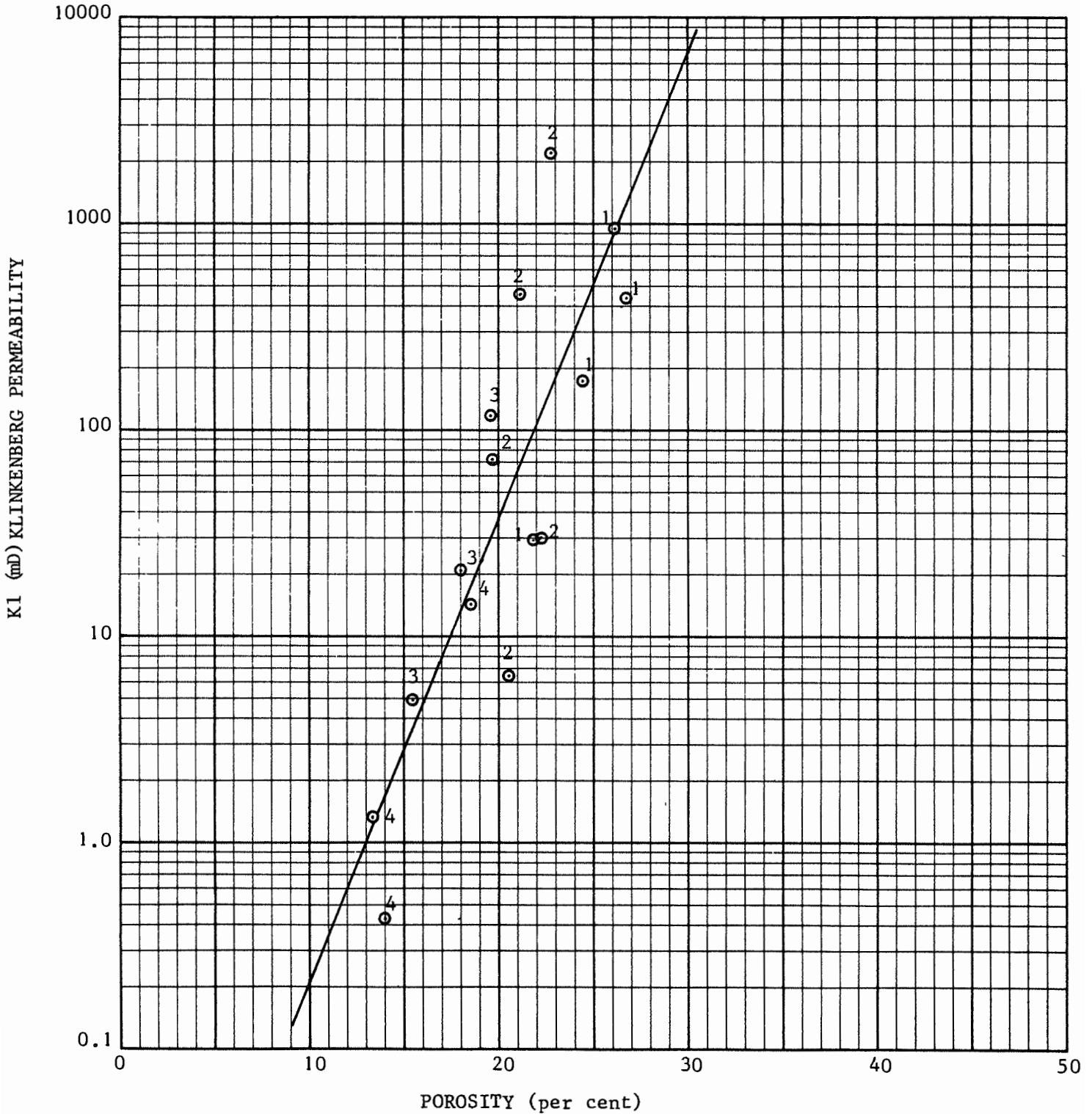
SAMPLE NUMBER	DEPTH (metres)	FORMATION	HELIUM POROSITY (per cent)	GRAIN DENSITY (g/c.c.)	GAS PERMEABILITY (mD)	MEAN PRESSURE (bars)	KLINKENBERG PERMEABILITY K1 (mD)
604.1	3401.65	ZONE 3	15.4	2.68	6.3 (Ka)		4.9
					5.8	1.47	
					5.7	1.93	
					5.5	2.59	
					5.2	4.82	
623.1	3407.50	ZONE 3	19.5	2.65	128 (Ka)		120
					126	1.32	
					125	1.65	
					124	2.13	
					123	2.89	
657.1	3419.10	ZONE 4	13.3	2.67	2.00 (Ka)		1.35
					1.72	1.68	
					1.67	1.99	
					1.57	2.70	
					1.48	4.82	
666.1	3422.10	ZONE 4	18.4	2.67	17.8 (Ka)		14.6
					16.4	1.77	
					16.0	2.30	
					15.5	2.60	
					15.3	4.60	
700.1	3433.70	ZONE 4	14	2.72	0.76 (Ka)		0.43
					0.60	1.87	
					0.58	2.20	
					0.54	2.90	
					0.49	5.07	

Figure 1.3.2.

COMPANY: STATOIL
 WELL: 34/10-16
 FIELD: GULLFAKS
 SAMPLE NUMBER:

FORMATION: ZONES 1,2,3,4
 LOCATION: NORWEGIAN NORTH SEA
 COUNTRY: NORWAY
 PERMEABILITY md :

KLINKENBERG PERMEABILITY versus POROSITY



1.3.3 BRINE PERMEABILITIES

SAMPLE NUMBER	DEPTH (metres)	FORMATION	AIR PERMEABILITY Ka (mD)	KLINKENBERG PERMEABILITY KL (mD)	BRINE PERMEABILITY Kw (mD)
7.1	3171.85	ZONE 1	1013	946	799
57.1	3190.00	ZONE 1	36	29	27
81.1	3200.00	ZONE 1	195	182	168
93.1	3204.15	ZONE 1	485	440	437
135.1	3219.00	ZONE 2	37	30	27
316.1	3284.25	ZONE 2	80	72	56
408.1	3325.15	ZONE 2	8.9	6.5	5.3
471.1	3347.50	ZONE 2	2316	2223	1923
487.1	3359.15	ZONE 2	511	465	407
586.1	3396.00	ZONE 3	27	21	18
604.1	3401.65	ZONE 3	6.3	4.9	4.2
623.1	3407.50	ZONE 3	128	120	117
657.1	3419.10	ZONE 4	2.00	1.35	0.61
666.1	3422.10	ZONE 4	17.8	14.6	11.8
700.1	3433.70	ZONE 4	0.76	0.43	0.16

1.3 SAMPLE PREPARATION AND BASE PERMEABILITY MEASUREMENTS

1.3.4 Irreducible Water Saturations

and

Klinkenberg Permeabilities at SW_{ir}

1.3.4 IRREDUCIBLE WATER SATURATIONS AND KLINKENBERG PERMEABILITIES AT SW_{ir}

SAMPLE NUMBER	DEPTH (metres)	FORMATION	SW_{ir} (per cent)	GAS PERMEABILITY (mD)	MEAN PRESSURE (bars)	KLINKENBERG PERMEABILITY K1 (mD)
7.1	3171.85	ZONE 1	8.5	884 (Ka) 875 868 865 861	1.25 1.51 1.78 2.05	838
57.1	3190.00	ZONE 1	20.2	31 (Ka) 28 28 28 28	2.61 3.29 3.99 4.64	27
81.1	3200.00	ZONE 1	17.7	180 (Ka) 177 175 174 173	1.38 1.73 2.11 2.42	169
93.1	3204.15	ZONE 1	14.8	462 (Ka) 455 450 451 448	1.91 2.57 3.26 3.94	437
135.1	3219.00	ZONE 2	22.2	32 (Ka) 30 29 29 29	1.91 2.57 3.26 3.94	27
316.1	3284.25	ZONE 2	22.4	69 (Ka) 67 67 66 66	1.29 1.56 1.82 2.09	63
408.1	3325.15	ZONE 2	33.8	6.7 (Ka) 6.2 6.0 5.7 5.5	1.59 1.89 3.41 6.85	5.3
471.1	3347.50	ZONE 2	5.3	2309 (Ka) 2283 2272 2246 2254	1.20 1.37 3.97 5.70	2192

1.3.4 IRREDUCIBLE WATER SATURATIONS AND KLINKENBERG PERMEABILITIES AT SW_{ir}

SAMPLE NUMBER	DEPTH (metres)	FORMATION	SW_{ir} (per cent)	GAS PERMEABILITY (mD)	MEAN PRESSURE (bars)	KLINKENBERG PERMEABILITY K1 (mD)
487.1	3359.15	ZONE 2	14.3	462 (Ka) 458 456 454 453	1.27 1.54 1.80 2.07	455
586.1	3396.00	ZONE 3	31.0	22 (Ka) 21 20 20 20	1.98 2.61 3.31 4.76	19
604.1	3401.65	ZONE 3	39.4	5.2 (Ka) 4.9 4.8 4.6 4.5	1.69 2.03 3.34 4.56	4.3
623.1	3407.50	ZONE 3	22.2	123 (Ka) 121 120 119 118	1.28 1.54 1.81 2.33	114
657.1	3419.10	ZONE 4	44.9	0.89 (Ka) 0.83 0.81 0.80 0.78	1.77 2.08 2.63 3.64	0.74
666.1	3422.10	ZONE 4	28.6	16.0 (Ka) 15.3 15.1 14.8 14.5	1.51 1.80 2.31 3.49	13.9
700.1	3433.70	ZONE 4	55.0	0.32 (Ka) 0.25 0.23 0.21 0.21	1.95 1.72 3.97 5.70	0.17

1.4 DETERMINATION OF RESIDUAL GAS SATURATION
BY LOW RATE OILFLOOD

1.4.1 Test and Calculation Procedures

1.4 DETERMINATION OF RESIDUAL GAS SATURATION BY LOW RATE OILFLOOD

1.4.1 Test and Calculation Procedures

The samples scheduled for this test had been driven to irreducible brine saturation in a single desaturating phase as described in Section 1.3.1. Each sample was then individually loaded into a specially prepared overburden cell. The cell containing the sample and the gas collection system were then pressurised until the core was sustaining approximately 20 bars pore pressure and 20 bars net overburden pressure.

The residual gas saturation of the samples was established by performing a low rate 4 c.c./hr constant rate oilflood. The differential pressure across the sample and downstream back pressure were monitored using electronic transducers.

The floods were continued until there was no more removal of gas and then the permeability to oil was measured.

1.4.2 RESIDUAL GAS DETERMINATION RESULTS

SAMPLE NUMBER	DEPTH (metres)	FORMATION	KLINKENBERG PERMEABILITY K1 (mD)	POROSITY (per cent)	SW _{ir} (per cent)	SW _{ir} (per cent)	GAS PERMEABILITY Kg (SW _{ir}) (mD)	RESIDUAL GAS PERMEABILITY Sgr (per cent)	OIL PERMEABILITY Ko (Sgr) (mD)
T5	7.1	ZONE 1	946	26.2	8.5	884	52.9	484	
T5	57.1	ZONE 1	29	21.9	20.2	31	41.2	24	
T4	81.1	ZONE 1	182	24.5	17.7	180	45.5	92	
T4	93.1	ZONE 1	440	25.8	14.8	462	41.8	175	
T4	135.1	ZONE 2	30	22.3	22.2	32	41.8	21	
N5	316.1	ZONE 2	72	19.6	22.4	69	43.0	45	
N3	408.1	ZONE 2	6.5	20.5	33.8	6.7	35.0	4.7	
N2B	471.1	ZONE 2	2223	22.8	5.3	2309	42.9	911	
N2A	487.1	ZONE 2	465	21.1	14.3	462	45.8	230	
E/U	586.1	ZONE 3	21	18.0	31.0	22	37.8	15	
E	604.1	ZONE 3	4.9	15.4	39.4	5.2	32.7	3.4	
E	623.1	ZONE 3	120	19.5	22.2	123	41.0	89	
R3	657.1	ZONE 4	1.35	13.3	44.9	0.89	35.9	0.52	
R3	666.1	ZONE 4	14.6	18.4	28.6	16	42.4	11.5	
R2	700.1	ZONE 4	0.43	14.0	55.0	0.32	24.8	0.21	

COMPANY: STATOIL

FORMATION: ZONES 1, 2, 3 and 4

WELL: 34/10-16

LOCATION: NORWEGIAN NORTH SEA

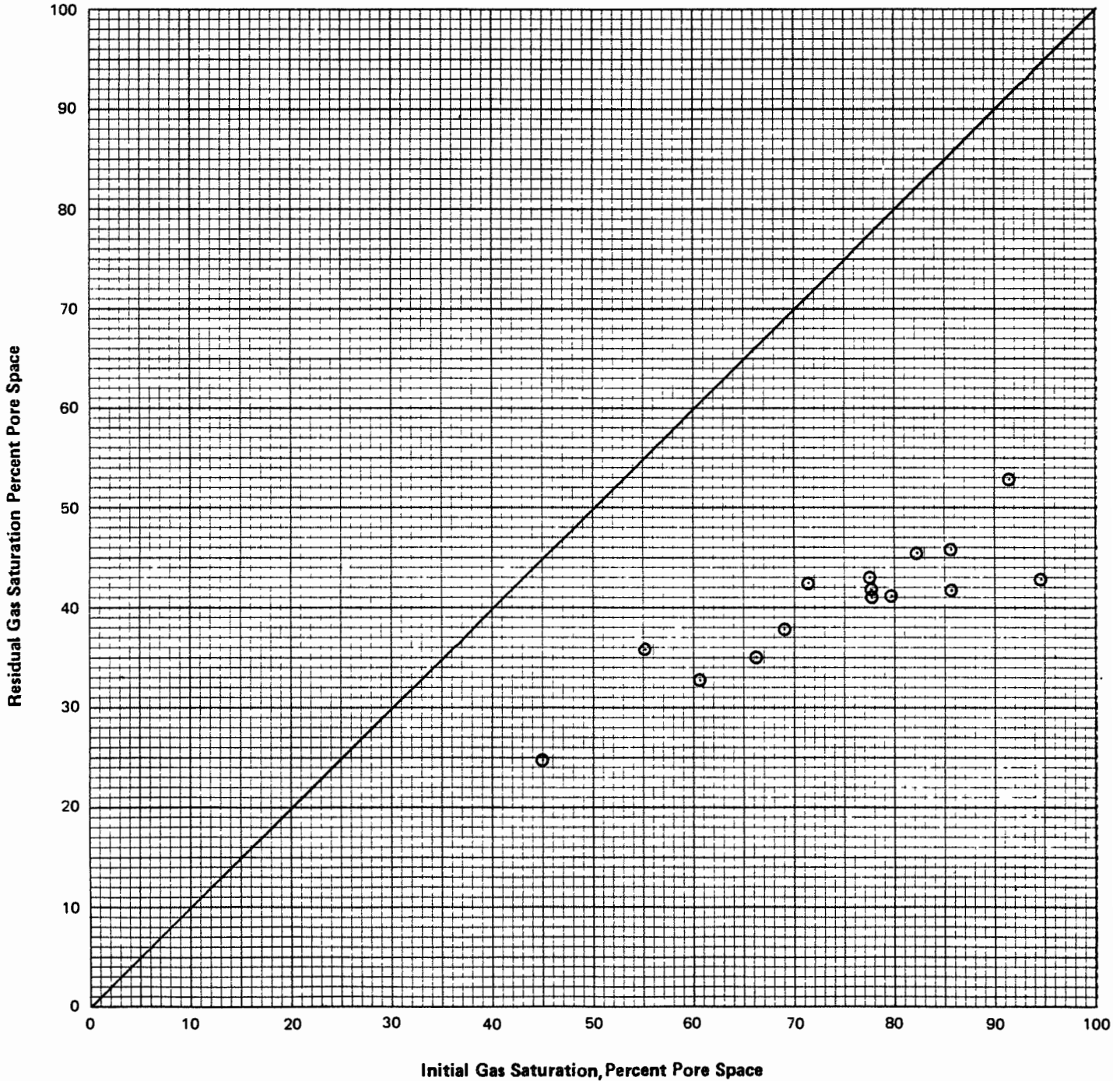
FIELD: GULLFAKS

COUNTRY: NORWAY

SAMPLE NUMBER:

PERMEABILITY md :

RESIDUAL GAS SATURATION versus INITIAL GAS SATURATION



1.5 GAS-OIL, RELATIVE PERMEABILITY TESTS

1.5.1. Test and Calculation Procedures

1.5 GAS-OIL, RELATIVE PERMEABILITY TESTS

1.5.1 Test and Calculation Procedures

The samples scheduled for testing had previously been used for residual gas saturation determination. They were restored for further testing by immersion in oil and evacuation, and then by flooding with oil against back pressure.

After removing the back pressure source the oil permeability of each sample was measured at three different pressures. From this data graphs of oil flowrate versus differential pressure were plotted. The samples were deemed to be fully restored when a straight line could be drawn through the data and the origin.

The gasfloods were performed using a constant differential pressure against a back pressure of approximately 20 bars. Throughout the flood oil and gas production was monitored against elapsed time. In the early stages of the flood the gas volume was collected using a 'sight glass' system similar to that used in the residual gas test, and as the gas volume increased the gas volume was recorded on a wet test meter. Throughout the test oil volumes were collected in a burette within the 'sight glass' system. The gas flood was continued until approximately 1000 pore volumes of gas had been flooded through each sample.

Liquid saturations and individual gas and oil relative permeabilities were then calculated using adaptations of the Johnson, Bossler and Nauman equations. Gas-Oil relative permeability ratios were then calculated from this data.

1.5 GAS-OIL, RELATIVE PERMEABILITY TESTS

1.5.2 Gasflood Production Data

1.5.2 GASFLOOD PRODUCTION DATA

SAMPLE NUMBER	DEPTH (metres)	FORMATION	AIR PERMEABILITY Ka (mD)	POROSITY (per cent)
7.1	3171.85	ZONE 1	1013	26.2

INITIAL WATER SATURATION SW _{ir} (per cent)	GAS PERMEABILITY SW _{ir} Kg (SW _{ir}) (mD)	OIL PERMEABILITY SW _{ir} Ko (SW _{ir}) (mD)
8.5	884	769

Cumulative Time (seconds)	Cumulative Oil Recovered (c.c.)	Cumulative Gas Recovered (c.c.)	Gasflood, Differential Pressure (bars)	Back Pressure (bars)
68.5	3.79	5.56	0.11	20.50
85.2	4.34	11.01	0.11	20.50
107.1	4.93	20.52	0.11	20.50
149.5	5.62	45.42	0.11	20.50
198.3	6.19	84.41	0.11	20.50
261.0	6.7	146.7	0.11	20.50
338.1	7.2	239.3	0.11	20.50
420.8	7.6	355.2	0.11	20.50
521.6	8.0	515.4	0.11	20.50
636.7	8.33	722.1	0.11	20.50
1058	9.15	1636	0.11	20.50
1217	9.34	2026	0.11	20.50
1380	9.52	2445	0.11	20.50
1558	9.67	2922	0.11	20.50
2000	9.96	4311	0.11	20.50
2500	10.20	5900	0.11	20.50
3600	10.46	9860	0.11	20.50
5950	10.86	18520	0.11	20.50

1.5.2 GASFLOOD PRODUCTION DATA

SAMPLE NUMBER	DEPTH (metres)	FORMATION	AIR PERMEABILITY Ka (mD)	POROSITY (per cent)
57.1	3190.00	ZONE 1	36	21.9

INITIAL WATER SATURATION SW_{ir} (per cent)	GAS PERMEABILITY SW_{ir} Kg (SW_{ir}) (mD)	OIL PERMEABILITY SW_{ir} Ko (SW_{ir}) (mD)
20.2	31	25

Cumulative Time (seconds)	Cumulative Oil Recovered (c.c.)	Cumulative Gas Recovered (c.c.)	Gasflood, Differential Pressure (bars)	Back Pressure (bars)
85.51	2.02	1.72	2.41	19.58
100.2	2.57	5.78	2.45	19.58
115.4	2.94	11.51	2.48	19.58
136.2	3.37	20.51	2.44	19.58
178.8	3.92	46.51	2.46	19.58
236.9	4.44	92.81	2.47	19.55
302.1	4.83	155.0	2.43	19.55
376.3	5.21	239.8	2.45	19.56
442.3	5.47	324.6	2.43	19.57
525.1	5.72	441.1	2.44	19.57
605.8	5.93	567.4	2.44	19.57
735.6	6.22	785.9	2.43	19.57
855.7	6.42	1003	2.44	19.57
1035	6.67	1356	2.44	19.57
1214	6.88	1732	2.44	19.57
1401	7.06	2146	2.45	19.56
1590	7.20	2583	2.45	19.55
1767	7.32	3009	2.45	19.60

Cumulative Time (seconds)	Cumulative Oil Recovered (c.c)	Cumulative Gas Recovered (c.c)	Gasflood, Differential Pressure (bars)	Back Pressure (bars)
2317	7.62	4407	2.44	19.55
2495	7.70	4881	2.46	19.53
2675	7.77	5367	2.51	19.55
2848	7.83	5841	2.45	19.55
3085	7.88	6500	2.45	19.55
3380	7.93	7333	2.45	19.55
6550	8.03	16227	2.45	19.55

1.5.2 GASFLOOD PRODUCTION DATA

SAMPLE NUMBER	DEPTH (metres)	FORMATION	AIR PERMEABILITY Ka (mD)	POROSITY (per cent)
81.1	3200.00	ZONE 1	195	24.5

INITIAL WATER SATURATION SW_{ir} (per cent)	GAS PERMEABILITY SW_{ir} Kg (SW_{ir}) (mD)	OIL PERMEABILITY SW_{ir} Ko (SW_{ir}) (mD)
17.7	180	166

Cumulative Time (seconds)	Cumulative Oil Recovered (c.c.)	Cumulative Gas Recovered (c.c.)	Gasflood, Differential Pressure (bars)	Back Pressure (bars)
60.90	1.41	2.83	0.33	20.24
92.8	2.27	12.20	0.34	20.24
116.6	2.76	21.60	0.34	20.24
154.3	3.31	39.40	0.34	20.24
209.1	3.92	74.10	0.34	20.24
271.4	4.42	120.6	0.34	20.24
341.3	4.82	181.4	0.34	20.24
421.3	5.21	258.7	0.34	20.24
526.7	5.60	371.2	0.34	20.23
626.9	5.88	488.6	0.34	20.25
739.2	6.16	629.5	0.34	20.25
862.4	6.38	794.0	0.34	20.25
995.6	6.60	982.0	0.34	20.25
1130	6.78	1182	0.34	20.25
1290	6.97	1429	0.34	20.25
1459	7.14	1699	0.34	20.26
1621	7.28	1969	0.34	20.26
1822	7.43	2315	0.34	20.27

Cumulative Time (seconds)	Cumulative Oil Recovered (c.c.)	Cumulative Gas Recovered (c.c.)	Gasflood, Differential Pressure (bars)	Back Pressure (bars)
1993	7.54	2616	0.34	20.25
2193	7.65	2980	0.34	20.23
2386	7.75	3338	0.34	20.22
2571	7.84	3686	0.34	20.23
3000	7.97	4520	0.34	20.23
5000	8.28	8483	0.34	20.23
9500	8.56	17840	0.34	20.23

1.5.2 GASFLOOD PRODUCTION DATA

SAMPLE NUMBER	DEPTH (metres)	FORMATION	AIR PERMEABILITY Ka (mD)	POROSITY (per cent)
93.1	3204.15	ZONE 1	485	25.8

INITIAL WATER SATURATION SW_{ir} (per cent)	GAS PERMEABILITY SW_{ir} Kg (SW_{ir}) (mD)	OIL PERMEABILITY SW_{ir} Ko (SW_{ir}) (mD)
14.8	462	402

Cumulative Time (seconds)	Cumulative Oil Recovered (c.c.)	Cumulative Gas Recovered (c.c.)	Gasflood, Differential Pressure (bars)	Back Pressure (bars)
56.8	2.13	4.38	0.15	20.54
70.9	2.49	9.73	0.15	20.54
83.2	2.75	15.5	0.16	20.54
101.3	3.08	25.0	0.15	20.54
117.9	3.31	34.6	0.15	20.54
175.7	3.90	74.8	0.15	20.54
228.1	4.29	120.8	0.15	20.53
292.8	4.69	185.4	0.16	20.54
363.4	5.05	263.9	0.15	20.54
439.0	5.35	356.4	0.15	20.54
525.4	5.62	472.1	0.15	20.55
606.3	5.85	587.9	0.15	20.55
698.3	6.06	726.9	0.15	20.55
827.6	6.31	935.5	0.15	20.55
949.8	6.50	1144	0.15	20.55
1092	6.69	1399	0.15	20.55
1241	6.85	1677	0.15	20.55
1398	6.99	1978	0.15	20.54
1571	7.14	2326	0.15	20.54

