

CORE LABORATORIES UK LTD.

Petroleum Reservoir Engineering

ABERDEEN, SCOTLAND

No 41

Reservoir Fluid Study

for

STATOIL

Well: 15/9 - 1

North Sea-Norway.

CORE LABORATORIES UK LTD.

Petroleum Reservoir Engineering

ABERDEEN, SCOTLAND

May 31st 1978.

Statoil,
Largardsveien 78,
P.O. Box 300,
4001, Stavanger,
Norway.

Attention: Mr. Per Thomassan.

Subject: Reservoir Fluid Study.
Well: 15/9 - 1
North Sea,
Norway
Our File Number: RFLA-77017

Gentlemen:

As indicated in our preliminary report, dated March 17th 1978, this final report has been issued for the purpose of completing the reservoir fluid study on the samples collected from the subject well.

After correcting the field separator gas rate for the factors shown on page one, the producing gas-liquid ratio was calculated to be 28112 cubic feet of separator gas at 14.73 psia and 60°F. per barrel of separator condensate at 542 psig and 80°F. The separator products were physically recombined in this gas-liquid ratio, and the resulting fluid was used for the entire study. The hydrocarbon composition of the producing well stream material was calculated on the basis of the producing gas-liquid ratio, and is presented on page two, along with the measured hydrocarbon compositions of the separator product.

The recombined reservoir fluid was initially subjected to constant composition expansion at the reported reservoir temperature of 241°F. During this expansion, a retrograde dew point was observed at 5789 psig. The results of the pressure-volume measurements are tabulated on page three, along with the deviation factor measurements at the dew point pressure and above.

To simulate well stream production below the dew point, a "step-wise equilibrium depletion" was performed on the reservoir fluid. This consisted of a series of expansions and constant pressure displacements terminating at the original reservoir volume. Each displaced well stream was charged to low temperature fractional distillation equipment for hydrocarbon analysis and volume measurements. The results of the constant volume depletion may be found on page four.

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Page Two.

Well: 15/9 - 1

The produced well stream volumes and their corresponding smooth compositions were used to calculate the cumulative stock tank liquid and sales gas recovery using normal temperature separation. Also calculated are the plant liquid products in the primary stage separator gas. The total plant products in the well stream are also shown on this page. All recoveries are based on one MMSCF of original reservoir fluid, and the results may be found on page five. It must be remembered in applying these data that the recoveries are based on 100 percent plant efficiency.

Gas viscosity calculations were performed to define the viscosity of the well stream over the full range of operating pressures at 241°F. These calculations were performed using the smooth well stream composition, and the correlation of Carr, Kobayashi and Burrows.

The volume of retrograde condensation was determined visually during the constant volume depletion. The results of these liquid volume measurements are tabulated on page seven.

Due to the small volume of the zero psig residual liquid, our high temperature distillation procedures are unable to recover sufficient volumes of the hydrocarbon fractions, in order that we could experimentally determine specific gravities and mol weights of the fractions. Consequently, the compositional analysis presented on page eight was determined using high temperature gas chromatography.

It was a pleasure to perform this study for you. If you have any questions concerning the data please do not hesitate to contact us.

Very truly yours

Core Laboratories U.K. Limited
Reservoir Fluid Analysis



JDO/rmb:
15cc/Addressee:

John D. Owen
Supervising Engineer.

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CompanySTATOIL..... Date Sampled23rd May, 1977.....
 Well15/9 - 1..... CountyNORTH SEA.....
 Field StateNORWAY.....

FORMATION CHARACTERISTICS

Formation NameJURASSIC.....
 Date First Well Completed 19.....
 Original Reservoir PressurePSIG @Ft.
 Original Produced Gas-Liquid RatioSCF/Bbl
 Production RateBbls/Day
 Separator Pressure and TemperaturePSIG°F.
 Liquid Gravity at 60°F. ° API
 Datum Ft. Subsea

WELL CHARACTERISTICS

Elevation Ft.
 Total Depth Ft.
 Producing Interval 11,817 - 11,834 Ft.
 Tubing Size and Depth 3½ In. to 3733 Ft.
 Open Flow Potential MMSCF/Day
 Last Reservoir Pressure 6400 PSIG @ Ft.
 Date 19.....
 Reservoir Temperature 241 * ° F. @ Ft.
 Status of Well
 Pressure Gauge