Cumulative Time (seconds)	Cumulative Oil Recovered (c.c.)	Cumulative Gas Recovered (c.c.)	Gasflood, Differential Pressure (bars)	Back Pressure (bars)
1763	7.26	2721	0.15	20.54
1939	7.36	3092	0.15	20.54
2121	7.46	3486	0.15	20.52
2360	7.54	4002	0.15	20.52
2660	7.64	4660	0.15	20.52
3255	7.77	5972	0.15	20.52
3770	7.86	7140	0.15	20.52
4515	7.95	8859	0.15	20.52
5820	8.04	11947	0.15	20.52
7550	8.67	16220	0.15	20.52

1.5.2 GASFLOOD PRODUCTION DATA

SAMPLE NUMBER	DEPTH (metres)	FORMATION	AIR PERMEABILITY Ka (mD)	POROSITY (per cent)
135.1	3219.00	ZONE 2	37	22.3

INITIAL WATER SATURATION SW_{ir} (per cent)	GAS PERMEABILITY SW_{ir} Kg (SW_{ir}) (mD)	OIL PERMEABILITY SW_{ir} Ko (SW_{ir}) (mD)
22.2	32	26

Cumulative Time (seconds)	Cumulative Oil Recovered (c.c.)	Cumulative Gas Recovered (c.c.)	Gasflood, Differential Pressure (bars)	Back Pressure (bars)
106.4	1.89	3.84	1.48	19.72
131.3	2.39	9.33	1.48	19.72
164.4	2.84	18.88	1.48	19.72
191.0	3.13	28.50	1.48	19.72
215.0	3.38	38.40	1.48	19.72
277.0	3.78	68.20	1.48	19.72
295.0	3.88	78.20	1.48	19.72
384.0	4.29	134.0	1.47	19.72
483.0	4.66	209.0	1.47	19.72
587.0	4.96	302.0	1.48	19.73
706.0	5.25	420.0	1.48	19.72
835.0	5.52	560.0	1.48	19.72
980.0	5.74	731.0	1.48	19.72
1124	5.93	912.0	1.48	19.72
1303	6.14	1153	1.48	19.71
1491	6.31	1418	1.48	19.70
1702	6.48	1731	1.48	19.71
1927	6.63	2081	1.48	19.71
2180	6.78	2488	1.48	19.72

Cumulative Time (seconds)	Cumulative Oil Recovered (c.c.)	Cumulative Gas Recovered (c.c.)	Gasflood, Differential Pressure (bars)	Back Pressure (bars)
2455	6.92	2949	1.48	19.72
2762	7.06	3479	1.48	19.72
3093	7.19	4070	1.48	19.72
3453	7.30	4733	1.48	19.72
4364	7.55	6470	1.47	19.74
4902	7.67	7531	1.48	19.74
5504	7.78	8749	1.48	19.74
6193	7.89	10172	1.47	19.74
6851	7.99	11558	1.48	19.74
7535	8.08	13030	1.49	19.74
8242	8.17	14573	1.48	19.74
9117	8.25	16504	1.49	19.74

1.5.2 GASFLOOD PRODUCTION DATA

SAMPLE NUMBER	DEPTH (metres)	FORMATION	AIR PERMEABILITY Ka (mD)	POROSITY (per cent)
316.1	3284.25	ZONE 2	80	19.6

INITIAL WATER SATURATION SW_{ir} (per cent)	GAS PERMEABILITY SW_{ir} Kg (SW_{ir}) (mD)	OIL PERMEABILITY SW_{ir} Ko (SW_{ir}) (mD)
22.4	69	61

Cumulative Time (seconds)	Cumulative Oil Recovered (c.c.)	Cumulative Gas Recovered (c.c.)	Gasflood, Differential Pressure (bars)	Back Pressure (bars)
64.5	1.41	2.64	0.67	21.10
83.0	1.75	7.58	0.67	21.10
107.0	2.11	16.7	0.66	21.10
163.0	2.55	40.0	0.62	21.10
225.0	2.90	74.3	0.66	21.10
295.0	3.21	120.7	0.64	21.10
342.0	3.37	155.6	0.65	21.10
484.0	3.76	272.0	0.66	21.10
575.0	3.97	353.6	0.65	21.10
661.0	4.15	435.2	0.67	21.10
778.0	4.34	551.8	0.66	21.10
885.0	4.50	663.8	0.66	21.10
999.0	4.64	785.1	0.66	21.10
1166	4.81	971.9	0.65	21.10
1388	5.01	1228	0.65	21.10
1564	5.15	1438	0.66	21.10
2174	5.52	2208	0.66	21.12
2456	5.65	2582	0.66	21.12
2733	5.75	2956	0.66	21.11

Cumulative Time (seconds)	Cumulative Oil Recovered (c.c.)	Cumulative Gas Recovered (c.c.)	Gasflood, Differential Pressure (bars)	Back Pressure (bars)
2902	5.81	3189	0.66	21.10
3071	5.86	3423	0.65	21.10
4000	6.09	4755	0.65	21.10
5000	6.28	6196	0.65	21.10
6500	6.46	8430	0.65	21.10
10300	6.81	14410	0.65	21.10

1.5.2 GASFLOOD PRODUCTION DATA

SAMPLE NUMBER	DEPTH (metres)	FORMATION	AIR PERMEABILITY Ka (mD)	POROSITY (per cent)
408.1	3325.15	ZONE 2	8.9	20.5

INITIAL WATER SATURATION SW_{ir} (per cent)	GAS PERMEABILITY SW_{ir} Kg (SW_{ir}) (mD)	OIL PERMEABILITY SW_{ir} Ko (SW_{ir}) (mD)
33.8	6.7	5.4

Cumulative Time (seconds)	Cumulative Oil Recovered (c.c.)	Cumulative Gas Recovered (c.c.)	Gasflood, Differential Pressure (bars)	Back Pressure (bars)
224.0	2.30	15.2	5.71	16.67
263.0	2.67	24.7	5.71	16.67
381.0	3.23	69.0	5.84	16.67
504.0	3.77	136.0	5.82	16.66
597.0	4.01	198.0	5.82	16.67
714.0	4.26	289.0	5.82	16.68
843.0	4.48	402.0	5.82	16.69
979.0	4.69	531.0	5.84	16.67
1113	4.86	673.0	5.84	16.67
1288	5.04	871.0	5.82	16.69
1496	5.23	1125	5.82	17.00
1733	5.42	1436	5.83	16.70
1977	5.58	1775	5.82	16.70
2209	5.70	2114	5.83	16.70
2468	5.83	2510	5.85	16.70
2718	5.94	2906	5.82	16.71
2995	6.05	3358	5.82	16.72
3296	6.15	3867	5.82	16.72

Cumulative Time (seconds)	Cumulative Oil Recovered (c.c.)	Cumulative Gas Recovered (c.c.)	Gasflood, Differential Pressure (bars)	Back Pressure (bars)
3606	6.25	4404	5.82	16.71
3908	6.33	4942	5.82	16.71
4219	6.41	5507	5.83	16.70
4523	6.48	6073	5.82	16.72
4822	6.54	6638	5.82	16.71
5124	6.60	7218	5.84	16.71
5436	6.66	7826	5.83	16.71
5750	6.72	8448	5.86	16.70
6116	6.78	9183	5.83	16.71
6496	6.84	9947	5.84	16.70
6876	6.89	10739	5.85	17.00
7575	6.97	12236	5.85	17.00
8540	7.03	14316	5.85	17.00

1.5.2 GASFLOOD PRODUCTION DATA

SAMPLE NUMBER	DEPTH (metres)	FORMATION	AIR PERMEABILITY Ka (mD)	POROSITY (per cent)
471.1	3347.50	ZONE 2	2316	22.8

INITIAL WATER SATURATION SW_{ir} (per cent)	GAS PERMEABILITY SW_{ir} Kg (SW_{ir}) (mD)	OIL PERMEABILITY SW_{ir} Ko (SW_{ir}) (mD)
5.3	2309	2144

Cumulative Time (seconds)	Cumulative Oil Recovered (c.c.)	Cumulative Gas Recovered (c.c.)	Gasflood, Differential Pressure (bars)	Back Pressure (bars)
37.6	2.85	1.74	0.05	20.55
55.2	3.87	8.43	0.05	20.55
66.9	4.25	14.21	0.04	20.55
84.9	4.68	23.69	0.05	20.55
126.1	5.39	51.07	0.05	20.55
380.6	7.32	350.2	0.05	20.55
787.0	8.21	1258	0.05	20.58
916.0	8.40	1582	0.05	20.55
1066	8.59	1976	0.05	20.55
1217	8.75	2394	0.05	20.55
1371	8.90	2835	0.05	20.55
1557	9.04	3391	0.05	20.55
1670	9.11	3739	0.05	20.55
1950	9.20	4633	0.05	20.55
2700	9.34	7060	0.05	20.55
3350	9.44	9196	0.05	20.55
3950	9.50	11179	0.05	20.55
5248	9.56	15529	0.05	20.55

1.5.2 GASFLOOD PRODUCTION DATA

SAMPLE NUMBER	DEPTH (metres)	FORMATION	AIR PERMEABILITY Ka (mD)	POROSITY (per cent)
487.1	3359.15	ZONE 2	511	21.1

INITIAL WATER SATURATION SW_{ir} (per cent)	GAS PERMEABILITY SW_{ir} Kg (SW_{ir}) (mD)	OIL PERMEABILITY SW_{ir} Ko (SW_{ir}) (mD)
14.3	462	419

Cumulative Time (seconds)	Cumulative Oil Recovered (c.c.)	Cumulative Gas Recovered (c.c.)	Gasflood, Differential Pressure (bars)	Back Pressure (bars)
49.5	1.96	2.29	0.15	20.45
62.2	2.43	5.92	0.16	20.45
74.6	2.79	10.70	0.15	20.45
87.6	3.08	16.63	0.15	20.45
103.0	3.37	24.76	0.16	20.45
145.3	3.89	53.16	0.16	20.45
186.7	4.28	87.75	0.16	20.45
240.3	4.66	141.0	0.16	20.45
305.5	5.05	215.2	0.16	20.44
382.9	5.40	315.2	0.16	20.44
474.9	5.73	447.8	0.16	20.44
595.0	6.05	641.0	0.15	20.44
734.4	6.33	885.6	0.16	20.44
924.5	6.61	1246	0.16	20.44
1079	6.79	1559	0.16	20.44
1251	6.96	1922	0.16	20.45
1437	7.11	2333	0.16	20.44
1614	7.24	2738	0.16	20.44

Cumulative Time (seconds)	Cumulative Oil Recovered (c.c.)	Cumulative Gas Recovered (c.c.)	Gasflood, Differential Pressure (bars)	Back Pressure (bars)
1791	7.34	3158	0.16	20.45
1966	7.43	3578	0.16	20.45
2200	7.53	4155	0.16	20.45
3000	7.63	6195	0.16	20.45
3850	7.70	8448	0.16	20.45
5050	7.77	11725	0.16	20.45
5800	7.79	13805	0.16	20.45

1.5.2 GASFLOOD PRODUCTION DATA

SAMPLE NUMBER	DEPTH (metres)	FORMATION	AIR PERMEABILITY Ka (mD)	POROSITY (per cent)
586.1	3396.0	ZONE 3	27	18.0

INITIAL WATER SATURATION SW _{ir} (per cent)	GAS PERMEABILITY SW _{ir} Kg (SW _{ir}) (mD)	OIL PERMEABILITY SW _{ir} Ko (SW _{ir}) (mD)
31.0	22	19

Cumulative Time (seconds)	Cumulative Oil Recovered (c.c.)	Cumulative Gas Recovered (c.c.)	Gasflood, Differential Pressure (bars)	Back Pressure (bars)
96.5	1.67	3.83	3.17	18.35
124.0	2.19	12.31	2.95	18.35
171.1	2.65	35.41	3.16	18.35
235.9	3.07	78.91	3.20	18.34
311.7	3.38	140.6	3.19	18.33
455.4	3.82	279.8	3.16	18.35
581.7	4.08	421.7	3.14	18.35
707.0	4.28	574.1	3.16	18.35
857.6	4.46	770.4	3.16	18.33
999.2	4.61	966.7	3.16	18.35
1158	4.74	1198	3.17	18.34
1346	4.87	1482	3.17	18.34
1542	4.99	1790	3.17	18.34
1732	5.08	2100	3.16	18.35
1917	5.16	2410	3.18	18.34
2128	5.24	2772	3.16	18.35
2549	5.37	3496	3.17	18.35
3176	5.53	4685	3.17	18.35

Cumulative Time (seconds)	Cumulative Oil Recovered (c.c.)	Cumulative Gas Recovered (c.c.)	Gasflood, Differential Pressure (bars)	Back Pressure (bars)
5000	5.74	8718	3.17	18.35
7000	5.84	13250	3.17	18.35

1.5.2 GASFLOOD PRODUCTION DATA

SAMPLE NUMBER	DEPTH (metres)	FORMATION	AIR PERMEABILITY Ka (mD)	POROSITY (per cent)
604.1	3401.65	ZONE 3	6.3	15.4

INITIAL WATER SATURATION SW_{ir} (per cent)	GAS PERMEABILITY SW_{ir} Kg (SW_{ir}) (mD)	OIL PERMEABILITY SW_{ir} Ko (SW_{ir}) (mD)
39.4	5.2	4.1

Cumulative Time (seconds)	Cumulative Oil Recovered (c.c.)	Cumulative Gas Recovered (c.c.)	Gasflood, Differential Pressure (bars)	Back Pressure (bars)
138.0	0.78	9.4	7.11	15.15
179.0	1.14	19.2	7.38	15.15
211.0	1.33	29.2	7.38	15.15
265.0	1.58	49.0	7.36	15.15
311.0	1.74	68.8	7.37	15.15
369.0	1.89	99.0	7.40	15.15
562.0	2.29	222.0	7.37	15.16
821.0	2.62	429.0	7.41	15.11
964.0	2.79	559.0	7.38	15.15
1110	2.92	702.0	7.40	15.15
1282	3.04	878.0	7.38	15.16
1454	3.14	1064	7.40	15.16
1686	3.26	1328	7.40	15.16
2020	3.39	1730	7.38	15.16
2326	3.49	2117	7.38	15.17
2655	3.59	2551	7.40	15.16
3005	3.68	3031	7.38	15.17
3367	3.76	3542	7.38	15.18

Cumulative Time (seconds)	Cumulative Oil Recovered (c.c.)	Cumulative Gas Recovered (c.c.)	Gasflood, Differential Pressure (bars)	Back Pressure (bars)
3750	3.84	4100	7.40	15.15
4123	3.90	4657	7.40	15.16
4498	3.96	5230	7.40	15.15
6064	4.14	7739	7.37	15.19
6483	4.18	8436	7.38	15.17
7355	4.26	9923	7.40	15.12
7854	4.30	10791	7.38	15.14

1.5.2 GASFLOOD PRODUCTION DATA

SAMPLE NUMBER	DEPTH (metres)	FORMATION	AIR PERMEABILITY Ka (mD)	POROSITY (per cent)
623.1	3407.50	ZONE 3	128	19.5

INITIAL WATER SATURATION SW_{ir} (per cent)	GAS PERMEABILITY SW_{ir} Kg (SW_{ir}) (mD)	OIL PERMEABILITY SW_{ir} Ko (SW_{ir}) (mD)
22.2	123	119

Cumulative Time (seconds)	Cumulative Oil Recovered (c.c.)	Cumulative Gas Recovered (c.c.)	Gasflood, Differential Pressure (bars)	Back Pressure (bars)
55.5	1.37	1.43	0.42	20.34
65.6	1.69	3.40	0.42	20.34
75.9	1.97	6.05	0.41	20.34
91.9	2.24	10.90	0.42	20.34
106.7	2.46	16.38	0.42	20.34
120.3	2.64	22.00	0.42	20.34
140.3	2.84	31.42	0.42	20.34
158.6	3.00	41.10	0.38	20.34
223.2	3.44	82.80	0.42	20.34
324.7	3.88	166.7	0.42	20.33
428.5	4.24	269.5	0.42	20.33
536.0	4.53	391.2	0.42	20.33
666.3	4.78	555.0	0.42	20.33
812.0	5.01	756.4	0.42	20.33
960.2	5.19	976.50	0.42	20.33
1138	5.36	1257	0.42	20.32
1302	5.49	1529	0.42	20.33
1497	5.63	1866	0.42	20.32

Cumulative Time (seconds)	Cumulative Oil Recovered (c.c.)	Cumulative Gas Recovered (c.c.)	Gasflood, Differential Pressure (bars)	Back Pressure (bars)
1692	5.74	2218	0.42	20.33
1888	5.84	2582	0.42	20.34
2085	5.92	2957	0.42	20.35

1.5.2 GASFLOOD PRODUCTION DATA

SAMPLE NUMBER	DEPTH (metres)	FORMATION	AIR PERMEABILITY Ka (mD)	POROSITY (per cent)
657.1	3419.10	ZONE 4	2.0	13.3

INITIAL WATER SATURATION SW_{ir} (per cent)	GAS PERMEABILITY SW_{ir} Kg (SW_{ir}) (mD)	OIL PERMEABILITY SW_{ir} Ko (SW_{ir}) (mD)
44.9	0.89	0.68

Cumulative Time (seconds)	Cumulative Oil Recovered (c.c.)	Cumulative Gas Recovered (c.c.)	Gasflood, Differential Pressure (bars)	Back Pressure (bars)
238.0	0.44	4.93	9.07	15.01
324.0	0.82	11.20	9.51	15.01
425.0	1.89	18.50	9.71	15.01
532.0	1.28	28.00	9.71	15.01
626.0	1.40	38.00	9.75	14.94
706.0	1.50	48.00	9.82	14.87
786.0	1.58	58.00	9.80	14.90
1063	1.78	98.50	9.75	14.87
1220	1.88	124.0	9.70	15.00
1364	1.96	149.0	9.68	15.01
1489	2.02	175.0	10.16	14.57
1654	2.09	210.0	10.00	15.01
1832	2.15	251.0	10.00	15.02
2221	2.28	344.0	9.65	15.04
2424	2.34	400.0	9.65	15.04
2639	2.40	460.0	10.00	15.00
3317	2.52	663.0	9.84	14.88
4218	2.70	971.0	9.65	15.08
4919	2.98	1210	9.65	15.10

Cumulative Time (seconds)	Cumulative Oil Recovered (c.c.)	Cumulative Gas Recovered (c.c.)	Gasflood, Differential Pressure (bars)	Back Pressure (bars)
8349	3.08	2602	9.70	15.00
9812	3.17	3258	9.70	15.00
13209	3.32	4884	9.72	15.02
18580	3.52	7667	9.70	15.04
20422	3.56	8667	9.71	15.03
22340	3.60	9931	9.72	15.03

1.5.2 GASFLOOD PRODUCTION DATA

SAMPLE NUMBER	DEPTH (metres)	FORMATION	AIR PERMEABILITY Ka (mD)	POROSITY (per cent)
666.1	3422.10	ZONE 4	17.8	18.4

INITIAL WATER SATURATION SW_{ir} (per cent)	GAS PERMEABILITY SW_{ir} Kg (SW_{ir}) (mD)	OIL PERMEABILITY SW_{ir} Ko (SW_{ir}) (mD)
28.6	16.	13.3

Cumulative Time (seconds)	Cumulative Oil Recovered (c.c.)	Cumulative Gas Recovered (c.c.)	Gasflood, Differential Pressure (bars)	Back Pressure (bars)
147.0	2.23	4.91	3.60	18.20
170.2	2.62	10.67	3.52	18.20
193.3	2.91	19.45	3.65	18.20
216.6	3.14	28.95	3.52	18.20
327.8	3.80	99.74	3.60	18.20
409.2	4.10	167.3	3.64	18.10
489.0	4.32	245.3	3.60	18.20
808.0	5.00	635.9	3.60	18.20
952.3	5.12	844.4	3.60	18.20
1053	5.23	1001	3.60	18.20
1183	5.35	1209	3.60	18.20
1366	5.50	1522	3.60	18.20
1553	5.61	1861	3.60	18.20
1749	5.73	2226	3.60	18.20
1955	5.83	2643	3.60	18.20
2194	5.93	3139	3.60	18.20
2449	6.03	3686	3.60	18.14
2694	6.12	4234	3.60	18.15

Cumulative Time (seconds)	Cumulative Oil Recovered (c.c.)	Cumulative Gas Recovered (c.c.)	Gasflood, Differential Pressure (bars)	Back Pressure (bars)
2955	6.20	4834	3.60	18.20
3241	6.28	5512	3.60	18.20
3531	6.35	6216	3.60	18.20
3950	6.42	7256	3.60	18.20
4710	6.53	9182	3.60	18.20
5550	6.63	11380	3.60	18.20
7120	6.71	15614	3.60	18.20

SPECIAL CORE ANALYSIS STUDY

STATOIL, NORWAY

WELL: 34/10-16 FIELD: GULLFAKS

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TABLE: 1.5.3 SUMMARY OF GAS-OIL RELATIVE PERMEABILITY DATA
UNSTEADY-STATE, RESTORED-STATE, GAS SATURATION INCREASING

SAMPLE NUMBER	DEPTH (metres)	FORMATION	KLINKENBERG PERMEABILITY K ₁ (mD)	POROSITY (per cent)	INITIAL CONDITIONS			TERMINAL CONDITIONS			OIL RECOVERED
					WATER SATURATION Sw _{1r} (per cent pore space)	OIL PERMEABILITY Ko (mD) k _o (Sw)	OIL SATURATION Sr _o (per cent pore space)	GAS PERMEABILITY Kg (mD) k _g (S _{gc})	GAS PERMEABILITY (per cent pore space) oil in place)		
7.1	3171.85	ZONE 1	946	26.2	8.5	769	34.3	370	57.2	62.5	
57.1	3190.00	ZONE 1	29	21.9	20.2	25	30.7	12	49.1	61.5	
81.1	3200.00	ZONE 1	182	24.5	17.7	166	35.1	69	47.2	57.4	
93.1	3204.15	ZONE 1	440	25.8	14.8	402	37.7	166	47.5	55.8	
135.1	3219.00	ZONE 2	30	22.3	22.2	26	27.8	16	50.0	64.3	
316.1	3284.25	ZONE 2	62	19.6	22.4	61	31.6	27	46.0	59.3	
408.1	3325.15	ZONE 2	6.5	20.5	33.8	5.4	17.7	3.6	48.5	73.3	
471.1	3347.50	ZONE 2	2223	22.8	5.3	2144	33.3	737	61.4	64.8	
487.1	3359.15	ZONE 2	465	21.1	14.3	419	33.1	195	52.5	61.3	
586.1	3396.00	ZONE 3	21	18.0	31.0	19	25.3	8.0	43.7	63.3	
604.1	3401.65	ZONE 3	4.9	15.4	39.4	4.1	20.6	2.3	40.0	66.0	
623.1	3407.50	ZONE 3	120	19.5	22.2	119	35.4	54	42.4	54.5	
657.1	3419.10	ZONE 4	1.35	13.0	28.6	13.3	17.5	0.59	37.6	52.7	
666.1	3422.10	ZONE 4	14.6	18.4	44.9	0.68	22.5	8.2	48.9	88.7	

1.5 GAS-OIL, RELATIVE PERMEABILITY TESTS

1.5.4 Gas-Oil, Relative Permeability Data



GAS-OIL RELATIVE PERMEABILITY DATA

SAMPLE NUMBER 7.1 INITIAL WATER SATURATION
PERCENT PORE SPACE 8.5
AIR PERMEABILITY md 10.13 POROSITY PERCENT 26.2
OIL PERMEABILITY AT
INITIAL WATER SATURATION md 769 SAMPLE DEPTH 3171.85 m

LIQUID SATURATION PERCENT PORE SPACE	GAS - OIL RELATIVE PERMEABILITY RATIO	RELATIVE PERMEABILITY TO GAS %, FRACTION	RELATIVE PERMEABILITY TO OIL *, FRACTION
100			1.00
78.4	0.096	0.043	0.444
75.4	0.157	0.057	0.363
72.0	0.351	0.077	0.219
68.6	0.665	0.105	0.158
65.8	1.19	0.130	0.110
63.1	1.80	0.157	0.087
60.7	2.82	0.184	0.065
58.6	3.89	0.208	0.054
56.6	6.09	0.235	0.039
53.6	10.8	0.284	0.026
50.9	19.9	0.321	0.016
49.9	22.6	0.337	0.015
49.0	30.9	0.351	0.011
47.8	46.5	0.412	0.0089
46.4	64.3	0.416	0.0065
45.1	148	0.472	0.0032
43.4	210	0.483	0.0023

* Relative to oil permeability

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GAS-OIL RELATIVE PERMEABILITY DATA

SAMPLE NUMBER 57.1 INITIAL WATER SATURATION
PERCENT PORE SPACE 20.2
AIR PERMEABILITY md 36 POROSITY PERCENT 21.9
OIL PERMEABILITY AT
INITIAL WATER SATURATION md. 25 SAMPLE DEPTH 3190.00 m