SAMPLING CONDITIONS

Flowing Tubing Pressure PSIG
 Flowing Bottom Hole Pressure 4540 PSIG
 Primary Separator Pressure 542 PSIG
 Primary Separator Temperature 80 ° F.
 Secondary Separator Pressure PSIG
 Secondary Separator Temperature ° F.
 Field Stock Tank Liquid Gravity ° API @ 60° F.
 Primary Separator Gas Production Rate 25751 MSCF/Day
 Pressure Base 14.73 PSIA
 Temperature Base 60 ° F.
 Compressibility Factor (F) 1.055
 Gas Gravity (Laboratory)^{PV} 0.704
 Gas Gravity Factor (F) 1.1918

Primary.....Liquid Production Rate @ 80° F. 916 Bbls/Day
 Primary Separator Gas/.....Primary.....Liquid Ratio 28112 SCF/Bbl
 or Bbls/MMSCF

Core Laboratories, Inc., Engineer

REMARKS : * Analysis temperature.

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Well15/9...-1.....

Hydrocarbon Analyses of Separator Products and Calculated Well Stream

<u>Component</u>	<u>Separator Liquid</u> Mol Per Cent *	<u>Separator Gas +</u> Mol Per Cent GPM		<u>Well Stream</u> Mol Per Cent	<u>GPM</u>
Hydrogen Sulfide	NIL	NIL		NIL ^{H₂S}	
Carbon Dioxide	1.89	4.82		4.72	
Nitrogen	0.07	0.58		0.56	
Methane	12.41	81.51		79.24	
Ethane	5.99	7.86		7.80	
Propane	7.51	3.48	0.957	3.61	0.988
iso-Butane	1.87	0.42	0.137	0.47	0.153
n-Butane	4.49	0.74	0.233	0.86	0.270
iso-Pentane	1.60	0.13	0.048	0.19	0.069
n-Pentane	4.19	0.23	0.083	0.36	0.130
Hexanes	5.58	0.12	0.049	0.30	0.122
Heptanes plus	54.40	0.11	0.050	1.89	1.090
	<hr/> 100.00	<hr/> 100.00	<hr/> 1.557	<hr/> 100.00	<hr/> 2.822

Properties of Heptanes plus

API gravity @ 60° F.40.8.....		
Specific gravity @ 60/60° F.0.8211.....	0.814.....
Molecular weight152.....103.....149.....

Calculated separator gas gravity (air=1.000)=0.704.....

Calculated gross heating value for separator gas=1119.....BTU

per cubic foot of dry gas @ 14.73 psia and 60° F.

Primary separator gas collected @542.....psig and80.....°F.

Primary separator liquid collected @542.....psig and80.....°F.

Primary separator gas/separator liquid ratio28112.....SCF/Bbl @ 80° F.

Primary separator gas/well stream ratio967.22.....MSCF/MMSCF*

* Cylinder 13266 - 46.

+ Cylinder 3792.

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Well ..15/9 - 1 DST 2

PRESSURE-VOLUME RELATIONS OF RESERVOIR FLUID AT 241°F.
 (CONSTANT COMPOSITION EXPANSION)

PRESSURE PSIG		RELATIVE VOLUME	DEVIATION FACTOR 2
6400	Reservoir Pressure	0.9442	1.104
6300		0.9524	1.096
6200		0.9623	1.090
6100		0.9714	1.083
5900		0.9892	1.067
5789	Dew Point Pressure	1.0000	1.058 *
5700		1.0087	
5501		1.0297	
5303		1.0528	
5000		1.0924	
4600		1.1546	
4200		1.2316	
3800		1.3299	
3400		1.4580	
3000		1.6299	
2600		1.8662	
2200		2.2014	
1862		2.6124	
1400		3.5150	

* Gas formation volume factor = 1.551 MSCF/Bbl

Depletion Study at 241 °F.

Hydrocarbon Analyses of Produced Well Stream - Mol Per Cent

Component	Reservoir Pressure - PSIG									
	6400*	5789 **	4600	3600	2600	1800	1200	700	0 ***	
Carbon Dioxide	4.72	4.72	4.74	4.76	4.76	4.76	4.76	4.76	4.76	
Nitrogen	0.56	0.56	0.57	0.57	0.57	0.57	0.57	0.56	0.55	
Methane	79.24	79.24	79.53	79.92	80.27	80.50	80.14	79.45	78.40	
Ethane	7.80	7.80	7.76	7.60	7.60	7.68	7.92	8.17	8.46	
Propane	3.61	3.61	3.50	3.44	3.44	3.56	3.70	3.89	4.11	
iso-Butane	0.47	0.47	0.46	0.44	0.43	0.43	0.46	0.51	0.58	
n-Butane	0.86	0.86	0.85	0.84	0.83	0.83	0.86	0.92	0.99	
iso-Pentane	0.19	0.19	0.18	0.17	0.17	0.17	0.18	0.21	0.26	
n-Pentane	0.36	0.36	0.35	0.34	0.32	0.33	0.36	0.41	0.47	
Hexanes	0.30	0.30	0.26	0.23	0.22	0.22	0.27	0.37	0.58	
Heptanes plus	1.89	1.89	1.80	1.69	1.39	0.95	0.78	0.75	0.84	