LIQUID SATURATION PERCENT PORE SPACE	GAS - OIL RELATIVE PERMEABILITY RATID	RELATIVE PERMEABILITY TO GAS *, FRACTION	RELATIVE PERMEABILITY TO OIL *, FRACTION
100			1.00
85.9	0.068	0.049	0.714
83.1	0.143	0.066	0.464
80.6	0.193	0.076	0.394
77.6	0.437	0.108	0.246
74.3	0.823	0.140	0.171
71.5	1.47	0.168	0.114
69.1	2.06	0.201	0.098
67.2	3.01	0.226	0.075
65.6	4.31	0.248	0.058
64.2	5.56	0.276	0.050
62.6	6.96	0.297	0.043
61.1	10.1	0.320	0.032
59.8	13.0	0.347	0.027
58.3	16.5	0.370	0.022
57.1	21.2	0.390	0.018
56.2	28.8	0.407	0.014
55.3	32.8	0.424	0.013
54.1	43.1	0.448	0.010
52.9	54.7	0.469	0.0086

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GAS-OIL RELATIVE PERMEABILITY DATA

SAMPLE NUMBER 57.1 INITIAL WATER SATURATION
 PERCENT PORE SPACE 20.2
 AIR PERMEABILITY md 36 POROSITY PERCENT 21.9
 OIL PERMEABILITY AT
 INITIAL WATER SATURATION md 25 SAMPLE DEPTH 3190.00 m

LIQUID SATURATION PERCENT PORE SPACE	GAS - OIL RELATIVE PERMEABILITY RATIO	RELATIVE PERMEABILITY TO GAS*, FRACTION	RELATIVE PERMEABILITY TO OIL*, FRACTION
52.4	64.1	0.476	0.0074
52.0	73.0	0.483	0.0066
51.7	122	0.489	0.0040
51.4	154	0.498	0.0032
50.9	822	0.494	0.0006

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GAS-OIL RELATIVE PERMEABILITY DATA

SAMPLE NUMBER 81.1 INITIAL WATER SATURATION
PERCENT PORE SPACE 17.7
AIR PERMEABILITY md 195 POROSITY PERCENT 24.5
OIL PERMEABILITY AT
INITIAL WATER SATURATION md 166 SAMPLE DEPTH 3200.00 m

LIQUID SATURATION PERCENT PORE SPACE	GAS - OIL RELATIVE PERMEABILITY RATIO	RELATIVE PERMEABILITY TO GAS*, FRACTION	RELATIVE PERMEABILITY TO OIL*, FRACTION
100			1.00
89.7	0.107	0.059	0.552
85.9	0.188	0.079	0.421
83.0	0.318	0.095	0.299
79.7	0.558	0.127	0.228
76.6	0.913	0.150	0.164
74.1	1.49	0.175	0.117
71.9	1.94	0.194	0.100
69.7	2.83	0.214	0.076
67.8	4.11	0.235	0.057
66.3	4.94	0.252	0.051
64.9	7.34	0.268	0.037
63.6	8.39	0.283	0.034
62.5	10.9	0.299	0.027
61.5	12.8	0.310	0.024
60.4	15.6	0.321	0.021
59.6	18.9	0.335	0.018
58.8	22.6	0.346	0.015
58.0	26.9	0.354	0.013
57.4	32.5	0.366	0.011

* Relative to oil permeability

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GAS-OIL RELATIVE PERMEABILITY DATA

SAMPLE NUMBER 81.1

INITIAL WATER SATURATION
PERCENT PORE SPACE 17.7

AIR PERMEABILITY md 195

POROSITY PERCENT 24.5

OIL PERMEABILITY AT
INITIAL WATER SATURATION md. 166

SAMPLE DEPTH 3200.00 m

LIQUID SATURATION PERCENT PORE SPACE	GAS - OIL RELATIVE PERMEABILITY RATIO	RELATIVE PERMEABILITY TO GAS %, FRACTION	RELATIVE PERMEABILITY TO OIL %, FRACTION
56.8	35.1	0.373	0.011
56.3	37.9	0.378	0.0100
55.7	63.0	0.390	0.0062
54.5	125	0.398	0.0032
52.8	328	0.418	0.0013

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GAS-OIL RELATIVE PERMEABILITY DATA

SAMPLE NUMBER 93.1 INITIAL WATER SATURATION
PERCENT PORE SPACE 14.8
AIR PERMEABILITY md 485 POROSITY PERCENT 25.8
OIL PERMEABILITY AT
INITIAL WATER SATURATION md 402 SAMPLE DEPTH 3204.15 m

LIQUID SATURATION PERCENT PORE SPACE	GAS - OIL RELATIVE PERMEABILITY RATIO	RELATIVE PERMEABILITY TO GAS*, FRACTION	RELATIVE PERMEABILITY TO OIL*, FRACTION
100			1.00
88.9	0.082	0.051	0.626
86.4	0.141	0.064	0.454
84.6	0.209	0.078	0.372
82.8	0.275	0.089	0.324
81.2	0.395	0.097	0.245
78.7	0.648	0.117	0.181
75.9	1.12	0.148	0.132
73.5	1.53	0.168	0.110
71.3	2.07	0.187	0.090
69.3	2.93	0.206	0.070
67.7	4.07	0.225	0.055
66.2	4.78	0.241	0.050
64.9	6.28	0.254	0.040
63.5	7.92	0.271	0.034
62.2	10.4	0.287	0.028
61.1	12.7	0.302	0.024
60.1	16.5	0.314	0.019
59.2	20.4	0.323	0.016
58.3	22.0	0.338	0.015

* Relative to oil permeability

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GAS-OIL RELATIVE PERMEABILITY DATA

SAMPLE NUMBER 93.1 INITIAL WATER SATURATION
 PERCENT PORE SPACE 14.8
 AIR PERMEABILITY md 485 POROSITY PERCENT 25.8
 OIL PERMEABILITY AT
 INITIAL WATER SATURATION md 402 SAMPLE DEPTH 3204.15 m

LIQUID SATURATION PERCENT PORE SPACE	GAS - OIL RELATIVE PERMEABILITY RATIO	RELATIVE PERMEABILITY TO GAS*, FRACTION	RELATIVE PERMEABILITY TO OIL*, FRACTION
57.6	31.3	0.346	0.011
56.9	35.2	0.355	0.010
56.3	37.4	0.364	0.0097
55.8	61.2	0.363	0.0059
55.3	62.5	0.369	0.0059
54.6	95.8	0.371	0.0039
53.9	123	0.382	0.0031
53.4	181	0.388	0.0021
52.9	326	0.398	0.0012
52.5	1352	0.416	0.0003

* Relative to oil permeability

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GAS-OIL RELATIVE PERMEABILITY DATA

SAMPLE NUMBER 135 . 1 INITIAL WATER SATURATION
 PERCENT PORE SPACE 22 . 2
 AIR PERMEABILITY md 37 POROSITY PERCENT 22 . 3
 OIL PERMEABILITY AT
 INITIAL WATER SATURATION md 26 SAMPLE DEPTH 3219.00 m

LIQUID SATURATION PERCENT PORE SPACE	GAS - OIL RELATIVE PERMEABILITY RATIO	RELATIVE PERMEABILITY TO GAS*, FRACTION	RELATIVE PERMEABILITY TO OIL*, FRACTION
100			1.00
87.0	0.101	0.063	0.622
84.1	0.195	0.082	0.421
81.8	0.305	0.103	0.338
80.2	0.364	0.118	0.323
78.2	0.685	0.137	0.200
76.7	0.920	0.158	0.172
75.1	1.25	0.179	0.143
72.8	1.87	0.216	0.116
70.7	2.85	0.255	0.089
68.9	3.74	0.283	0.075
67.2	4.77	0.309	0.065
65.7	7.15	0.336	0.047
64.5	8.77	0.358	0.041
63.3	10.6	0.384	0.036
62.1	14.3	0.402	0.028
61.1	16.9	0.423	0.025
60.1	21.5	0.443	0.021
59.2	25.0	0.458	0.018
58.3	30.3	0.478	0.016

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GAS-OIL RELATIVE PERMEABILITY DATA

SAMPLE NUMBER 135.1 INITIAL WATER SATURATION
PERCENT PORE SPACE 22.2
AIR PERMEABILITY md 37 POROSITY PERCENT 22.3
OIL PERMEABILITY AT
INITIAL WATER SATURATION md 26 SAMPLE DEPTH 3219.00 m

LIQUID SATURATION PERCENT PORE SPACE	GAS - OIL RELATIVE PERMEABILITY RATIO	RELATIVE PERMEABILITY TO GAS*, FRACTION	RELATIVE PERMEABILITY TO OIL*, FRACTION
57.5	34.8	0.492	0.014
56.6	41.8	0.509	0.012
55.9	55.5	0.525	0.0095
55.2	61.0	0.536	0.0088
54.4	66.6	0.550	0.0082
53.7	81.4	0.562	0.0069
53.0	102	0.577	0.0057
52.3	119	0.589	0.0049
51.7	128	0.600	0.0047
51.1	150	0.613	0.0041
50.6	158	0.622	0.0039
50.0	222	0.629	0.0028

* Relative to oil permeability

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GAS-OIL RELATIVE PERMEABILITY DATA

SAMPLE NUMBER 316.1 INITIAL WATER SATURATION
PERCENT PORE SPACE 22.4

AIR PERMEABILITY md 80 POROSITY PERCENT 19.6

OIL PERMEABILITY AT
INITIAL WATER SATURATION md 61 SAMPLE DEPTH 3284.25 m

LIQUID SATURATION PERCENT PORE SPACE	GAS - OIL RELATIVE PERMEABILITY RATIO	RELATIVE PERMEABILITY TO GAS*, FRACTION	RELATIVE PERMEABILITY TO OIL*, FRACTION
100			1.00
89.0	0.139	0.074	0.536
86.6	0.242	0.106	0.438
83.8	0.505	0.116	0.229
81.1	0.935	0.154	0.165
78.8	1.43	0.185	0.129
77.2	2.08	0.207	0.099
75.3	2.85	0.228	0.080
73.2	3.71	0.250	0.067
71.8	4.32	0.264	0.061
70.5	5.85	0.277	0.047
69.3	6.68	0.291	0.044
68.3	8.27	0.296	0.036
67.2	10.5	0.311	0.030
65.9	12.2	0.322	0.026
64.8	14.3	0.332	0.023
63.0	19.9	0.351	0.018
61.2	27.4	0.369	0.013
60.4	35.7	0.376	0.011
59.9	37.0	0.384	0.010

* Relative to oil permeability

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GAS-OIL RELATIVE PERMEABILITY DATA

SAMPLE NUMBER 316.1 INITIAL WATER SATURATION
 PERCENT PORE SPACE 22.4
 AIR PERMEABILITY md 80 POROSITY PERCENT 19.6
 OIL PERMEABILITY AT
 INITIAL WATER SATURATION md 61 SAMPLE DEPTH 3284.25 m

LIQUID SATURATION PERCENT PORE SPACE	GAS - OIL RELATIVE PERMEABILITY RATIO	RELATIVE PERMEABILITY TO GAS*, FRACTION	RELATIVE PERMEABILITY TO OIL*, FRACTION
59.5	44.6	0.385	0.0086
58.5	55.2	0.399	0.0072
57.1	72.4	0.401	0.0055
55.8	118	0.415	0.0035
54.0	163	0.438	0.0027

* Relative to oil permeability

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GAS-OIL RELATIVE PERMEABILITY DATA

SAMPLE NUMBER 408..1 INITIAL WATER SATURATION
PERCENT PORE SPACE 33.8

AIR PERMEABILITY md 8.9 POROSITY PERCENT 20.5

OIL PERMEABILITY AT
INITIAL WATER SATURATION md 5.4 SAMPLE DEPTH 3325.15 m

LIQUID SATURATION PERCENT PORE SPACE	GAS - OIL RELATIVE PERMEABILITY RATIO	RELATIVE PERMEABILITY TO GAS *, FRACTION	RELATIVE PERMEABILITY TO OIL *, FRACTION
100			1.00
82.8	0.218	0.076	0.347
79.6	0.668	0.116	0.174
75.7	1.05	0.168	0.161
73.0	2.18	0.206	0.094
71.3	3.07	0.240	0.078
69.7	4.34	0.271	0.062
68.2	5.19	0.293	0.057
66.9	7.06	0.328	0.046
65.7	9.29	0.350	0.038
64.4	11.3	0.378	0.033
63.1	13.8	0.406	0.029
61.9	17.9	0.430	0.024
60.9	23.9	0.452	0.019
60.1	25.7	0.473	0.018
59.2	30.4	0.490	0.016
58.4	34.7	0.505	0.015
57.7	43.0	0.523	0.012
57.0	45.4	0.536	0.012
56.4	56.8	0.551	0.0097

* Relative to oil permeability

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GAS-OIL RELATIVE PERMEABILITY DATA

SAMPLE NUMBER 408.1

INITIAL WATER SATURATION
PERCENT PORE SPACE 33.8

AIR PERMEABILITY md 8.9

POROSITY PERCENT 20.5

OIL PERMEABILITY AT
INITIAL WATER SATURATION md 5.4

SAMPLE DEPTH 3325.15 m

LIQUID SATURATION PERCENT PORE SPACE	GAS - OIL RELATIVE PERMEABILITY RATIO	RELATIVE PERMEABILITY TO GAS*, FRACTION	RELATIVE PERMEABILITY TO OIL*, FRACTION
55.9	59.7	0.562	0.0094
55.3	68.3	0.576	0.0084
54.9	79.5	0.584	0.0073
54.5	81.7	0.594	0.0073
54.1	85.6	0.603	0.0070
53.6	87.6	0.612	0.0070
53.2	103	0.621	0.0060
52.8	108	0.622	0.0058
52.4	134	0.644	0.0048
52.0	158	0.662	0.0042
51.5	293	0.666	0.0023

* Relative to oil permeability

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GAS-OIL RELATIVE PERMEABILITY DATA

SAMPLE NUMBER 471.1 INITIAL WATER SATURATION
PERCENT PORE SPACE 5.3

AIR PERMEABILITY md 2316 POROSITY PERCENT 22.8

OIL PERMEABILITY AT
INITIAL WATER SATURATION md 2144 SAMPLE DEPTH 3347.50 m

LIQUID SATURATION PERCENT PORE SPACE	GAS - OIL RELATIVE PERMEABILITY RATIO	RELATIVE PERMEABILITY TO GAS*, FRACTION	RELATIVE PERMEABILITY TO OIL*, FRACTION
100			1.00
78.4	0.065	0.039	0.603
73.9	0.150	0.051	0.337
71.3	0.218	0.054	0.249
67.6	0.381	0.068	0.179
59.1	1.53	0.121	0.079
50.0	10.1	0.230	0.023
46.5	16.8	0.258	0.015
45.3	20.5	0.270	0.013
44.2	25.8	0.285	0.011
43.2	29.0	0.294	0.010
42.2	39.2	0.307	0.0078
41.6	49.1	0.317	0.0065
41.1	98.1	0.328	0.0033
40.3	171	0.333	0.0019
39.5	211	0.338	0.0016
39.0	327	0.340	0.0010
38.6	716	0.345	0.0005

* Relative to oil permeability

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GAS-OIL RELATIVE PERMEABILITY DATA

SAMPLE NUMBER 487.1 INITIAL WATER SATURATION
PERCENT PORE SPACE 14.3
AIR PERMEABILITY md 511 POROSITY PERCENT 21.1
OIL PERMEABILITY AT
INITIAL WATER SATURATION md 419 SAMPLE DEPTH 3359.15 m

LIQUID SATURATION PERCENT PORE SPACE	GAS - OIL RELATIVE PERMEABILITY RATIO	RELATIVE PERMEABILITY TO GAS*, FRACTION	RELATIVE PERMEABILITY TO OIL*, FRACTION
100			1.00
85.1	0.075	0.049	0.658
82.3	0.129	0.066	0.512
80.1	0.199	0.078	0.394
78.2	0.272	0.091	0.335
75.4	0.530	0.115	0.218
72.4	0.861	0.144	0.167
69.8	1.36	0.171	0.126
67.1	1.85	0.196	0.106
64.6	2.77	0.222	0.080
62.3	3.90	0.248	0.064
60.2	5.86	0.277	0.047
58.1	8.48	0.302	0.036
56.2	12.5	0.326	0.026
54.7	16.9	0.348	0.021
53.5	20.7	0.363	0.018
52.4	26.6	0.380	0.014
51.4	30.2	0.394	0.013
50.7	40.8	0.408	0.010
50.0	45.3	0.413	0.0091

* Relative to oil permeability

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GAS-OIL RELATIVE PERMEABILITY DATA

SAMPLE NUMBER 487.1 INITIAL WATER SATURATION
 PERCENT PORE SPACE 14.3

AIR PERMEABILITY md 511 POROSITY PERCENT 21.1

OIL PERMEABILITY AT
 INITIAL WATER SATURATION md 419 SAMPLE DEPTH 3359.15 m

LIQUID SATURATION PERCENT PORE SPACE	GAS - OIL RELATIVE PERMEABILITY RATIO	RELATIVE PERMEABILITY TO GAS *, FRACTION	RELATIVE PERMEABILITY TO OIL *, FRACTION
49.4	56.0	0.424	0.0076
48.7	198	0.439	0.0022
48.1	312	0.456	0.0015
47.7	454	0.470	0.0010
47.4	1010	0.477	0.0005

* Relative to oil permeability

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GAS-OIL RELATIVE PERMEABILITY DATA

SAMPLE NUMBER 586.1 INITIAL WATER SATURATION
PERCENT PORE SPACE 31.0
AIR PERMEABILITY md 27 POROSITY PERCENT 18.0
OIL PERMEABILITY AT
INITIAL WATER SATURATION md 19 SAMPLE DEPTH 3396.00 m

LIQUID SATURATION PERCENT PORE SPACE	GAS - OIL RELATIVE PERMEABILITY RATIO	RELATIVE PERMEABILITY TO GAS*, FRACTION	RELATIVE PERMEABILITY TO OIL*, FRACTION
100			1.00
85.4	0.147	0.056	0.381
81.7	0.452	0.089	0.197
78.4	0.933	0.122	0.131
75.7	1.79	0.148	0.083
72.8	2.85	0.177	0.062
70.2	4.91	0.202	0.041
68.4	6.86	0.221	0.032
67.0	9.82	0.237	0.024
65.8	11.8	0.252	0.021
64.7	16.1	0.266	0.017
63.7	19.7	0.274	0.014
62.8	23.1	0.285	0.012
62.0	31.0	0.296	0.0096
61.4	34.9	0.304	0.0087
60.8	40.7	0.312	0.0077
60.0	50.1	0.312	0.0062
58.9	66.9	0.344	0.0051
57.5	173	0.402	0.0023
56.3	408	0.412	0.0010

* Relative to oil permeability

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GAS-OIL RELATIVE PERMEABILITY DATA

SAMPLE NUMBER 604.1 INITIAL WATER SATURATION
PERCENT PORE SPACE 39.4
AIR PERMEABILITY md 6.3 POROSITY PERCENT 15.4
OIL PERMEABILITY AT
INITIAL WATER SATURATION md 4.1 SAMPLE DEPTH 3401.65 m

LIQUID SATURATION PERCENT PORE SPACE	GAS - OIL RELATIVE PERMEABILITY RATIO	RELATIVE PERMEABILITY TO GAS %, FRACTION	RELATIVE PERMEABILITY TO OIL %, FRACTION
100			1.00
91.0	0.212	0.075	0.354
88.5	0.411	0.098	0.239
86.4	0.618	0.115	0.187
84.5	0.966	0.135	0.140
83.1	1.57	0.164	0.104
80.5	2.40	0.200	0.083
77.1	4.90	0.251	0.051
74.7	5.97	0.286	0.048
73.3	8.58	0.308	0.036
72.2	11.4	0.322	0.028
71.1	14.5	0.340	0.023
70.1	17.2	0.358	0.021
68.9	24.1	0.378	0.016
67.9	30.2	0.398	0.013
66.9	33.9	0.415	0.012
66.1	41.6	0.431	0.010
65.3	49.8	0.444	0.0089
64.5	54.4	0.458	0.0084
63.9	72.4	0.469	0.0065

* Relative to oil permeability

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GAS-OIL RELATIVE PERMEABILITY DATA

SAMPLE NUMBER 604.1 INITIAL WATER SATURATION
 PERCENT PORE SPACE 39.4

AIR PERMEABILITY md 6.3 POROSITY PERCENT 15.4

OIL PERMEABILITY AT
 INITIAL WATER SATURATION md 4.1 SAMPLE DEPTH 3401.65 m

LIQUID SATURATION PERCENT PORE SPACE	GAS - OIL RELATIVE PERMEABILITY RATIO	RELATIVE PERMEABILITY TO GAS*, FRACTION	RELATIVE PERMEABILITY TO OIL*, FRACTION
63.3	74.5	0.480	0.0065
62.2	109	0.504	0.0046
61.2	136	0.523	0.0038
60.6	145	0.536	0.0037
60.0	169	0.547	0.0032

* Relative to oil permeability

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GAS-OIL RELATIVE PERMEABILITY DATA

SAMPLE NUMBER 623.1 INITIAL WATER SATURATION
PERCENT PORE SPACE 22.2
AIR PERMEABILITY md 128 POROSITY PERCENT 19.5
OIL PERMEABILITY AT
INITIAL WATER SATURATION md 119 SAMPLE DEPTH 3407.50 m

LIQUID SATURATION PERCENT PORE SPACE	GAS - OIL RELATIVE PERMEABILITY RATIO	RELATIVE PERMEABILITY TO GAS*, FRACTION	RELATIVE PERMEABILITY TO OIL*, FRACTION
100			1.00
89.0	0.059	0.045	0.755
86.8	0.091	0.059	0.650
84.8	0.173	0.070	0.403
83.0	0.240	0.085	0.355
81.6	0.301	0.095	0.316
80.2	0.454	0.108	0.239
78.9	0.584	0.122	0.209
76.8	0.914	0.149	0.163
73.6	1.84	0.190	0.103
70.7	2.76	0.228	0.083
68.4	4.05	0.261	0.064
66.4	6.32	0.289	0.046
64.7	8.45	0.318	0.038
63.2	11.8	0.342	0.029
61.9	15.9	0.363	0.023
60.9	20.2	0.382	0.019
59.9	23.2	0.398	0.017
59.0	30.9	0.416	0.013
58.2	35.1	0.428	0.012

* Relative to oil permeability

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GAS-OIL RELATIVE PERMEABILITY DATA

SAMPLE NUMBER 623.1 INITIAL WATER SATURATION
PERCENT PORE SPACE 22.2
AIR PERMEABILITY md 128 POROSITY PERCENT 19.5
OIL PERMEABILITY AT
INITIAL WATER SATURATION md 119 SAMPLE DEPTH 3407.5 m

LIQUID SATURATION PERCENT PORE SPACE	GAS - OIL RELATIVE PERMEABILITY RATIO	RELATIVE PERMEABILITY TO GAS*, FRACTION	RELATIVE PERMEABILITY TO OIL*, FRACTION
57.6	45.2	0.438	0.0097
56.3	61.3	0.447	0.0073
53.8	210	0.525	0.0025

* Relative to oil permeability

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GAS-OIL RELATIVE PERMEABILITY DATA

SAMPLE NUMBER 657.1

INITIAL WATER SATURATION

PERCENT PORE SPACE 44.9

AIR PERMEABILITY md 2.00

POROSITY PERCENT 13.3

OIL PERMEABILITY AT

INITIAL WATER SATURATION md 0.68

SAMPLE DEPTH

3419.10 m

LIQUID SATURATION PERCENT PORE SPACE	GAS - OIL RELATIVE PERMEABILITY RATIO	RELATIVE PERMEABILITY TO GAS %, FRACTION	RELATIVE PERMEABILITY TO OIL %, FRACTION
100			1.00
93.4	0.121	0.098	0.808
90.0	0.198	0.097	0.489
87.6	0.358	0.116	0.325
85.9	0.610	0.142	0.233
84.8	0.739	0.169	0.228
83.8	0.906	0.166	0.183
82.4	1.49	0.197	0.132
80.8	1.87	0.217	0.116
79.8	2.29	0.232	0.102
79.1	3.17	0.278	0.088
78.4	3.66	0.284	0.078
77.7	5.00	0.308	0.062
76.7	5.24	0.328	0.063
75.7	6.83	0.352	0.051
75.2	8.78	0.373	0.042
74.2	11.4	0.401	0.035
72.7	14.1	0.457	0.032
71.3	17.5	0.456	0.026
70.3	25.3	0.467	0.018

* Relative to oil permeability

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GAS-OIL RELATIVE PERMEABILITY DATA