Molecular weight of heptanes plus	149	136	126	118	111	108	107	108
Specific gravity of heptanes plus	0.814	0.803	0.793	0.784	0.777	0.773	0.772	0.773

Deviation Factor - Z

Equilibrium gas	1.058	0.974	0.919	0.892	0.900	0.920	0.948
Two-phase	1.058	0.968	0.911	0.882	0.884	0.898	0.904

Well Stream produced-
 Cumulative per cent of initial

0.000	13.064	27.642	45.950	62.588	75.328	85.585	99.295
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GPM from Smooth Compositions

Propane plus	2.836	2.645	2.485	2.279	2.083	2.091	2.232	2.506
Butanes plus	1.843	1.683	1.538	1.333	1.104	1.073	1.162	1.375
Pentanes plus	1.418	1.264	1.130	0.931	0.701	0.652	0.706	0.874

*** Composition assumed to represent the mid-point of the depletion interval (350 psig)

** Dew Point pressure

* Original Reservoir Pressure.

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Calculated Cumulative Recovery During Depletion

Cumulative Recovery per MMSCF of Original Fluid	Initial in Place	Reservoir Pressure—PSIG						
		5789*	4600	3600	2600	1800	1200	700
<u>Well Stream—MSCF</u>	1000	0	130.64	276.42	459.50	625.88	753.28	855.85
<u>Normal Temperature Separation**</u>								
Stock tank liquid—barrels @ 60°F.	29.50	0	3.40	6.81	10.10	12.05	13.31	14.37
Primary separator gas—MSCF	962.77	0	126.11	267.23	445.50	608.84	734.19	834.96
Stock tank gas—MSCF	13.72	0	1.65	3.34	5.09	6.23	7.02	7.75
<u>Total "Plant Products" in Primary Separator Gas-Gallons***</u>								
Propane	899	0	115	241	403	557	682	786
Butanes (total)	335	0	44	92	154	213	261	303
Pentanes plus	206	0	26	56	94	132	164	194
<u>Total "Plant Products" in Well Stream-Gallons ***</u>								
Propane	993	0	126	264	437	600	730	839
Butanes (total)	425	0	55	114	188	255	308	355
Pentanes plus	1418	0	165	330	500	677	700	772

* Dew point pressure

** Recovery Basis: Primary separation at 542 psig and 80°F.
 Stock tank at 0 psig and 60°F.

*** Recovery assumes 100 per cent plant efficiency.

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Calculated Gas Viscosity at 241°F.

<u>Pressure</u> <u>PSIG</u>	<u>Viscosity</u> <u>Centipoise *</u>
6400	0.0312
6300	0.0309
6200	0.0306
6100	0.0303
5900	0.0297
5789 Dew Point Pressure	0.0293
4600	0.0253
3600	0.0219
2600	0.0183
1800	0.0163
1200	0.0148
700	0.0137
350	0.0134

Calculated using the correlation of Carr, Kobayashi and Burrows. AIME Transactions, 1954, Vol.201, p.264.

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Retrograde Condensation During Gas Depletion at 241 °F.

<u>Pressure</u> <u>PSIG</u>		<u>Retrograde Liquid Volume</u> <u>Per Cent of Hydrocarbon Pore Space</u>
<u>5789</u>	Dew Point Pressure	0.0
5501		0.1
5303		0.2
5000		0.3
<u>4600</u>	First Depletion Level	0.6
3600		1.4
2600		2.1
1800		2.4
1200		2.5
700		2.4
0		2.0

Properties of Zero PSIG Residual Liquid

Gravity : ..35.0.....°API @ 60° F.
 Density :0.8442.....gms/cc @ 60°F.
 Molecular weight : ..194.....