SAMPLE NUMBER 657.1 INITIAL WATER SATURATION
PERCENT PORE SPACE 44.9

AIR PERMEABILITY md 2.00 POROSITY PERCENT 13.3

OIL PERMEABILITY AT
INITIAL WATER SATURATION md 0.68 SAMPLE DEPTH 3419.10 m

LIQUID SATURATION PERCENT PORE SPACE	GAS – OIL RELATIVE PERMEABILITY RATIO	RELATIVE PERMEABILITY TO GAS *, FRACTION	RELATIVE PERMEABILITY TO OIL *, FRACTION
68.7	38.3	0.574	0.015
67.2	53.4	0.600	0.011
65.9	79.3	0.640	0.0081
64.1	102	0.693	0.0068
62.8	183	0.726	0.0040
62.4	231	0.882	0.0038

* Relative to oil permeability

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GAS-OIL RELATIVE PERMEABILITY DATA

SAMPLE NUMBER 666.1

INITIAL WATER SATURATION
PERCENT PORE SPACE 28.6

AIR PERMEABILITY md 17.8

POROSITY PERCENT 18.4

OIL PERMEABILITY AT
INITIAL WATER SATURATION md 13.3

SAMPLE DEPTH 3422.10 m

LIQUID SATURATION PERCENT PORE SPACE	GAS - OIL RELATIVE PERMEABILITY RATIO	RELATIVE PERMEABILITY TO GAS*, FRACTION	RELATIVE PERMEABILITY TO OIL*, FRACTION
100			1.00
82.2	0.134	0.056	0.416
79.7	0.274	0.085	0.311
77.8	0.373	0.092	0.245
74.6	0.972	0.143	0.147
71.1	2.11	0.186	0.088
69.2	3.07	0.220	0.072
66.2	6.21	0.275	0.044
63.3	8.21	0.324	0.040
62.1	12.9	0.346	0.027
61.2	15.7	0.360	0.023
60.3	20.2	0.384	0.019
59.3	25.6	0.407	0.016
58.4	27.5	0.420	0.015
57.6	37.8	0.453	0.012
56.9	44.9	0.466	0.010
56.2	49.5	0.482	0.0097
55.5	55.1	0.502	0.0091
54.8	67.9	0.517	0.0076
54.3	76.7	0.532	0.0069

* Relative to oil permeability

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GAS-OIL RELATIVE PERMEABILITY DATA

SAMPLE NUMBER 666.1 INITIAL WATER SATURATION
 PERCENT PORE SPACE 28.6
 AIR PERMEABILITY md 17.8 POROSITY PERCENT 18.4
 OIL PERMEABILITY AT
 INITIAL WATER SATURATION md 13.3 SAMPLE DEPTH 3422.10 m

LIQUID SATURATION PERCENT PORE SPACE	GAS - OIL RELATIVE PERMEABILITY RATIO	RELATIVE PERMEABILITY TO GAS*, FRACTION	RELATIVE PERMEABILITY TO OIL*, FRACTION
53.7	91.1	0.546	0.0060
53.2	135	0.557	0.0041
52.5	159	0.569	0.0036
51.8	199	0.587	0.0030
51.1	479	0.605	0.0013

* Relative to oil permeability

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COMPANY: STATOIL

FORMATION: ZONE 1

WELL: 34/10-16

LOCATION: NORWEGIAN NORTH SEA

FIELD: GULLFAKS

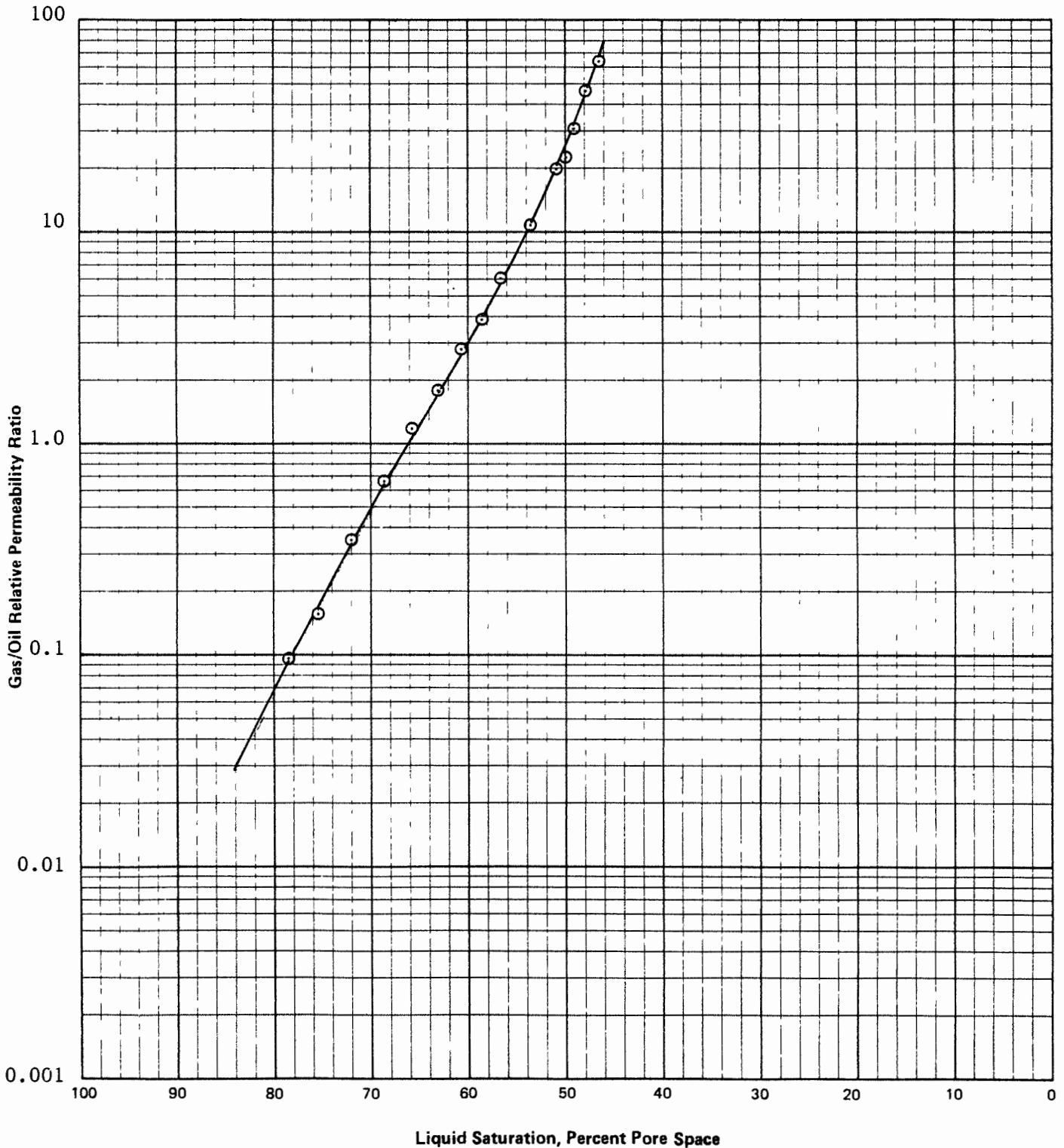
COUNTRY: NORWAY ..

SAMPLE NUMBER: 7-1

PERMEABILITY_{md}: 769 (K_o at SW_{ir})

SAMPLE DEPTH: 3171.85 m

GAS-OIL RELATIVE PERMEABILITY
Unsteady-State, Restored-State, Increasing Gas Saturation



ROBERTSON
RESEARCH

COMPANY: STATOIL

FORMATION: ZONE 1

WELL: 34/10-16

LOCATION: NORWEGIAN NORTH SEA

FIELD: GULLFAKS

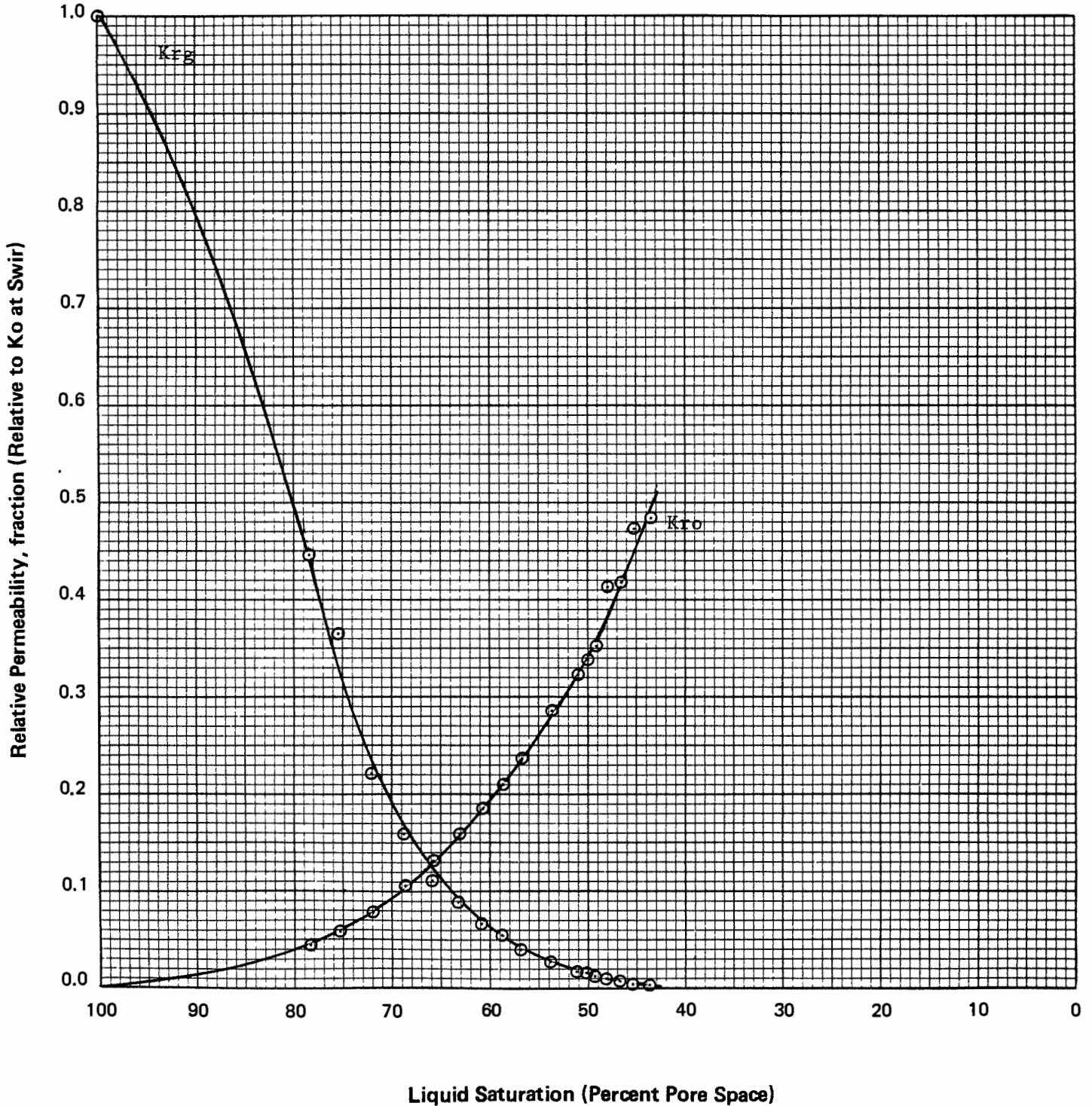
COUNTRY: NORWAY

SAMPLE No.: 7.1

PERMEABILITY md: 769 (Ka at SWIR)

SAMPLE DEPTH: 3171.85 m

GAS – OIL RELATIVE PERMEABILITY
 Unsteady State, Restored State, Increasing Gas Saturation



COMPANY: STATOIL

FORMATION: ZONE 1

WELL: 34/10-16

LOCATION: NORWEGIAN NORTH SEA

FIELD: GULLFAKS

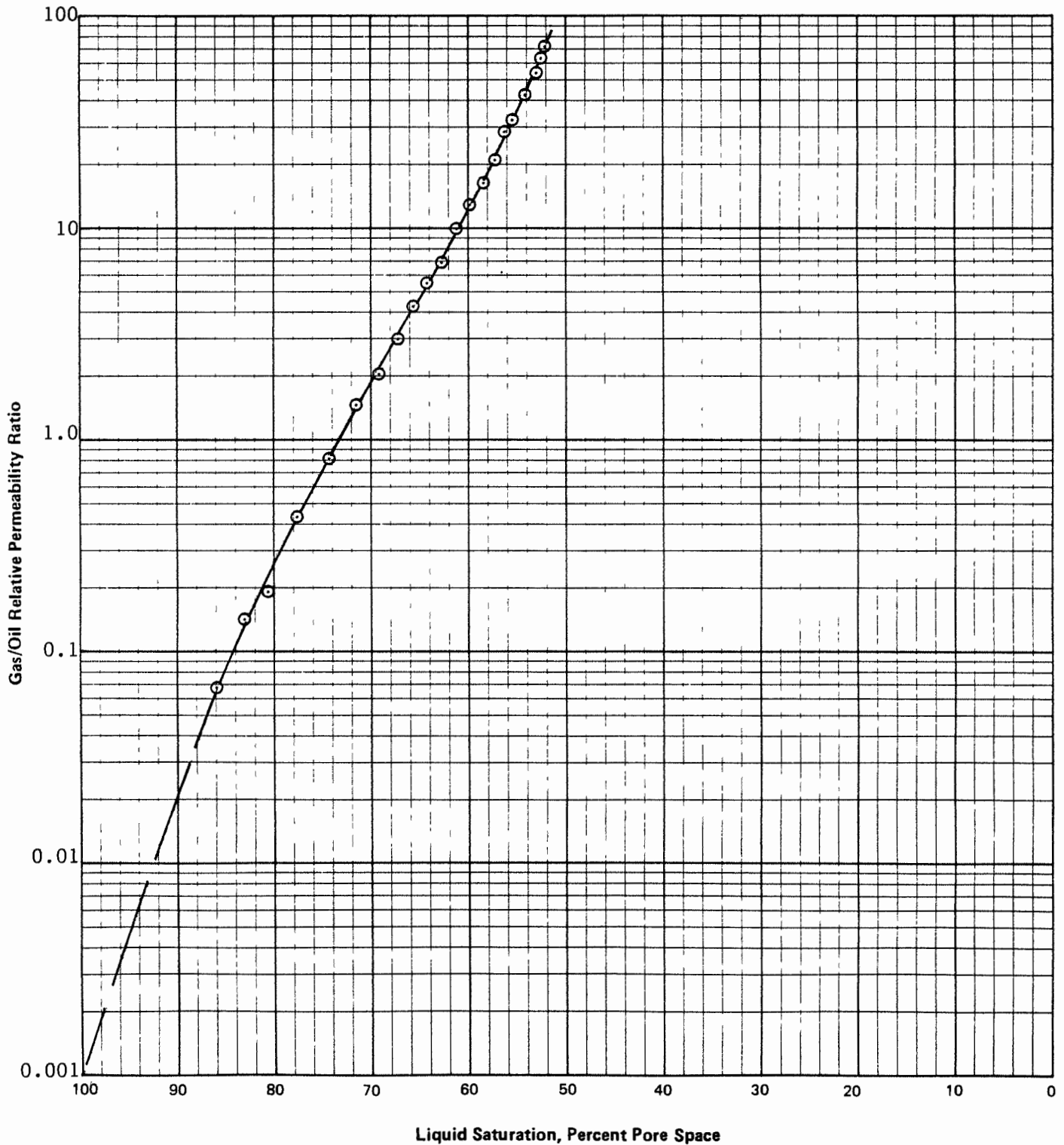
COUNTRY: NORWAY

SAMPLE NUMBER: 57-1

PERMEABILITY_{md}: 25 (K_o at SWIR)

SAMPLE DEPTH: 3190.00 m

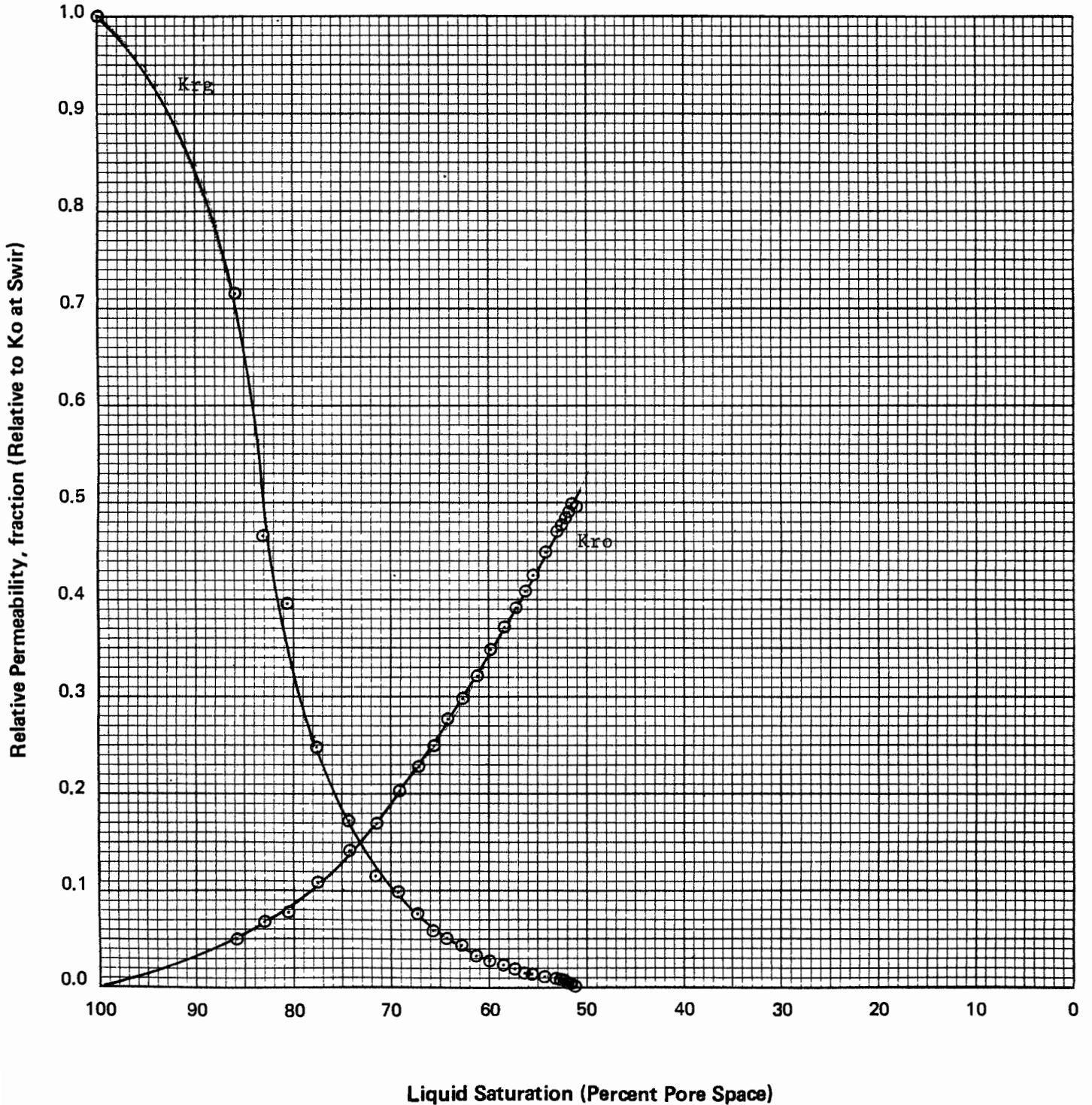
GAS-OIL RELATIVE PERMEABILITY
Unsteady-State, Restored-State, Increasing Gas Saturation



COMPANY: STATOIL
 WELL: 34/10-16
 FIELD: GULLFAKS
 SAMPLE No.: 57-1

FORMATION: ZONE 1
 LOCATION: NORWEGIAN NORTH SEA
 COUNTRY: NORWAY
 PERMEABILITY md: 25 (Ko at SWir)
 SAMPLE DEPTH: 3190.00 m

GAS - OIL RELATIVE PERMEABILITY
 Unsteady State, Restored State, Increasing Gas Saturation



COMPANY: TAT OIL

FORMATION: ZONE 1

WELL: 34/10-16

LOCATION: NORWEGIAN NORTH SEA

FIELD: GULLFAKS

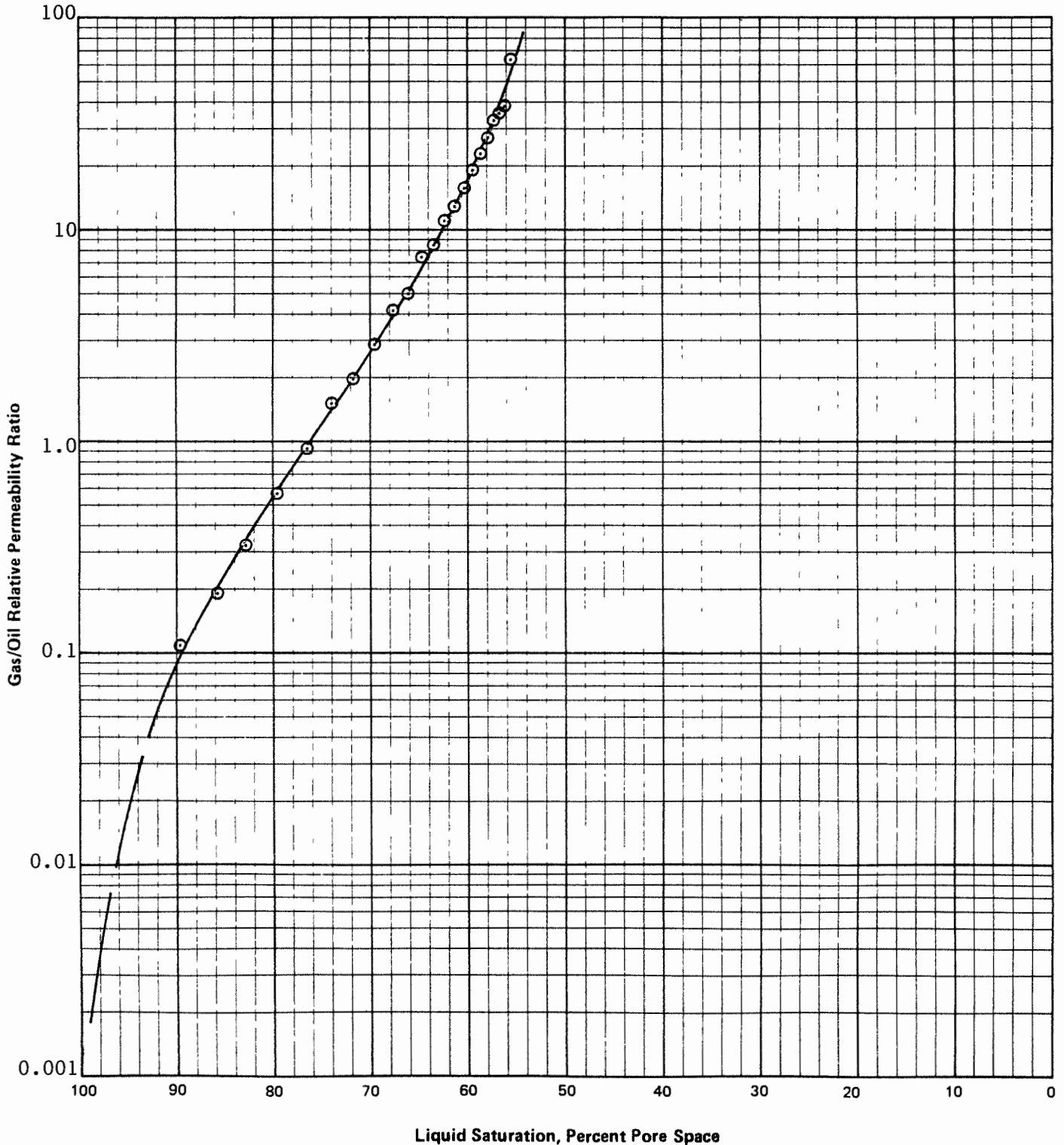
COUNTRY: NORWAY

SAMPLE NUMBER: 81.1

PERMEABILITY_{md}: 166 (K_o at SW_{ir})

SAMPLE DEPTH: 3200.00 m

GAS-OIL RELATIVE PERMEABILITY
Unsteady-State, Restored-State, Increasing Gas Saturation