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Well 15/9 - 1

Compositional Analysis of Zero Psig Residual Liquid Sample

<u>Component</u>	<u>Mol Percent</u>	<u>Weight Percent</u>
Pentanes and Lighter	1.35	0.45
Hexane	1.11	0.49
Heptanes	1.58	0.81
Octanes	3.38	1.97
Nonanes	2.93	1.92
Decanes	6.12	4.44
Undecanes	6.41	5.11
Dodecanes	5.85	5.08
Tridecanes	6.39	6.02
Tetradecanes	6.04	6.11
Pentadecanes	6.96	7.55
Hexadecanes	4.99	5.77
Heptadecanes	5.28	6.50
Octadecanes	4.05	5.27
Nonadecanes	3.15	4.33
Eicosanes	2.56	3.72
Heneicosanes	2.66	4.05
Docosanes	2.09	3.33
Tricosanes	1.70	2.83
Tetracosanes	1.39	2.39
Pentacosanes	1.47	2.66
Hexacosanes	1.08	2.03
Heptacosanes	1.00	1.94
Octacosanes	0.92	1.86
Nonacosanes	0.80	1.69
Triacotanes plus	1.27	2.80
<u>Aromatics</u>		
Benzene	0.86	0.34
Toluene	3.71	1.75
Ethyl Benzene	0.57	0.31
m + p Xylene	4.61	2.50
o-Xylene	1.52	0.83
1,2,4, Trimethylbenzene	1.62	1.00
<u>Napthenes</u>		
Methylcyclopentane	0.49	0.21
Cyclohexane	1.43	0.61
Methylcyclohexane	2.66	1.33