COMPANY: STATOIL

FORMATION: ZONE 1

WELL: 34/10-1.6

LOCATION: NORWEGIAN NORTH SEA

FIELD: GULLFAKS

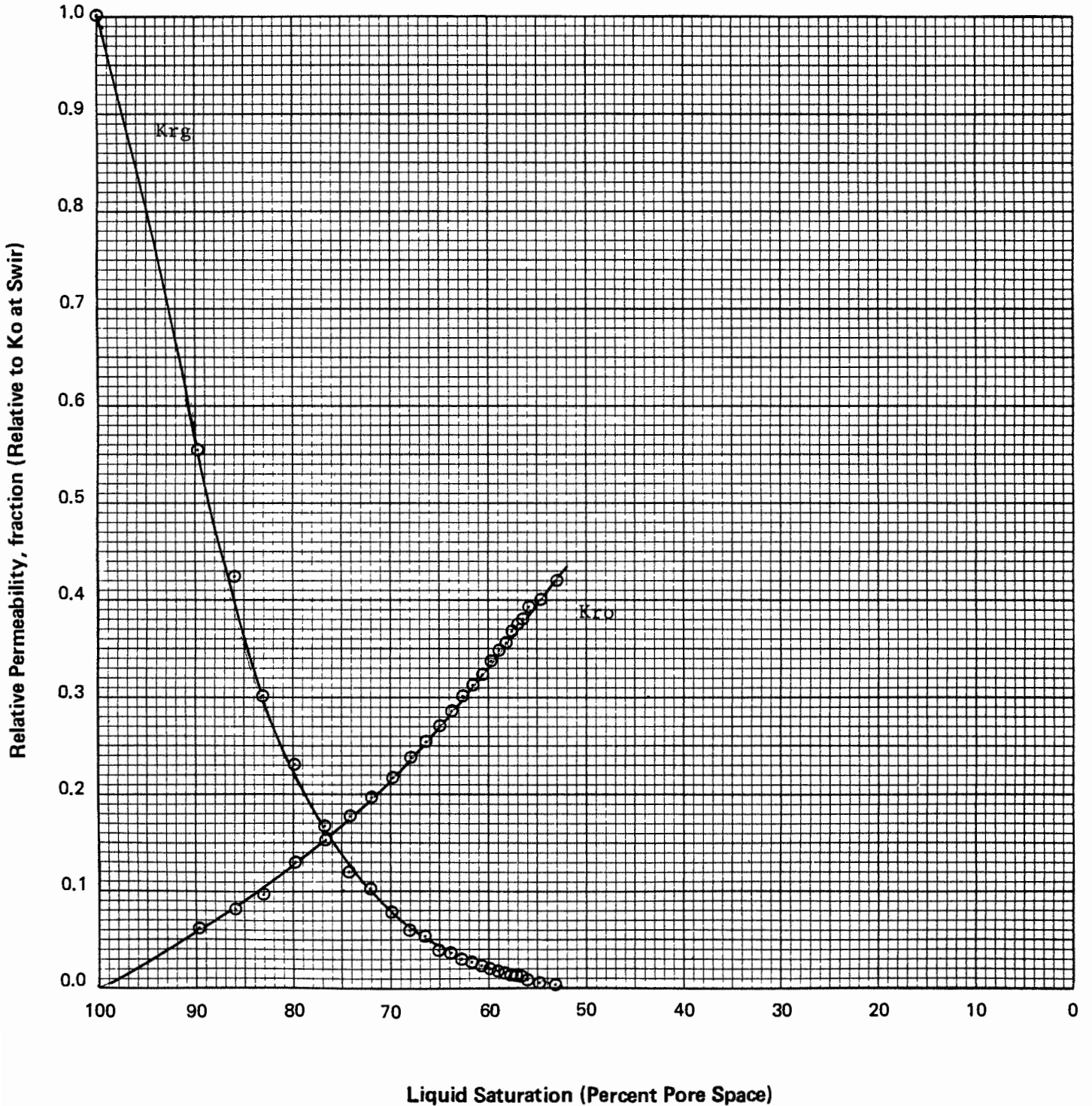
COUNTRY: NORWAY

SAMPLE No.: 81.1

PERMEABILITY md: 166 (Ko at Swir)

SAMPLE DEPTH: 3200.00 m

GAS - OIL RELATIVE PERMEABILITY
 Unsteady State, Restored State, Increasing Gas Saturation



COMPANY: STATOIL

FORMATION: ZONE 1

WELL: 34/10-16

LOCATION: NORWEGIAN NORTH SEA

FIELD: GULLFAKS

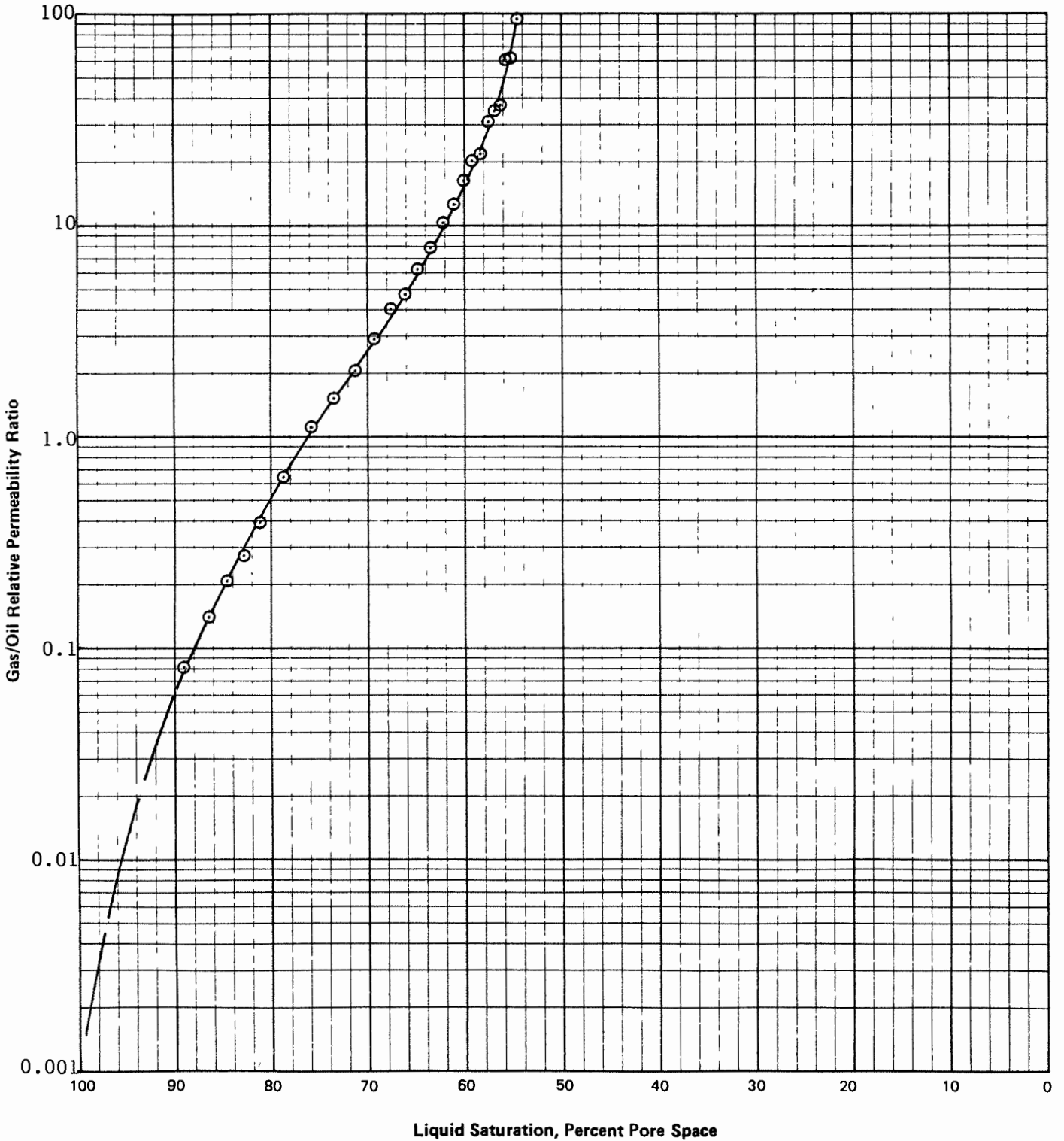
COUNTRY: NORWAY

SAMPLE NUMBER: 93-1

PERMEABILITY_{md}: 402 (K_o at SW_{ir})

SAMPLE DEPTH: 3204.15 m

GAS-OIL RELATIVE PERMEABILITY
Unsteady-State, Restored-State, Increasing Gas Saturation



ROBERTSON
RESEARCH

COMPANY: STATOIL

FORMATION: ZONE 1

WELL: 34/10-16

LOCATION: NORWEGIAN NORTH SEA

FIELD: GULLFAKS

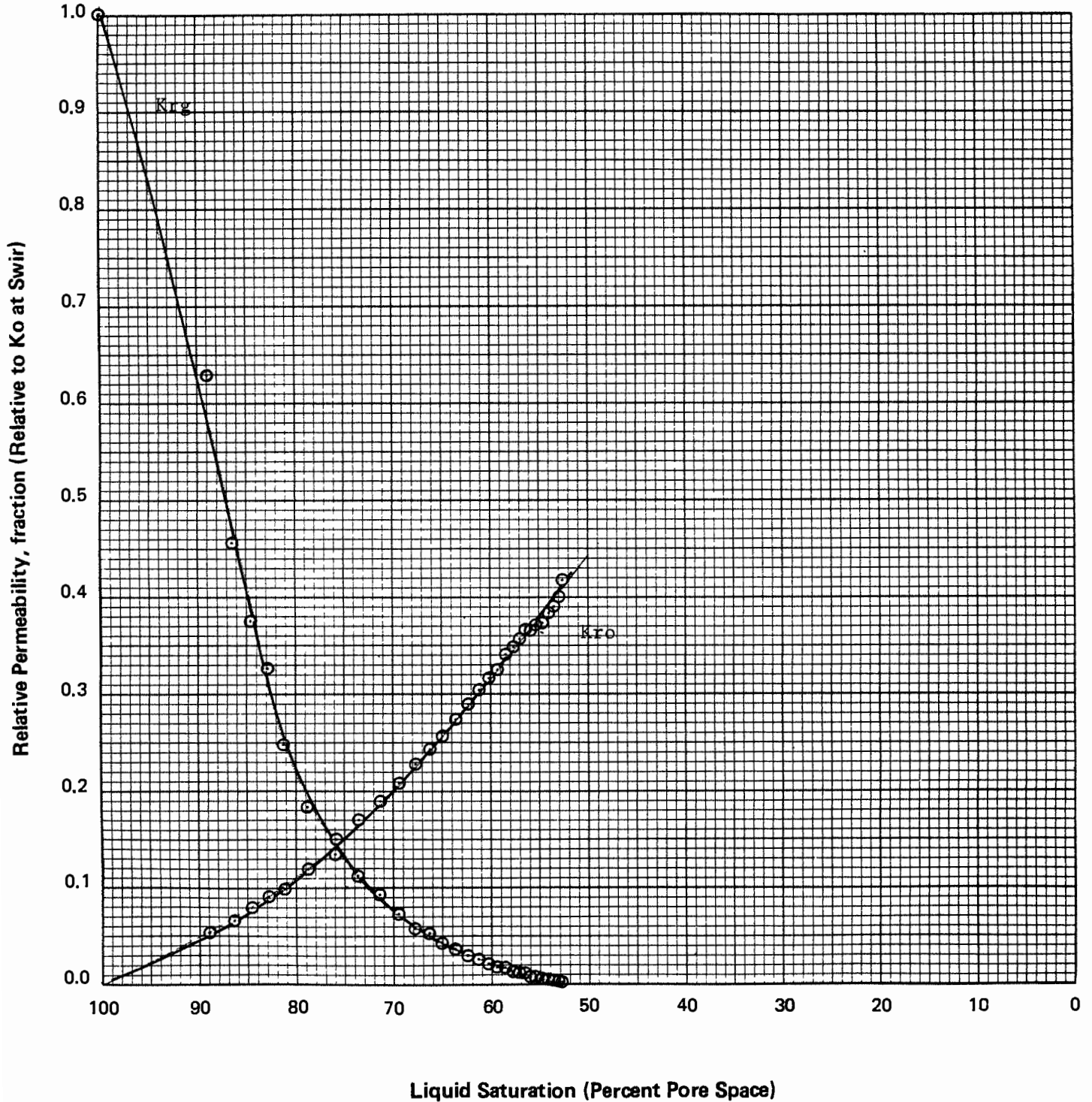
COUNTRY: NORWAY

SAMPLE No.: 93.1

PERMEABILITY md: 402 (Ko at Swir)

SAMPLE DEPTH: 3204.15 m

GAS - OIL RELATIVE PERMEABILITY
 Unsteady State, Restored State, Increasing Gas Saturation



COMPANY: STATOIL

FORMATION: ZONE 2

WELL: 34/10-16

LOCATION: NORWEGIAN NORTH SEA

FIELD: GULLFAKS

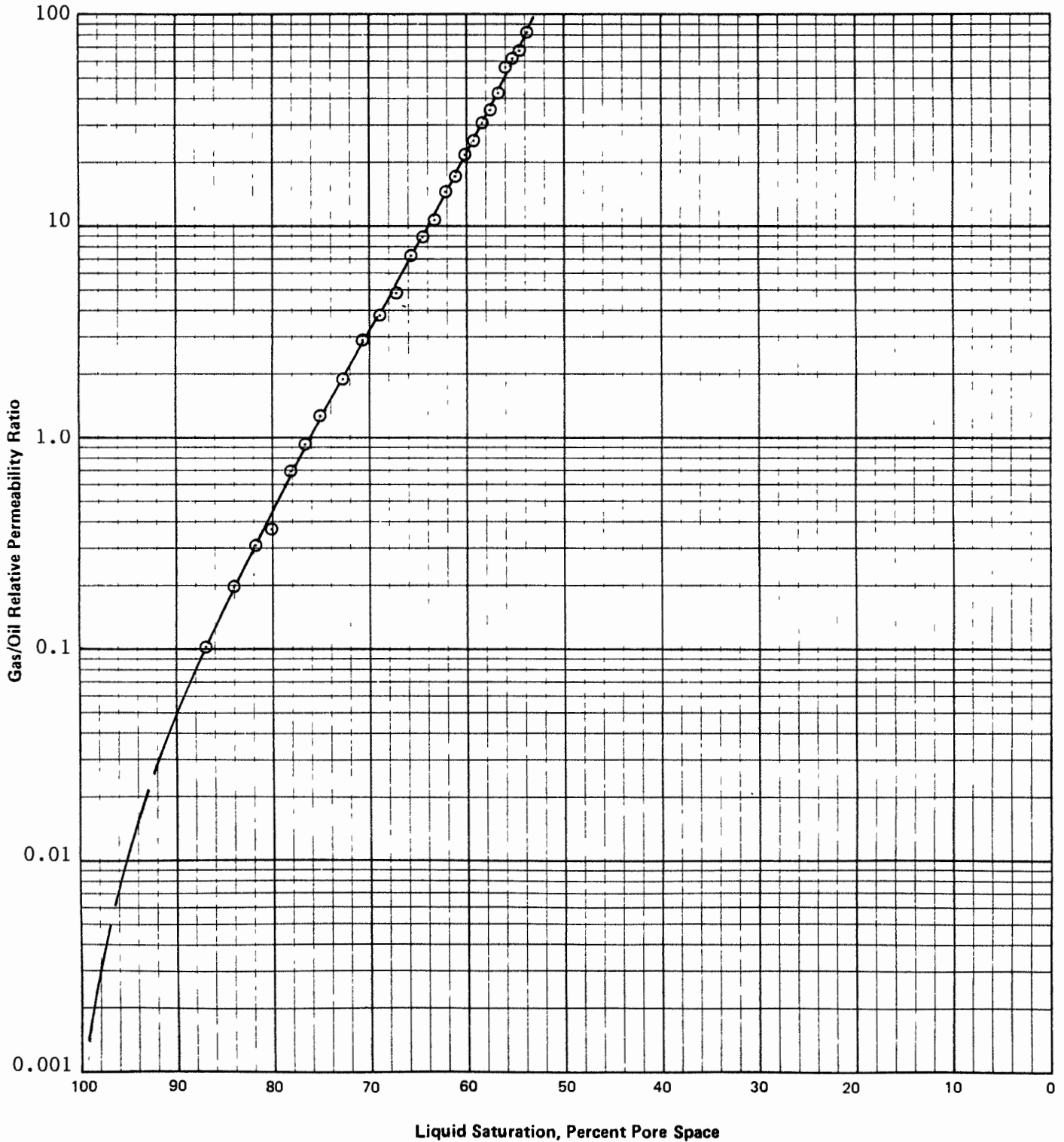
COUNTRY: NORWAY

SAMPLE NUMBER: 135-1

PERMEABILITY_{md}: 26 (K_o at SW_{ir})

SAMPLE DEPTH: 3219.00 m

GAS-OIL RELATIVE PERMEABILITY
Unsteady-State, Restored-State, Increasing Gas Saturation



COMPANY: STATOIL

FORMATION: ZONE 2

WELL: 34/10-16

LOCATION: NORWEGIAN NORTH SEA

FIELD: GULLFAKS

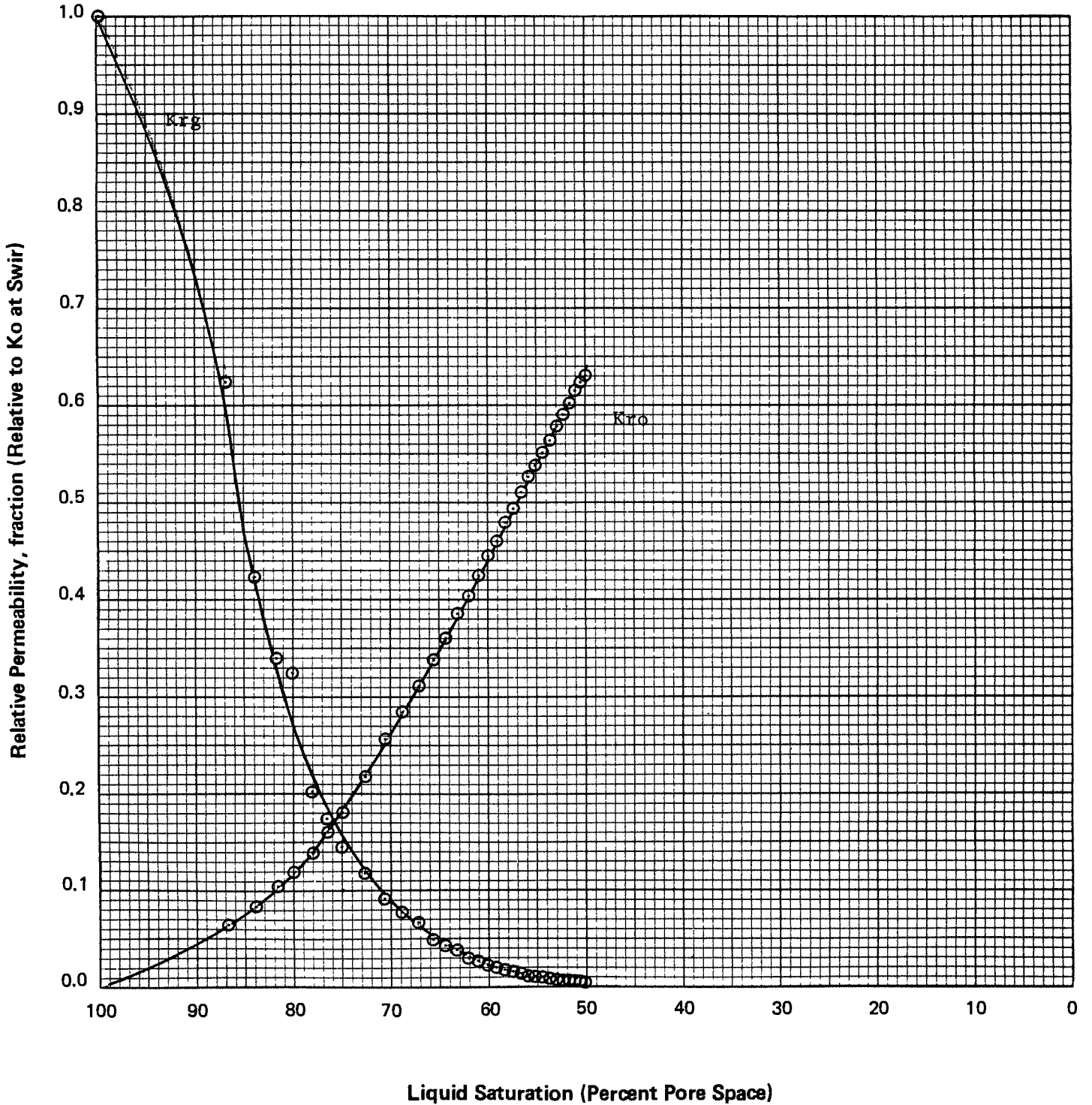
COUNTRY: NORWAY

SAMPLE No.: 135.1

PERMEABILITY md: 26 (Ko at SWIR)

SAMPLE DEPTH: 3219.00 m

GAS - OIL RELATIVE PERMEABILITY Unsteady State, Restored State, Increasing Gas Saturation



COMPANY: STATOIL

FORMATION: ZONE 2

WELL: 34/10-16

LOCATION: NORWEGIAN NORTH SEA

FIELD: GULLFAKS

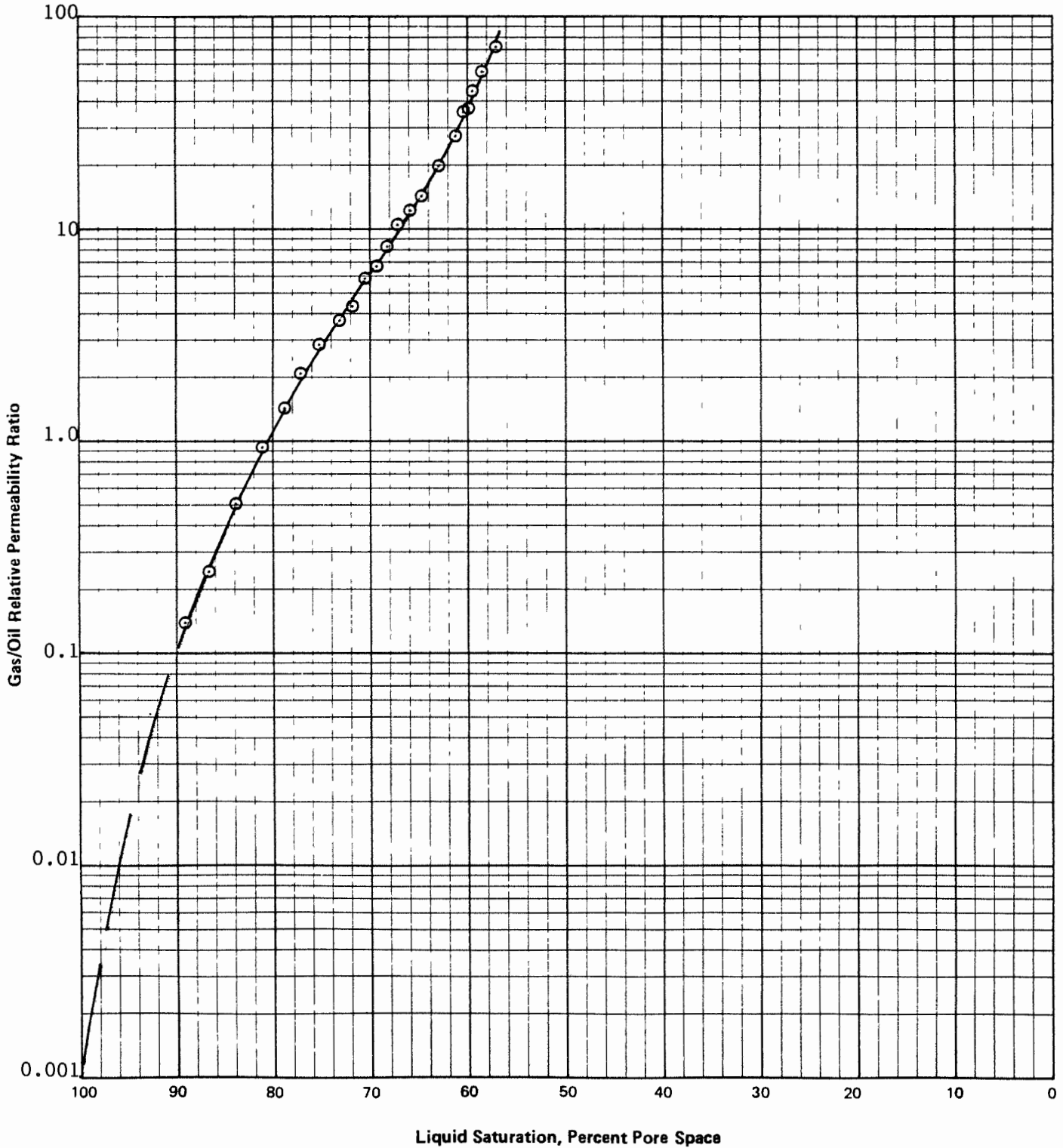
COUNTRY: NORWAY.

SAMPLE NUMBER: 316.1

PERMEABILITY_{md}: 61 (K_o at SW_{ir})

SAMPLE DEPTH: 3284.25 m

GAS-OIL RELATIVE PERMEABILITY
Unsteady-State, Restored-State, Increasing Gas Saturation



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COMPANY: STATOIL

FORMATION: ZONE 2

WELL: 34/10-16

LOCATION: NORWEGIAN NORTH SEA

FIELD: GULLFAKS

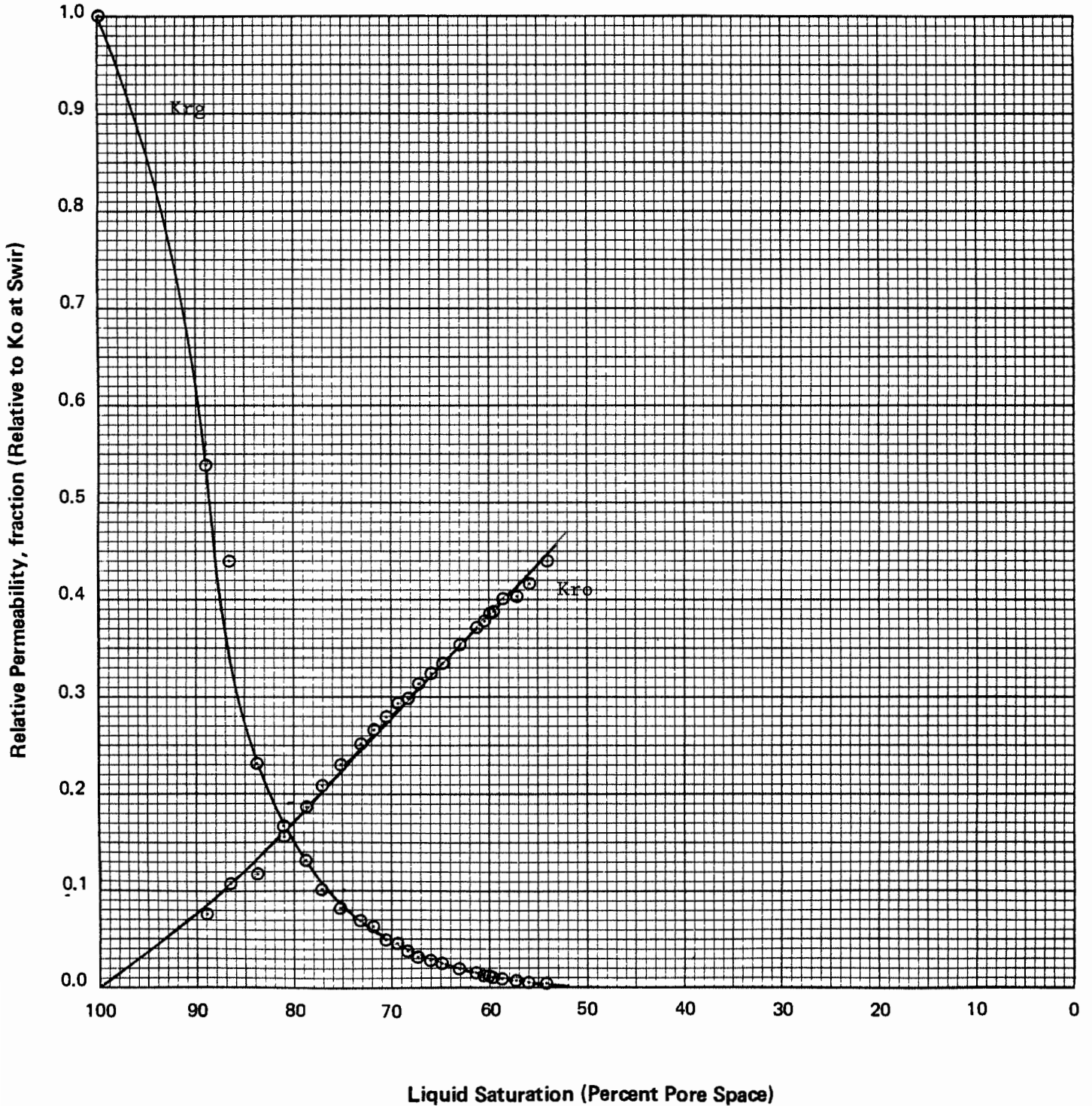
COUNTRY: NORWAY

SAMPLE No.: 316-1

PERMEABILITY md: 61 (Ko at Swir)

SAMPLE DEPTH: 3284.25 m

GAS - OIL RELATIVE PERMEABILITY
 Unsteady State, Restored State, Increasing Gas Saturation



COMPANY: STATOIL

FORMATION: ZONE 2

WELL: 34/10-16

LOCATION: NORWEGIAN NORTH SEA

FIELD: GULLFAKS

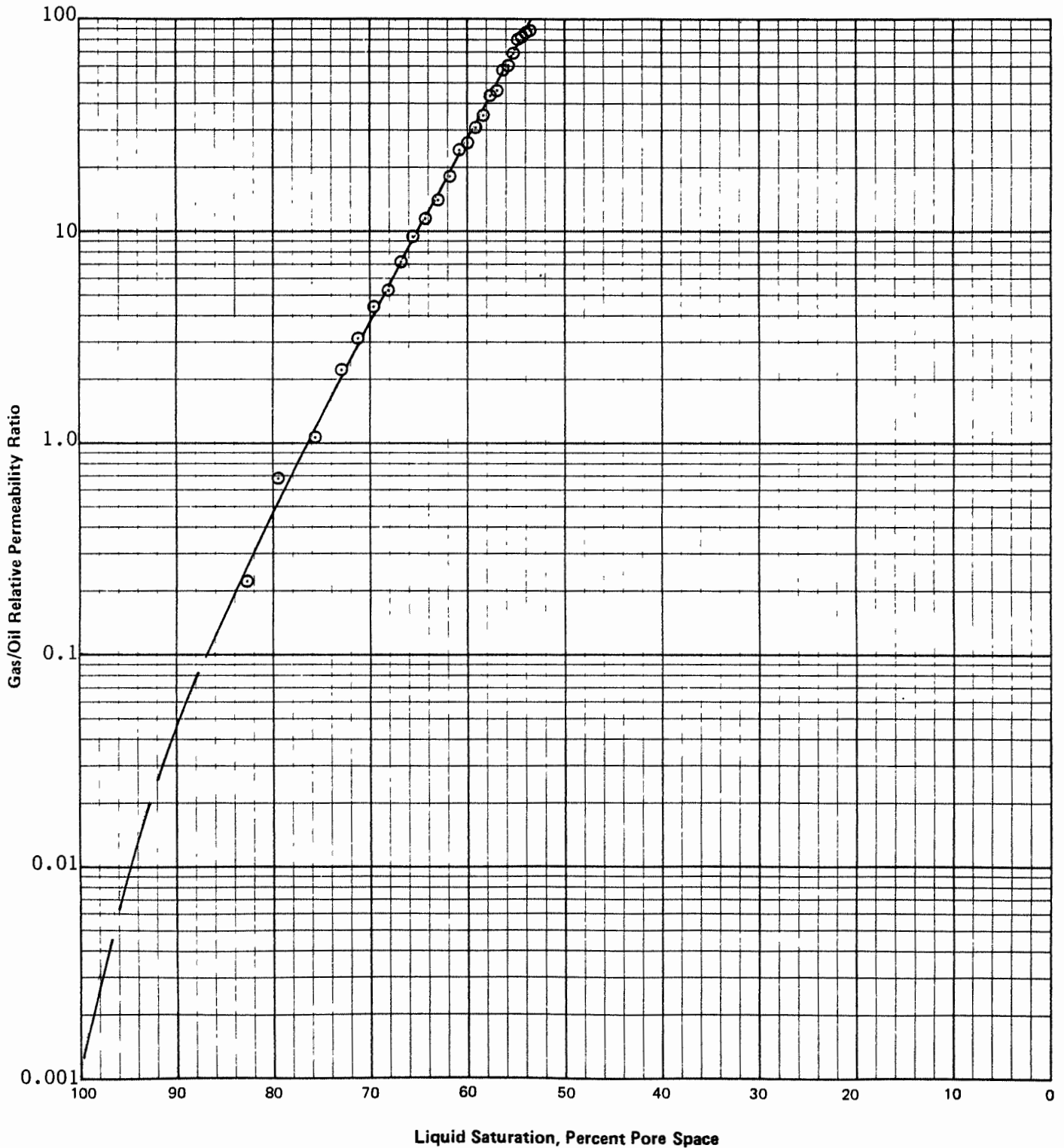
COUNTRY: NORWAY

SAMPLE NUMBER: 408.1

PERMEABILITY_{md}: 5.4 ($K_o \cdot t \cdot SWIr$)

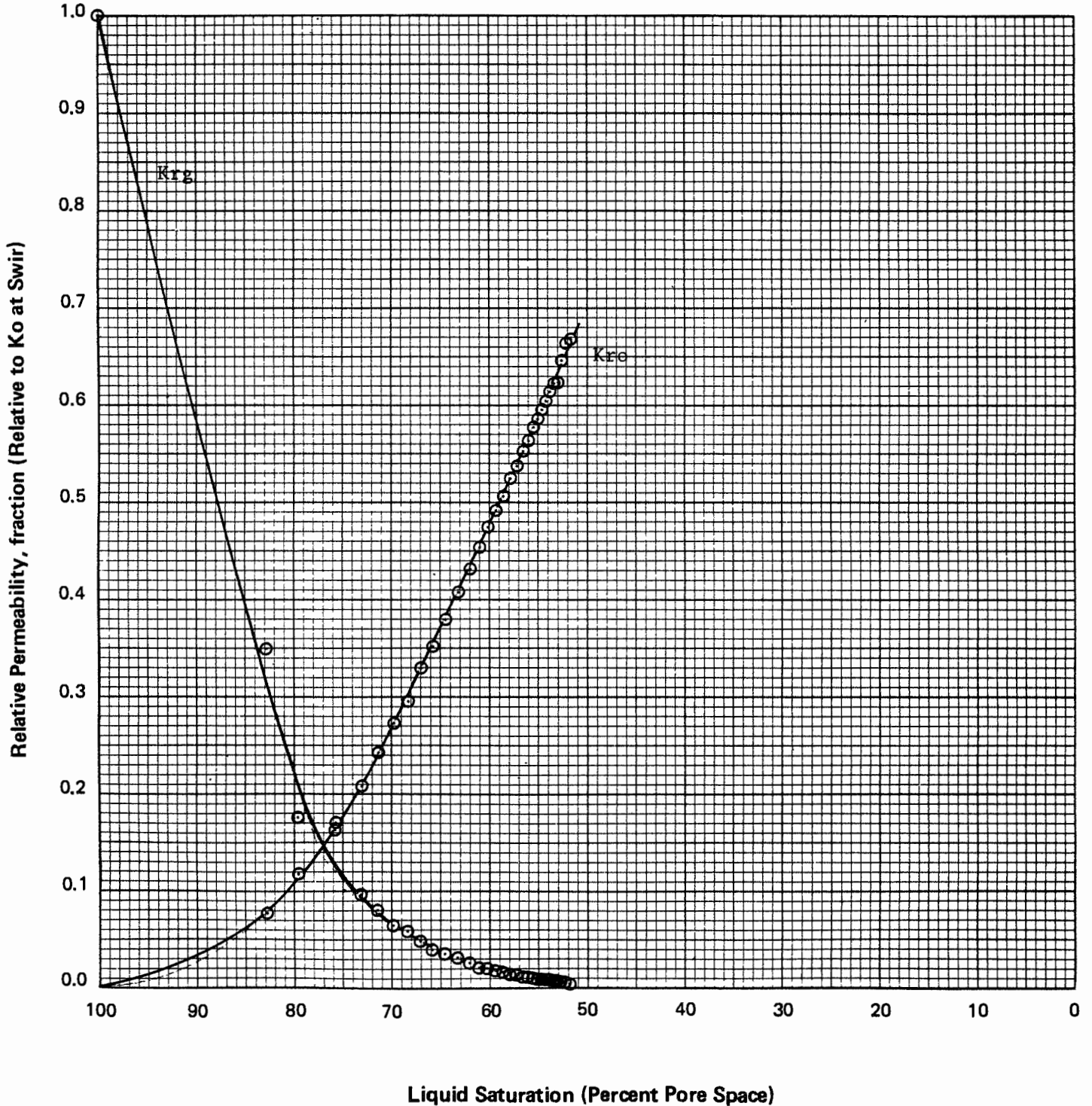
SAMPLE DEPTH: 3325.15 m

GAS-OIL RELATIVE PERMEABILITY
Unsteady-State, Restored-State, Increasing Gas Saturation



COMPANY: STATOIL FORMATION: ZONE 2
 WELL: 34/10-16 LOCATION: NORWEGIAN NORTH SEA
 FIELD: GULLFAKS COUNTRY: NORWAY
 SAMPLE No.: 408-1 PERMEABILITY md: 5.4 (Ka at SWIR)
 SAMPLE DEPTH: 3325.15 m

GAS – OIL RELATIVE PERMEABILITY
 Unsteady State, Restored State, Increasing Gas Saturation



COMPANY: STATOIL

FORMATION: ZONE 2

WELL: 34/10-16

LOCATION: NORWEGIAN NORTH SEA

FIELD: GULLFAKS

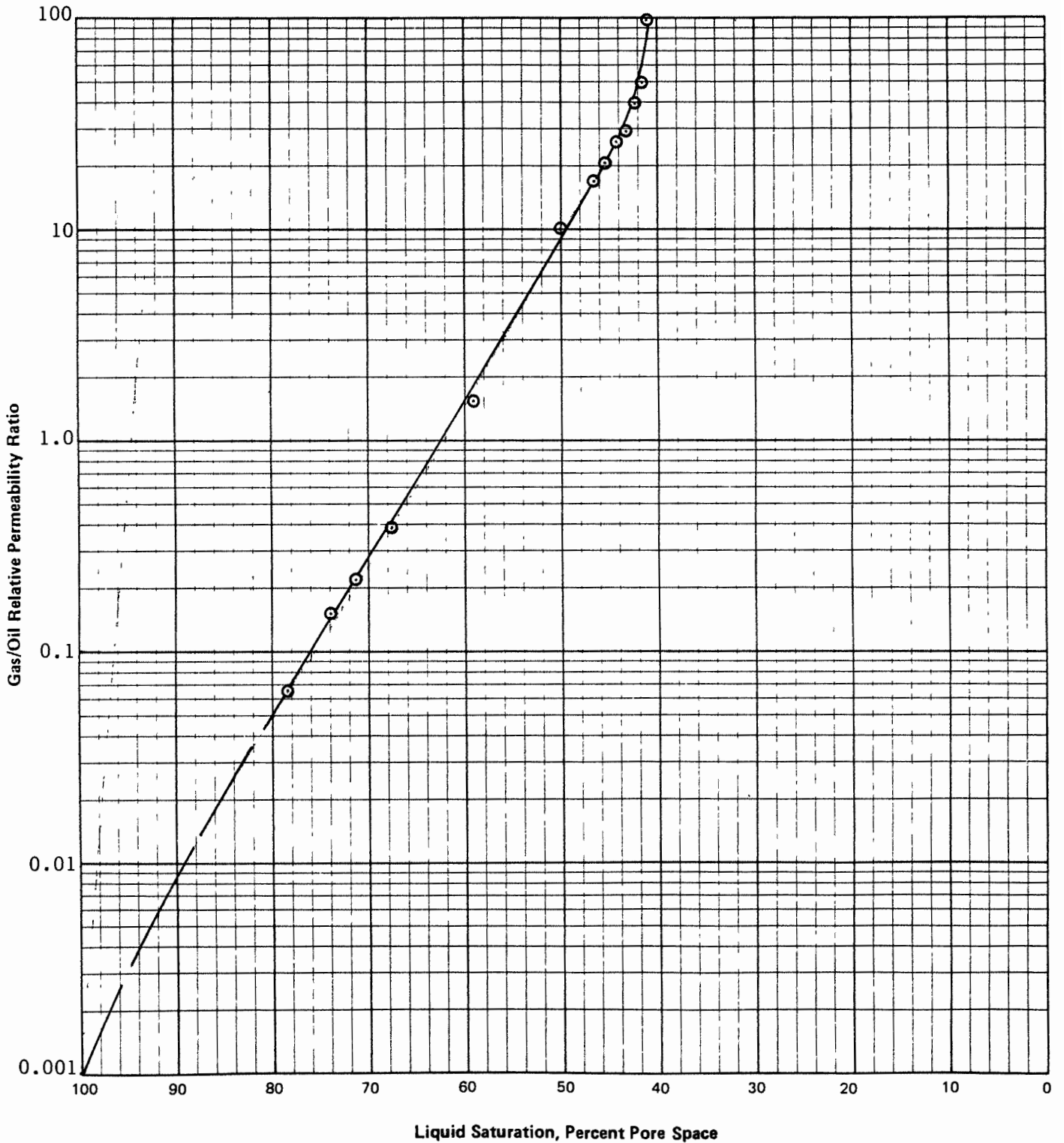
COUNTRY: NORWAY

SAMPLE NUMBER: 471-1

PERMEABILITY md: 2144 (K_o at $SWir$)

SAMPLE DEPTH: 3347.50 m

GAS-OIL RELATIVE PERMEABILITY
Unsteady-State, Restored-State, Increasing Gas Saturation



COMPANY: STATOIL

FORMATION: ZONE 2

WELL: 34/10-16

LOCATION: NORWEGIAN NORTH SEA

FIELD: GULLFAKS

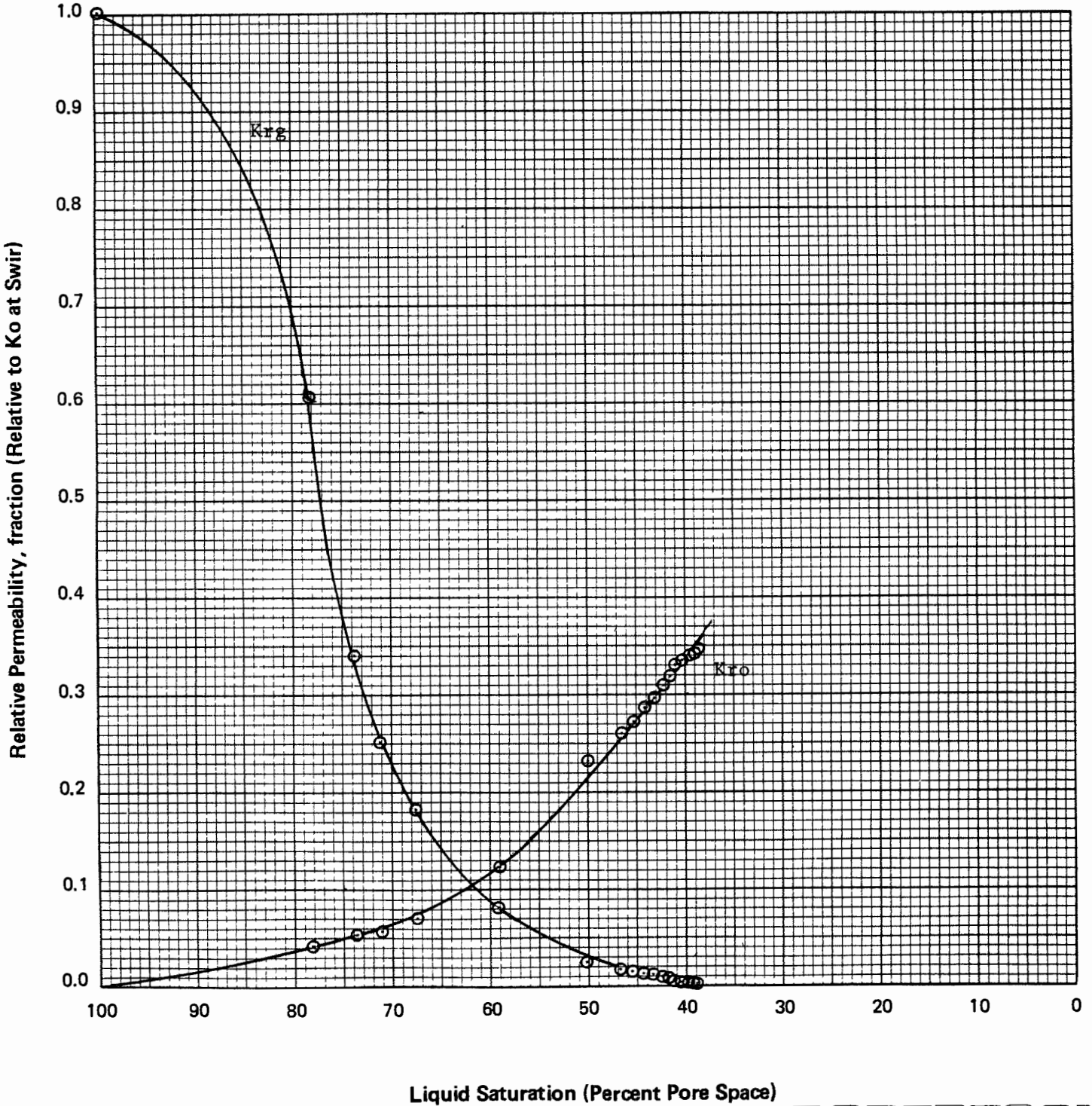
COUNTRY: NORWAY

SAMPLE No.: 471-1

PERMEABILITY md: 2144 (Ko at Swir)

SAMPLE DEPTH: 3347.50 m

GAS - OIL RELATIVE PERMEABILITY
 Unsteady State, Restored State, Increasing Gas Saturation



COMPANY: STATOIL

FORMATION: ZONE 2

WELL: 34/10-16

LOCATION: NORWEGIAN NORTH SEA

FIELD: GULLFAKS

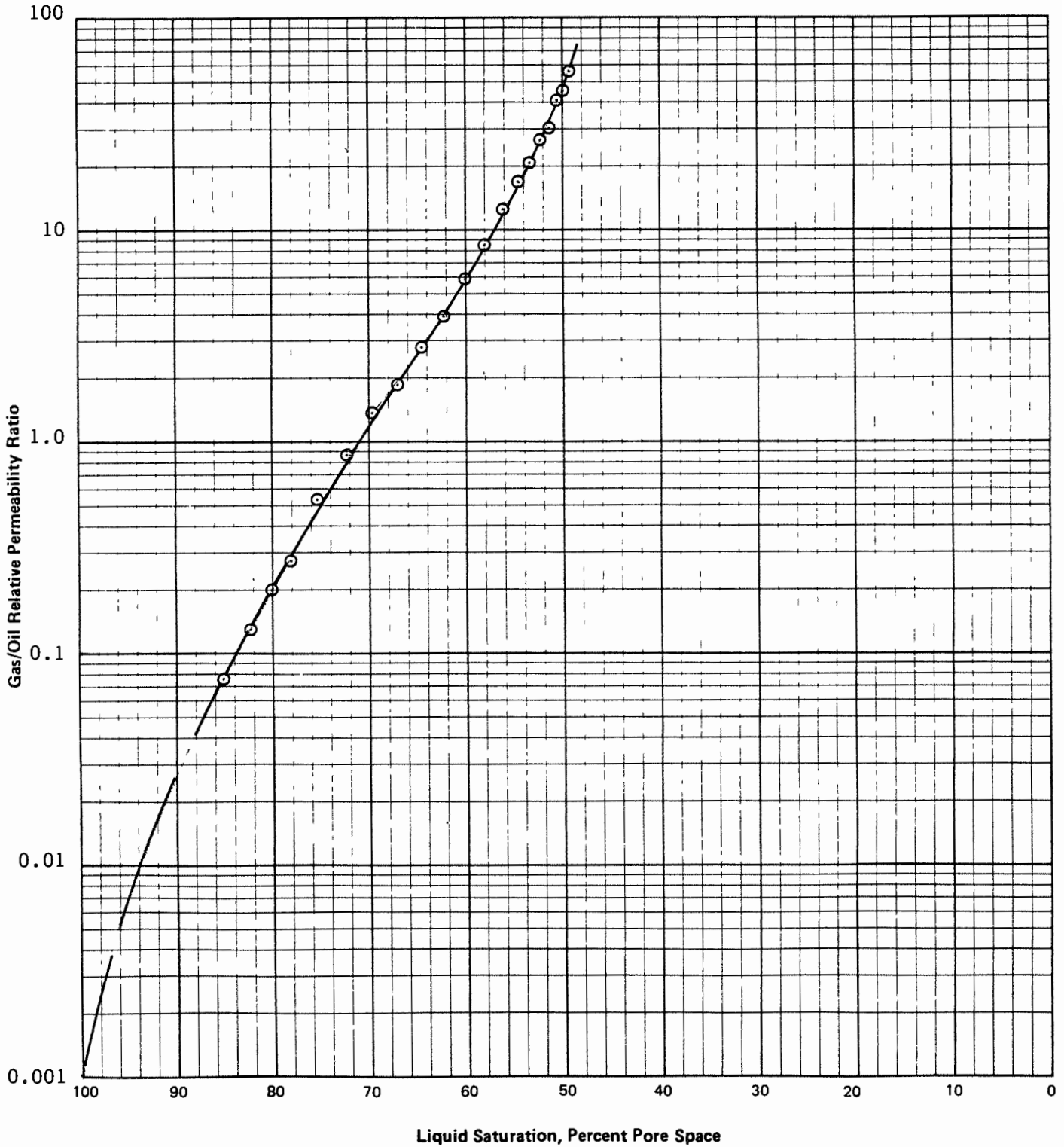
COUNTRY: NORWAY

SAMPLE NUMBER: 487-1

PERMEABILITY_{md}: 419 (Ko at SWIr)