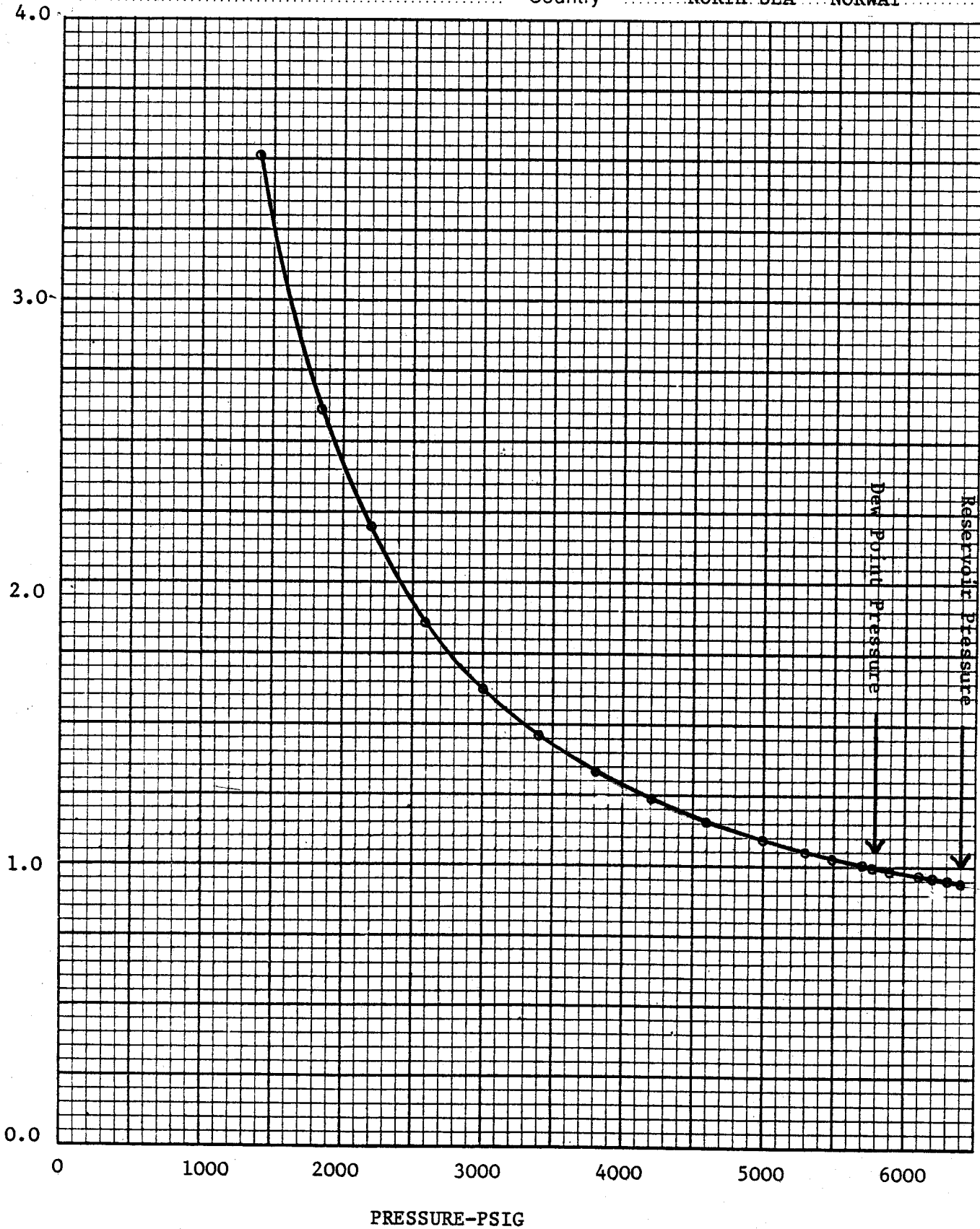
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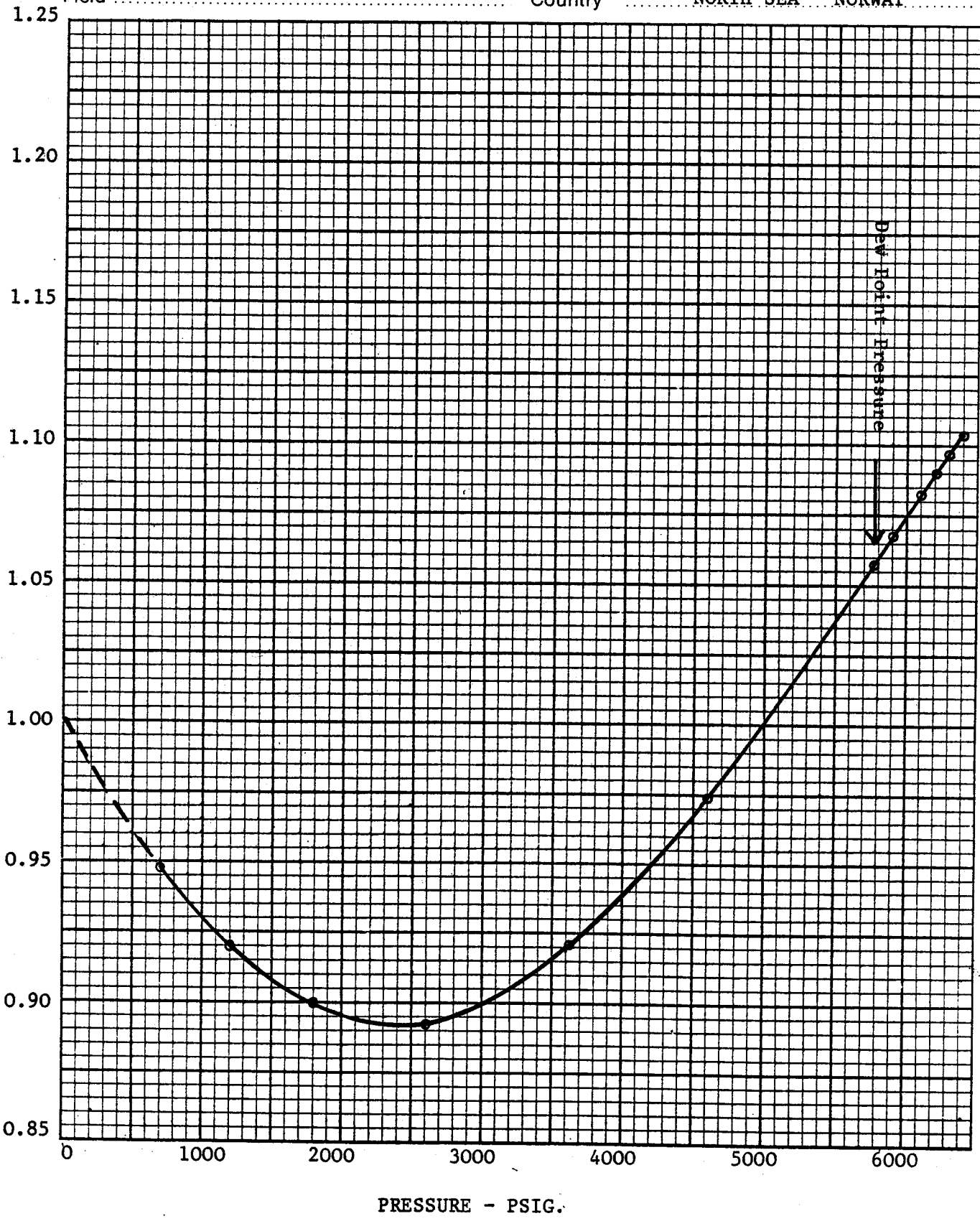
PRESSURE-VOLUME RELATIONS OF RESERVOIR FLUID