SAMPLE DEPTH: 3359.15 m

GAS-OIL RELATIVE PERMEABILITY
Unsteady-State, Restored-State, Increasing Gas Saturation



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COMPANY: STATOIL

FORMATION: ZONE 2

WELL: 34/10-16

LOCATION: NORWEGIAN NORTH SEA

FIELD: GULLFAKS

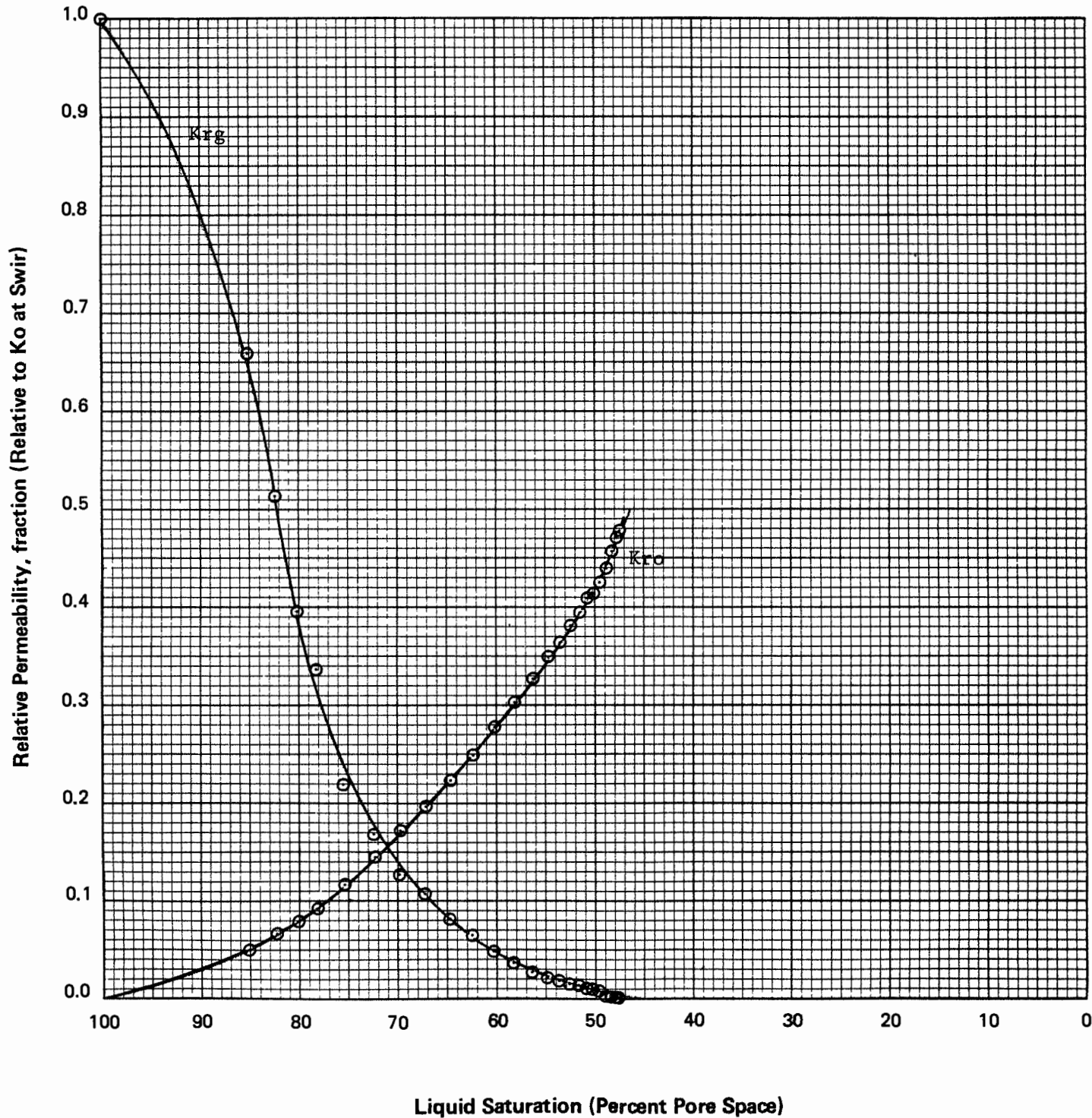
COUNTRY: NORWAY

SAMPLE No.: 487.1

PERMEABILITY md: 419 (Ko at Swir)

SAMPLE DEPTH: 3359.15 m

GAS - OIL RELATIVE PERMEABILITY
 Unsteady State, Restored State, Increasing Gas Saturation



COMPANY: STATOIL

FORMATION: ZONE 3

WELL: 34/10-16

LOCATION: NORWEGIAN NORTH SEA

FIELD: GULLFAKS

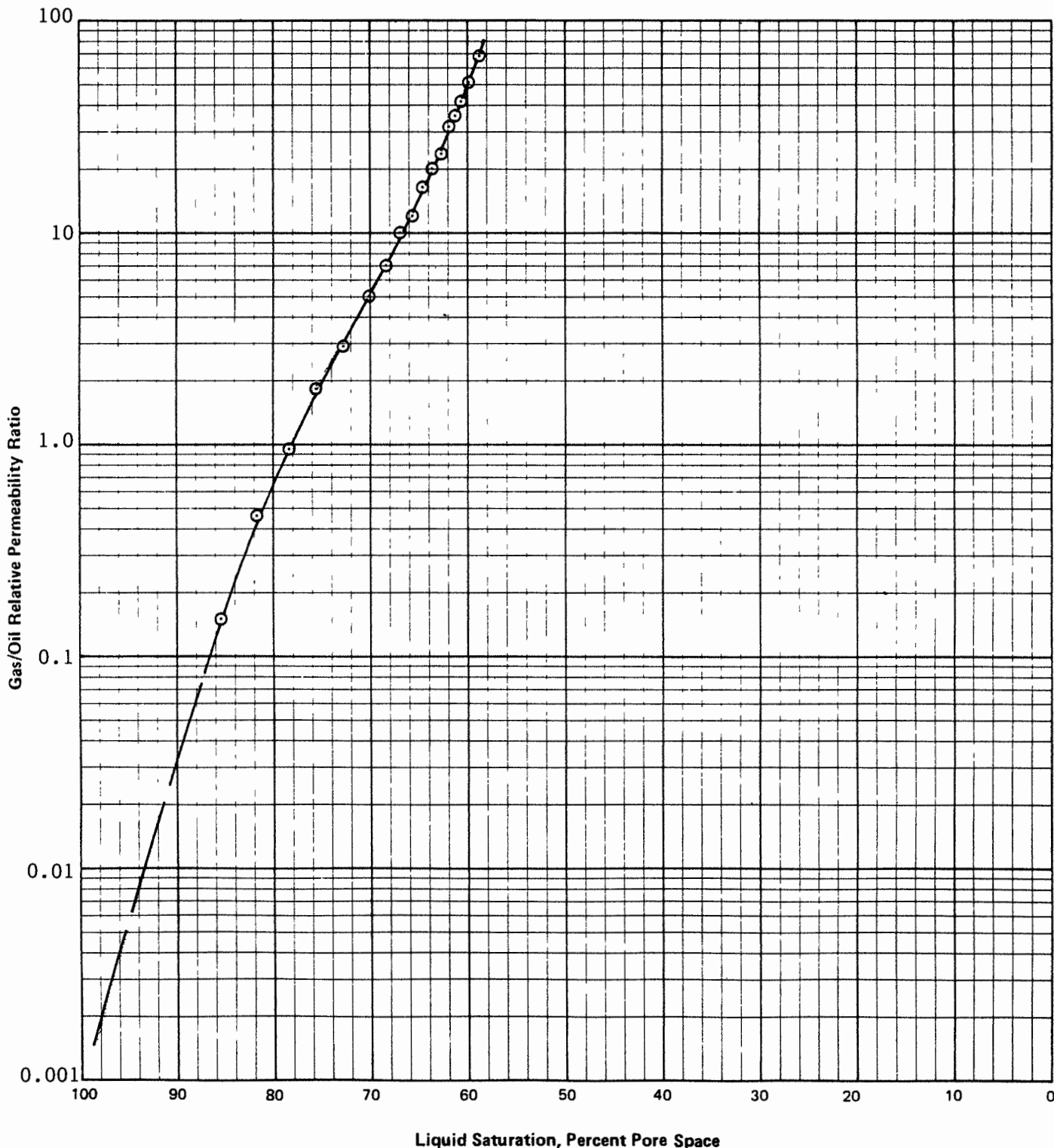
COUNTRY: NORWAY

SAMPLE NUMBER: 586.1

PERMEABILITY_{md}: 19 (K_o at SW_{ir})

SAMPLE DEPTH: 3396.00 m

GAS-OIL RELATIVE PERMEABILITY
Unsteady-State, Restored-State, Increasing Gas Saturation



COMPANY: STATOIL

FORMATION: ZONE 3.

WELL: 34/10-16

LOCATION: NORWEGIAN NORTH SEA.

FIELD: GULLFAKS

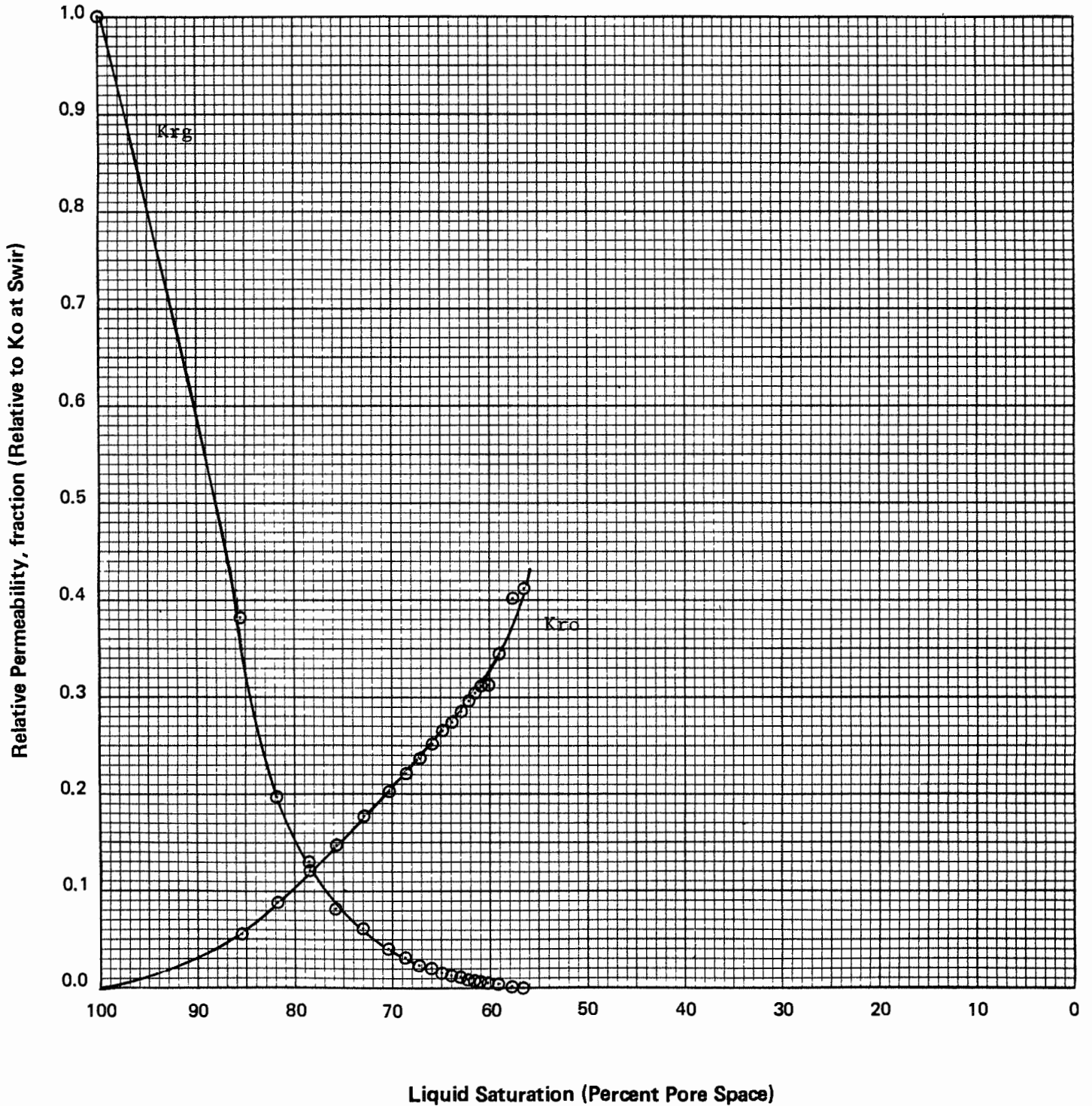
COUNTRY: NORWAY.

SAMPLE No.: 586-1

PERMEABILITY md: 19 (Ko. at SWIr).

SAMPLE DEPTH: 3396.00 m

GAS – OIL RELATIVE PERMEABILITY
 Unsteady State, Restored State, Increasing Gas Saturation



COMPANY: STATOIL

FORMATION: ZONE 3

WELL: . . . 34/10-16

LOCATION: NORWEGIAN NORTH SEA

FIELD: GULLFAKS

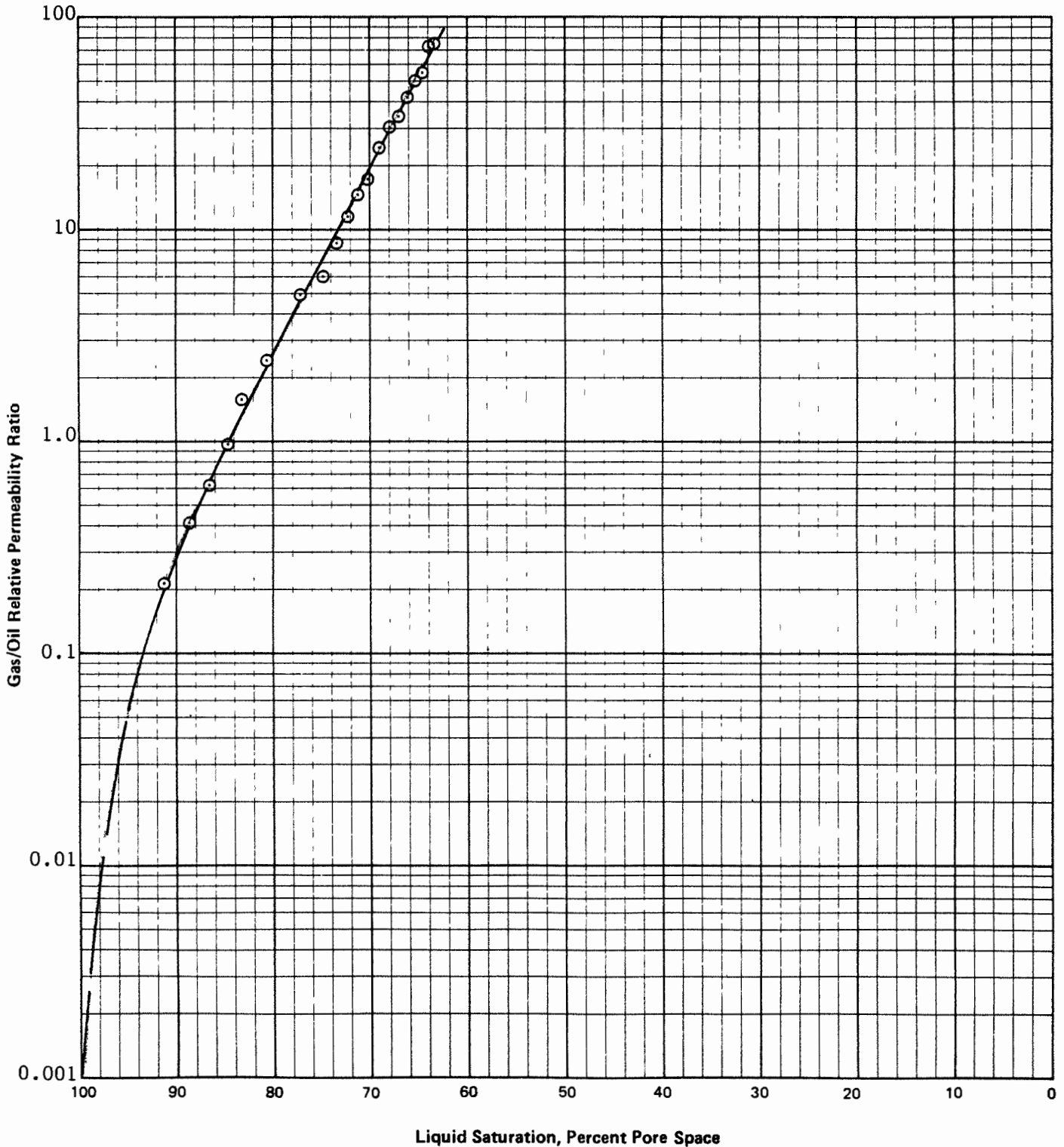
COUNTRY: NORWAY

SAMPLE NUMBER: 604-1

PERMEABILITY_{md}: 4.1 (K_o at SW_{ir})

SAMPLE DEPTH: 3401.65 m

GAS-OIL RELATIVE PERMEABILITY
Unsteady-State, Restored-State, Increasing Gas Saturation



COMPANY: STATOIL

FORMATION: ZONE 3

WELL: 34/10-16

LOCATION: NORWEGIAN NORTH SEA

FIELD: GULLFAKS

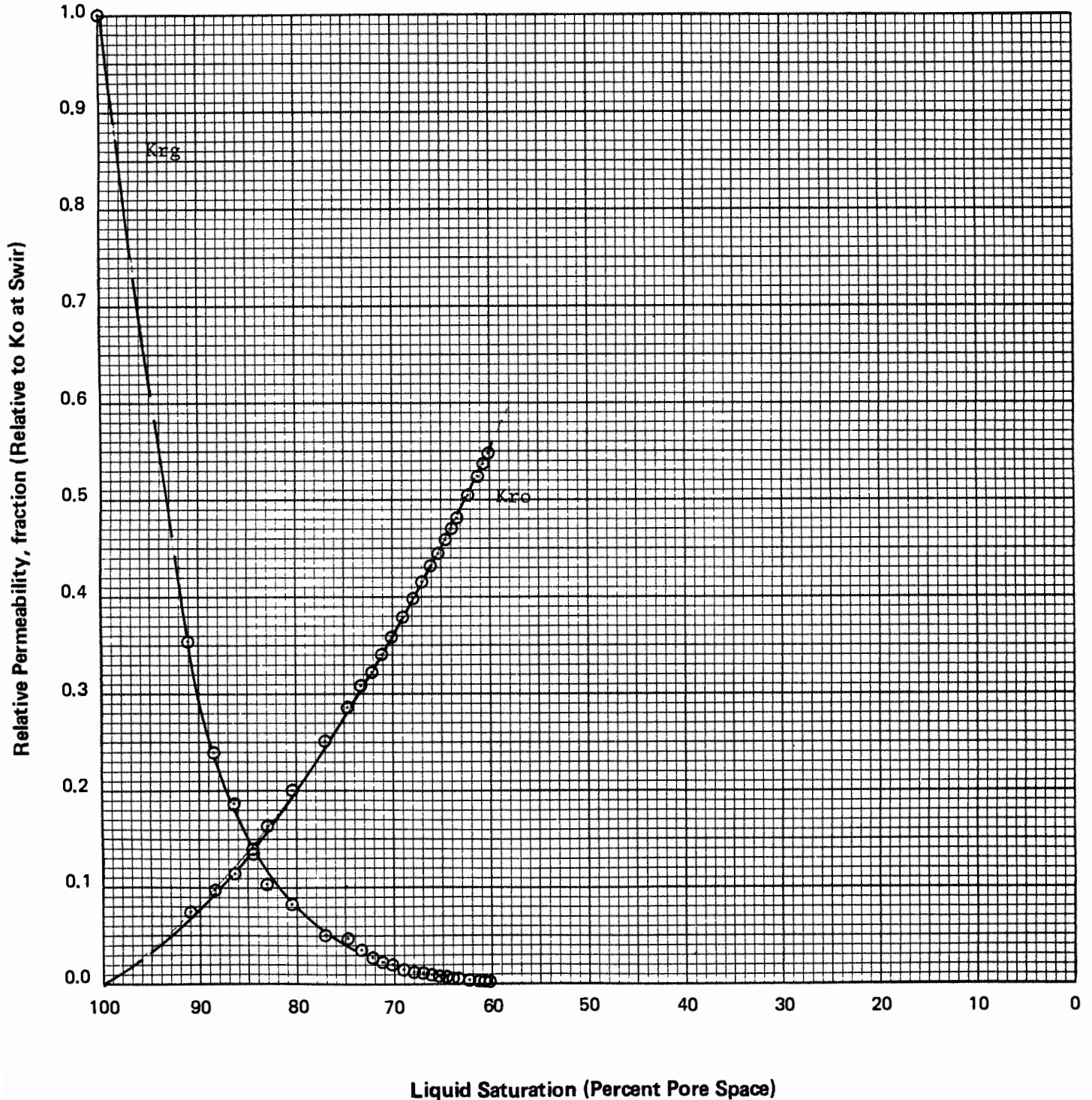
COUNTRY: NORWAY

SAMPLE No.: 604.1

PERMEABILITY md: 4.1 (Ko at Swir)

SAMPLE DEPTH: 3401.65 m

GAS - OIL RELATIVE PERMEABILITY
 Unsteady State, Restored State, Increasing Gas Saturation



COMPANY: STATOIL

FORMATION: ZONE 3

WELL: 34/10-16

LOCATION: NORWEGIAN NORTH SEA

FIELD: GULLFAKS

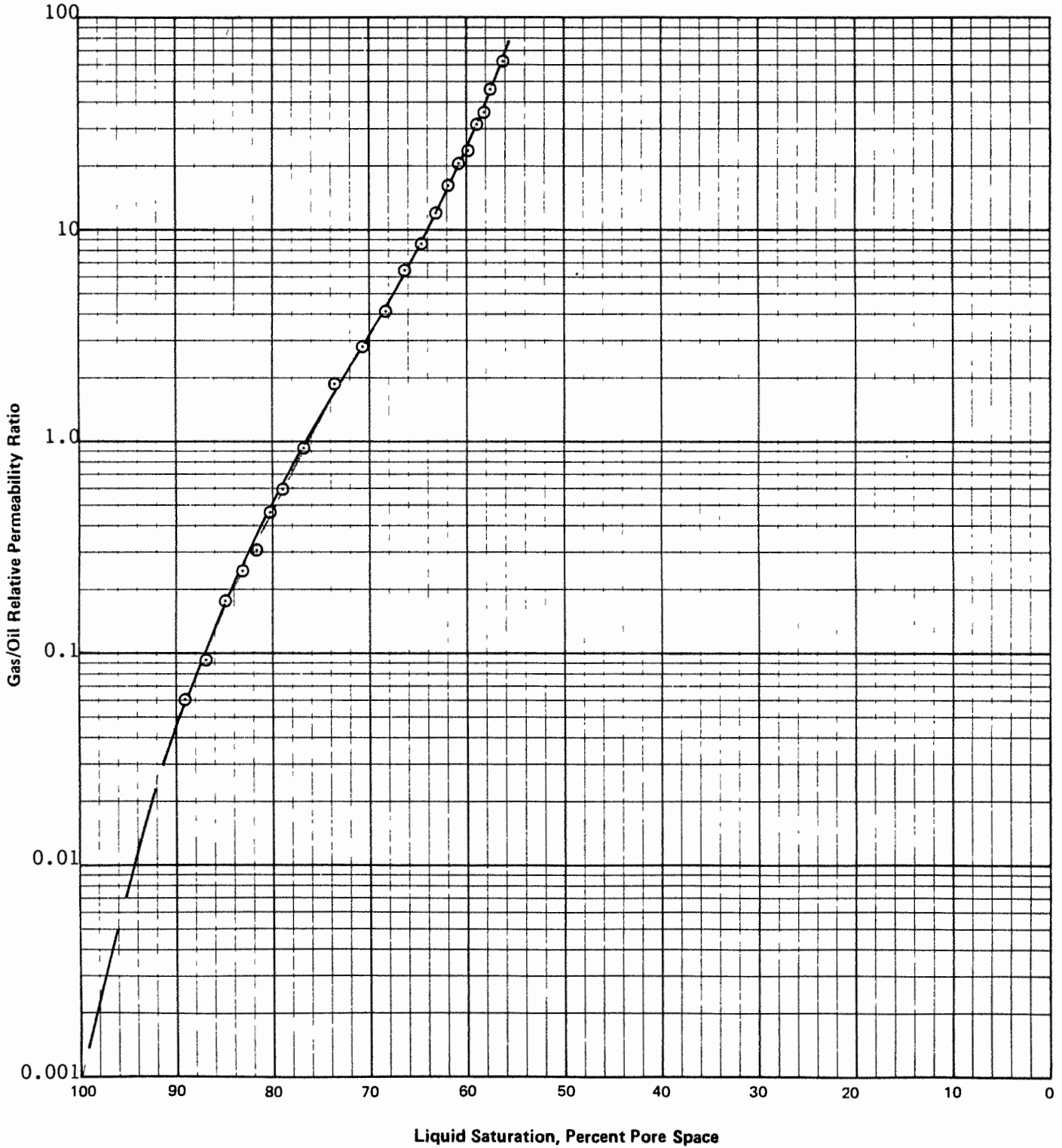
COUNTRY: NORWAY

SAMPLE NUMBER: 623.1

PERMEABILITY_{md}: 119 (K_o at SW_{ir})

SAMPLE DEPTH: 3407.50 m

GAS-OIL RELATIVE PERMEABILITY
Unsteady-State, Restored-State, Increasing Gas Saturation



COMPANY: STATOIL

FORMATION: ZONE 3

WELL: 34/10-1.6

LOCATION: NORWEGIAN NORTH SEA

FIELD: GULLFAKS

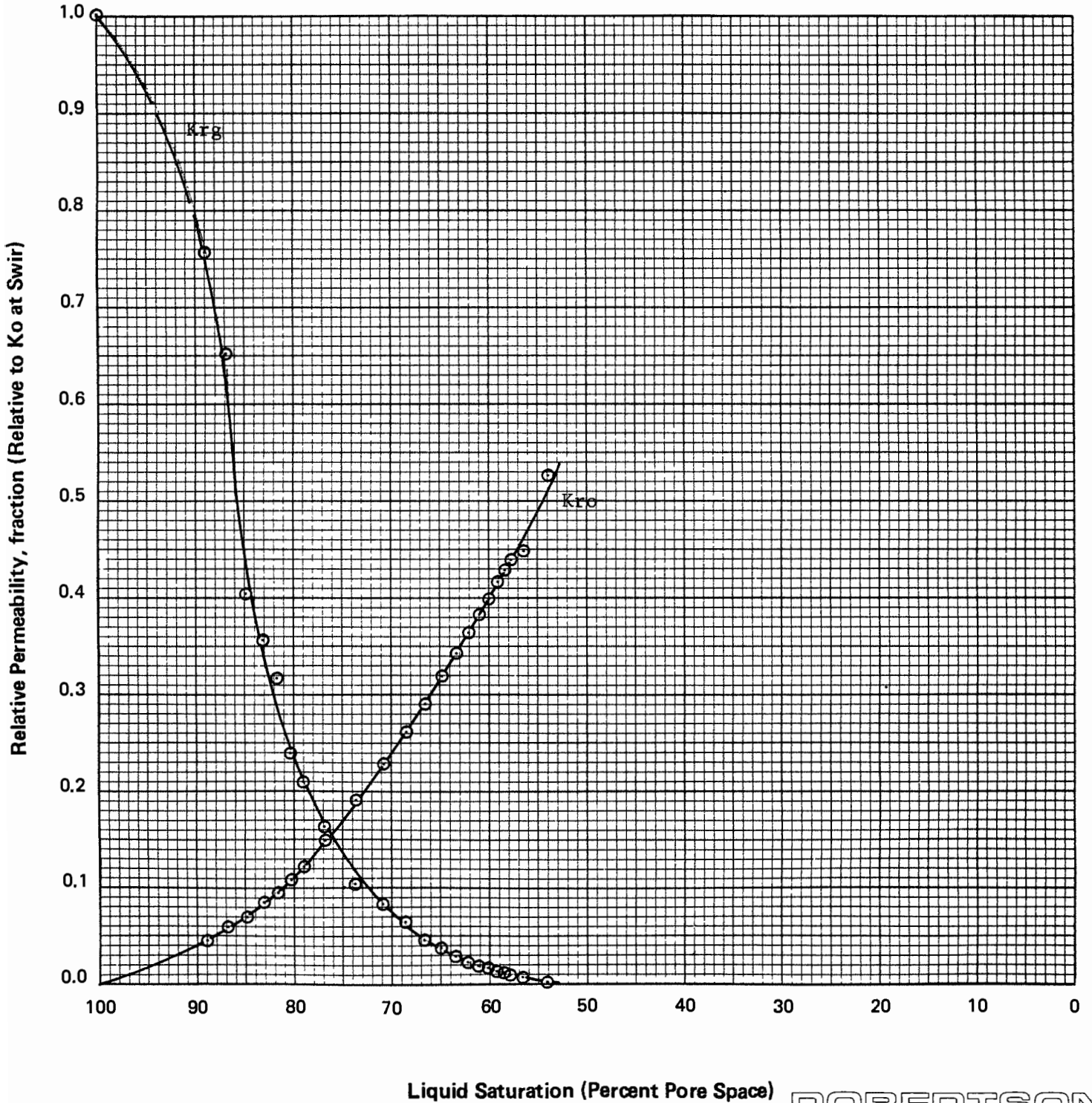
COUNTRY: NORWAY

SAMPLE No.: 623-1

PERMEABILITY md: 119 (Ko at Swir)

SAMPLE DEPTH: 3407.50 m

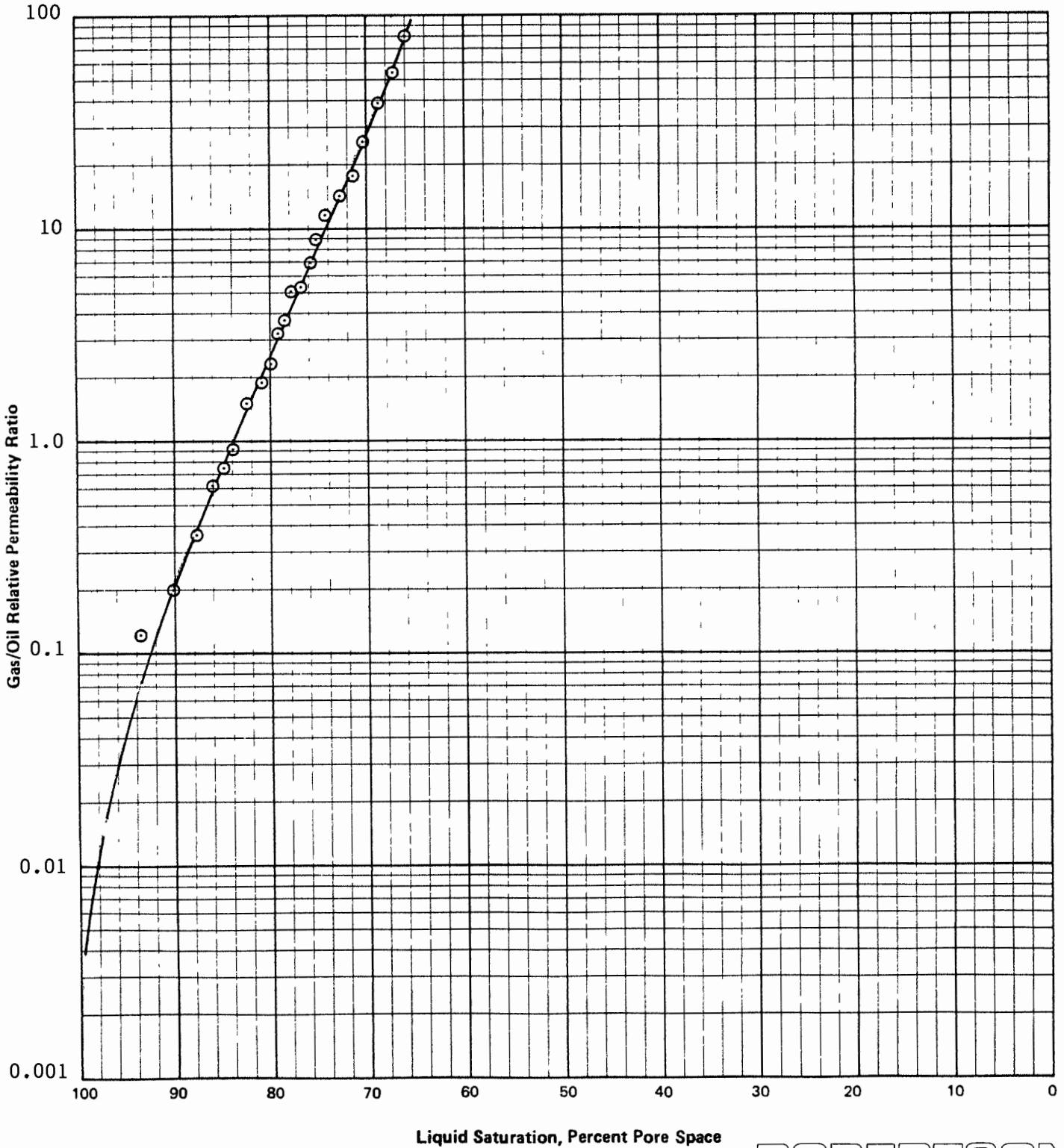
GAS - OIL RELATIVE PERMEABILITY Unsteady State, Restored State, Increasing Gas Saturation



COMPANY: STATOIL
WELL: 34/10-16
FIELD: GULLFAKS
SAMPLE NUMBER: 657.1

FORMATION: ZONE 4
LOCATION: NORWEGIAN NORTH SEA
COUNTRY: NORWAY
PERMEABILITY_{md}: 0.68 (K_o at SWir)
SAMPLE DEPTH: 3419.10 m

GAS-OIL RELATIVE PERMEABILITY
Unsteady-State, Restored-State, Increasing Gas Saturation

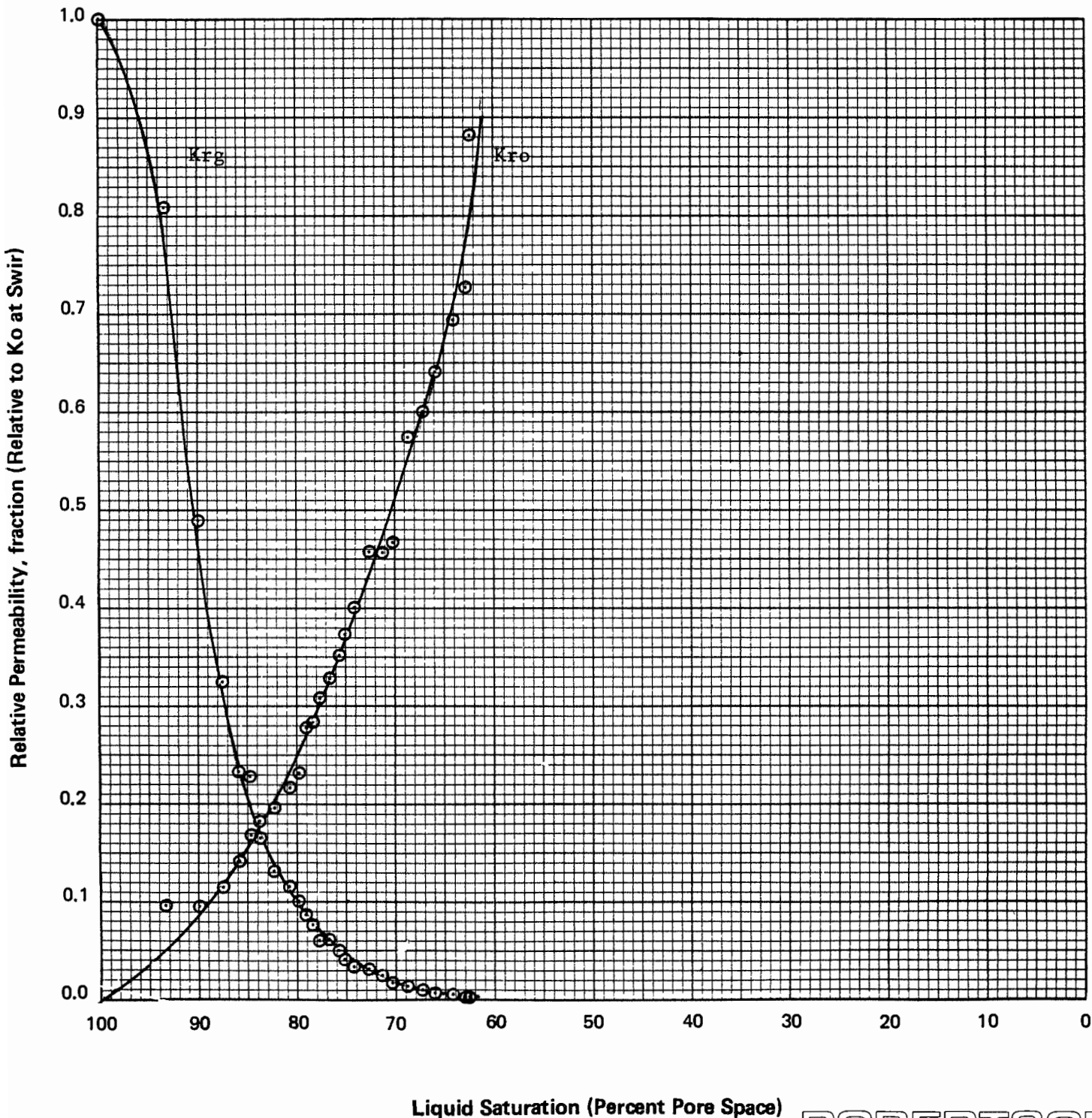


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COMPANY: STATOIL
 WELL: 34/10-16
 FIELD: GULLFAKS
 SAMPLE No.: 657.1

FORMATION: ZONE 4
 LOCATION: NORWEGIAN NORTH SEA
 COUNTRY: NORWAY
 PERMEABILITY md: 0.68 (Ko at Swir)
 SAMPLE DEPTH: 3419.10 m

GAS - OIL RELATIVE PERMEABILITY
 Unsteady State, Restored State, Increasing Gas Saturation



COMPANY: STATOIL

FORMATION: ZONE 4

WELL: 34/10-16

LOCATION: NORWEGIAN NORTH SEA

FIELD: GULLFAKS

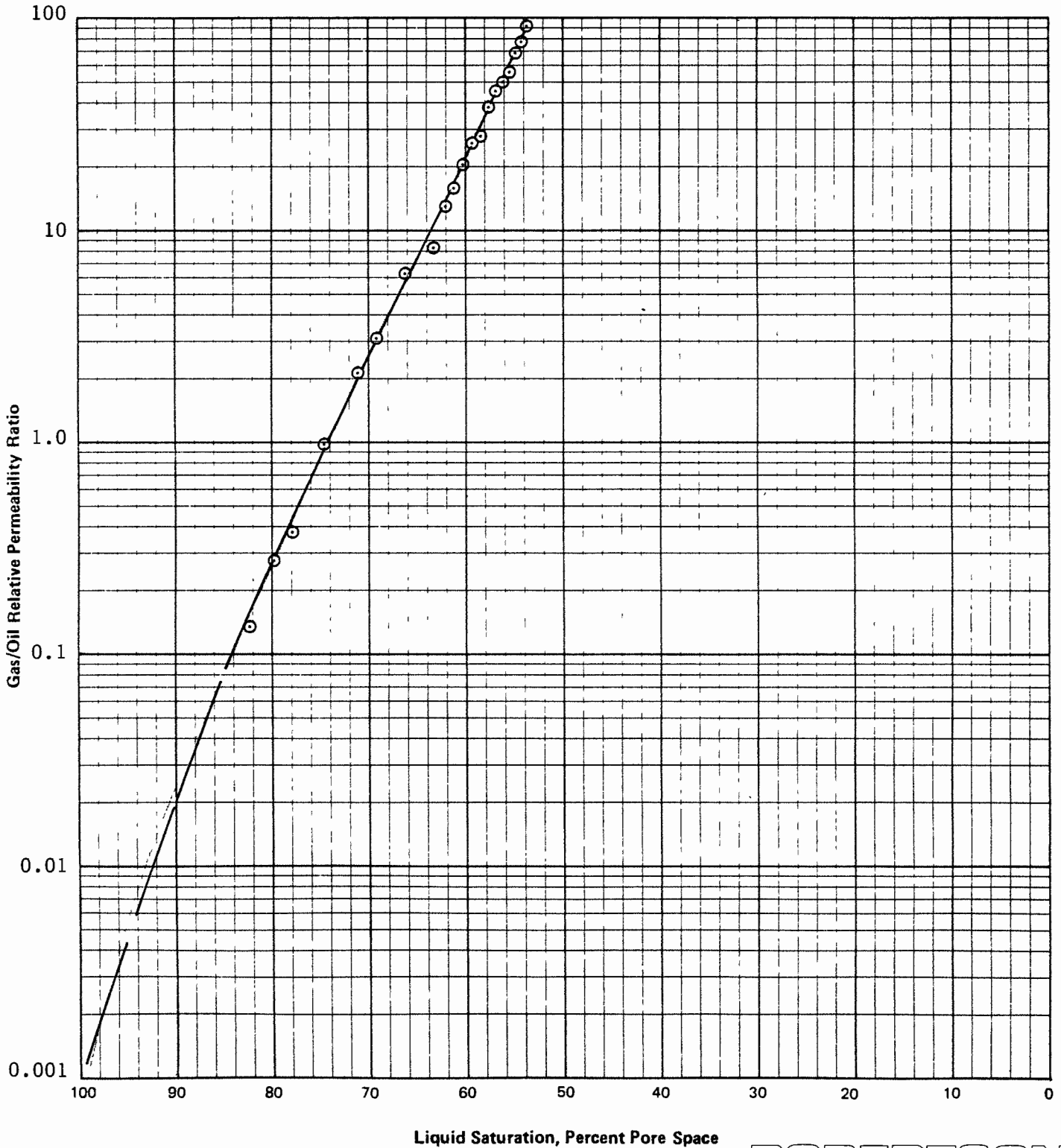
COUNTRY: NORWAY

SAMPLE NUMBER: 666.1

PERMEABILITY_{md}: 13.3 (K_o at SWIr)

SAMPLE DEPTH: 3422.10 m

GAS-OIL RELATIVE PERMEABILITY
Unsteady-State, Restored-State, Increasing Gas Saturation

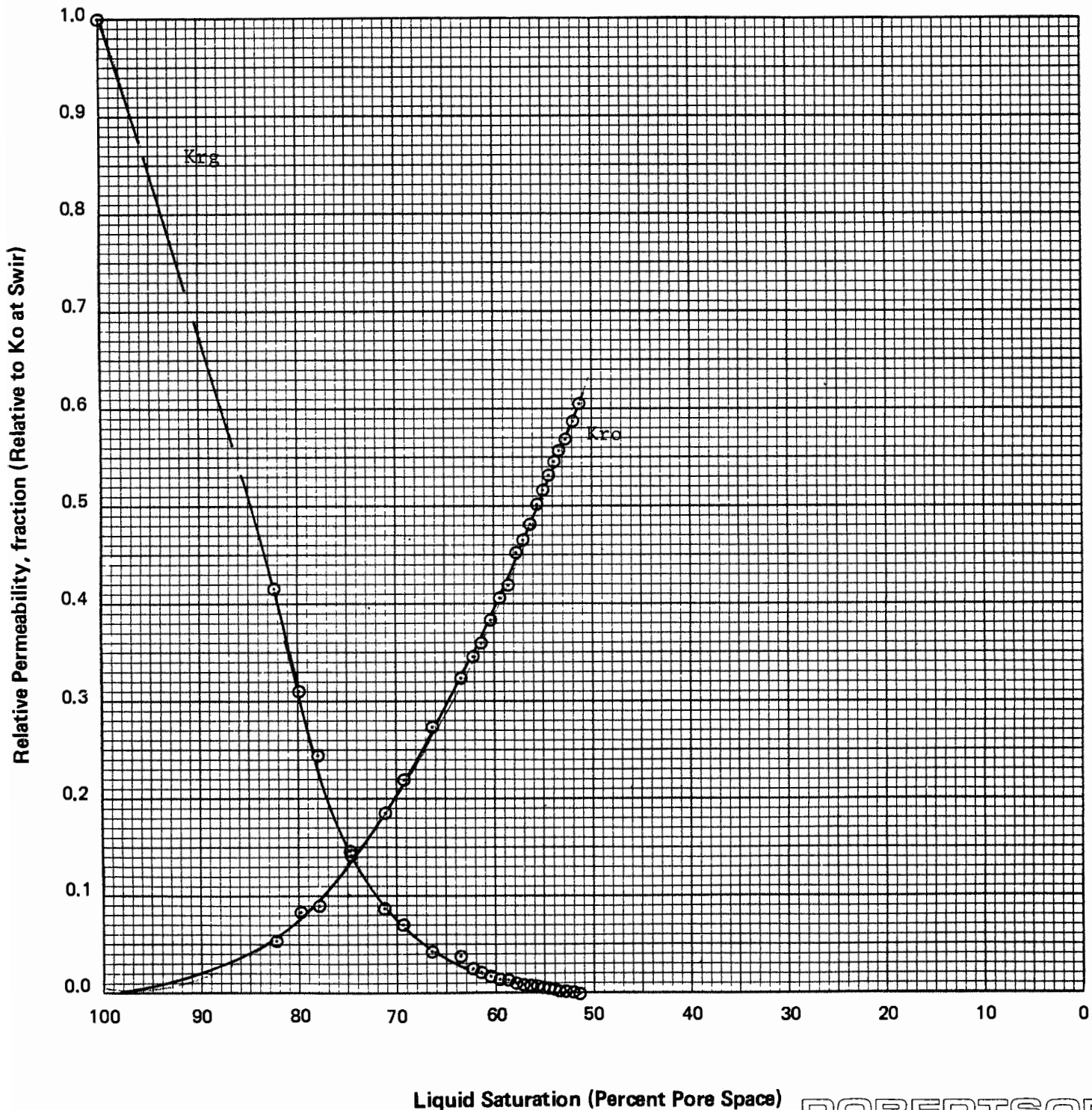


ROBERTSON
RESEARCH

COMPANY: STATOIL
 WELL: 34/10-16
 FIELD: GULLFAKS
 SAMPLE No.: 666.1

FORMATION: ZONE 4
 LOCATION: NORWEGIAN NORTH SEA
 COUNTRY: NORWAY
 PERMEABILITY md: 13.3 (Ko at Swir)
 SAMPLE DEPTH: 3422.10 m

GAS – OIL RELATIVE PERMEABILITY
 Unsteady State, Restored State, Increasing Gas Saturation



APPENDIX I

SAMPLE DIMENSIONS

SAMPLE NUMBER	DEPTH (metres)	FORMATION	LENGTH (cm)	AREA (cm ²)
7.1	3171.85	ZONE 1	6.954	10.956
57.1	3190.00	ZONE 1	6.860	10.986
81.1	3200.00	ZONE 1	6.902	10.986
93.1	3204.15	ZONE 1	6.356	10.986
135.1	3219.00	ZONE 2	6.840	10.986
316.1	3284.25	ZONE 2	6.868	11.104
408.1	3325.15	ZONE 2	6.720	10.810
471.1	3347.50	ZONE 2	6.618	10.706
487.1	3359.15	ZONE 2	6.724	10.810
586.1	3396.00	ZONE 3	6.936	10.810
604.1	3401.65	ZONE 3	6.888	10.781
623.1	3407.50	ZONE 3	6.700	10.810
657.1	3419.10	ZONE 4	6.796	10.810
666.1	3422.10	ZONE 4	6.836	10.781
700.1	3433.70	ZONE 4	6.886	10.810

APPENDIX II

COMPOSITION AND SPECIFICATIONS OF THE FLUIDS USED DURING TESTING

SIMULATED FORMATION BRINE

<u>Salt</u>	<u>g/l</u>
Na Cl	39.4
K Cl	0.72
Ca Cl ₂ .6H ₂ O	600
Mg Cl ₂ .6H ₂ O	0.92
Sr Cl ₂ .6H ₂ O	0.7

Viscosity at 20°C = 1.0896 cP

Density at 20°C = 1.029 g/c.c.

DEPOLARIZED KEROSENE

Viscosity at 20°C = 1.92 cP

Density at 20°C = 0.7882 g/c.c.

APPENDIX III

ABBREVIATIONS

Ka	Air Permeability
Kg	Gas Permeability
Kl	Klinkenberg Permeability
Krg	Gas Permeability relative to $Kg(SW_{ir})$
Kro	Oil Permeability relative to $Kg(SW_{ir})$
Kw	Brine Permeability
Krw	Brine Permeability relative to $Ko(SW_{ir})$
Ko	Oil Permeability
Kw/Ko	Water-Oil, Relative Permeability
Kg/Ko	Gas-Oil, Relative Permeability
mD	Millidarcies
SW_{ir}	Irreducible Brine Saturation
Sgr	Residual Gas Saturation
Sor	Residual Oil Saturation
L.R.	Low Rate
H.R.	High Rate
g	Grams
c.c.	Cubic centimetres
cm	Centimetres
cP	Centipoise
hr	Hour
Res Gas	Residual Gas determination