Company STATOIL
Well 15/9 - 1
Field
Formation
Province
Country NORTH SEA - NORWAY



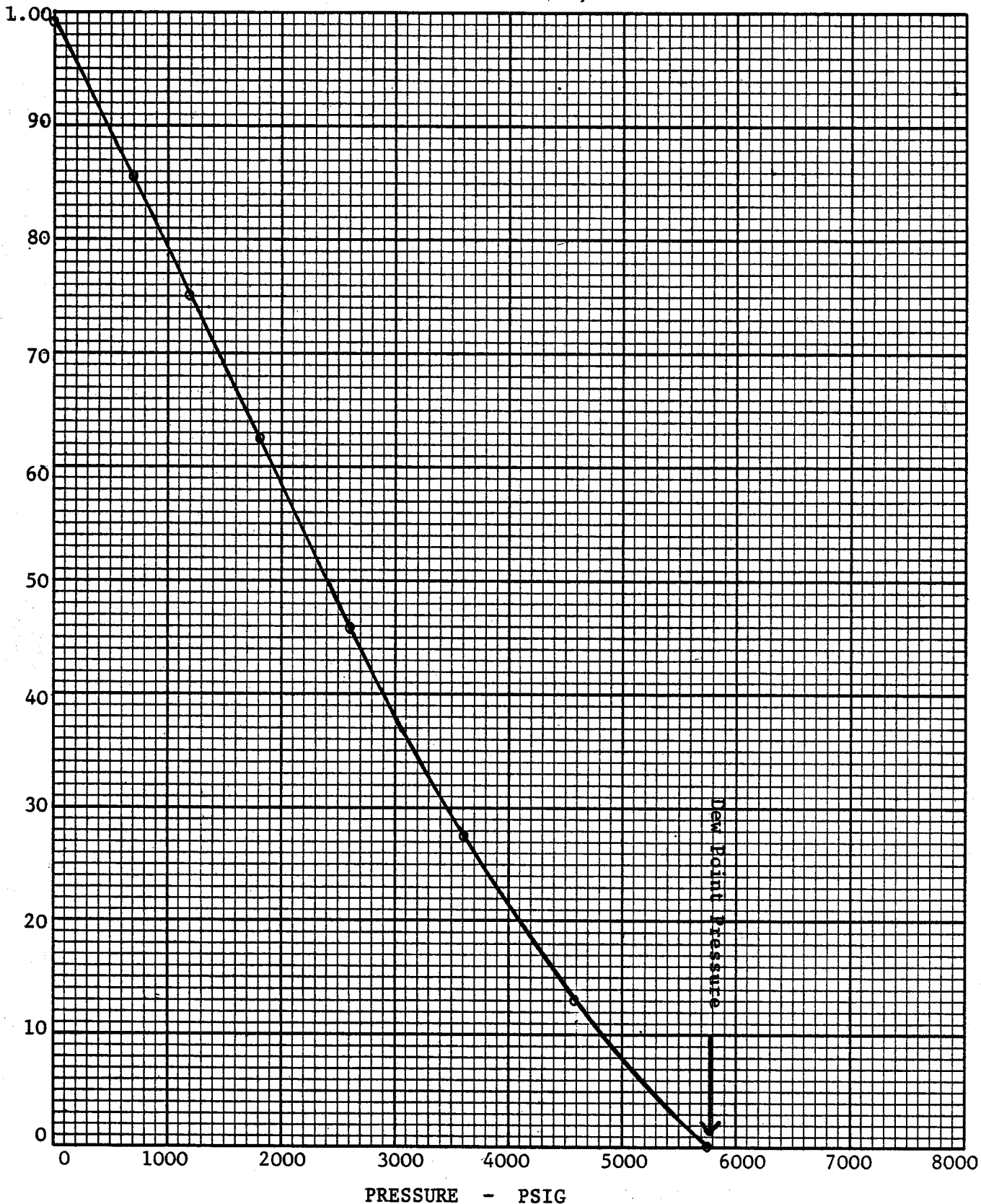
DEVIATION FACTOR Z OF WELL STREAM DURING DEPLETION

Company STATOIL
Well 15/9 - 1
Field
Formation
Province
Country NORTH SEA - NORWAY



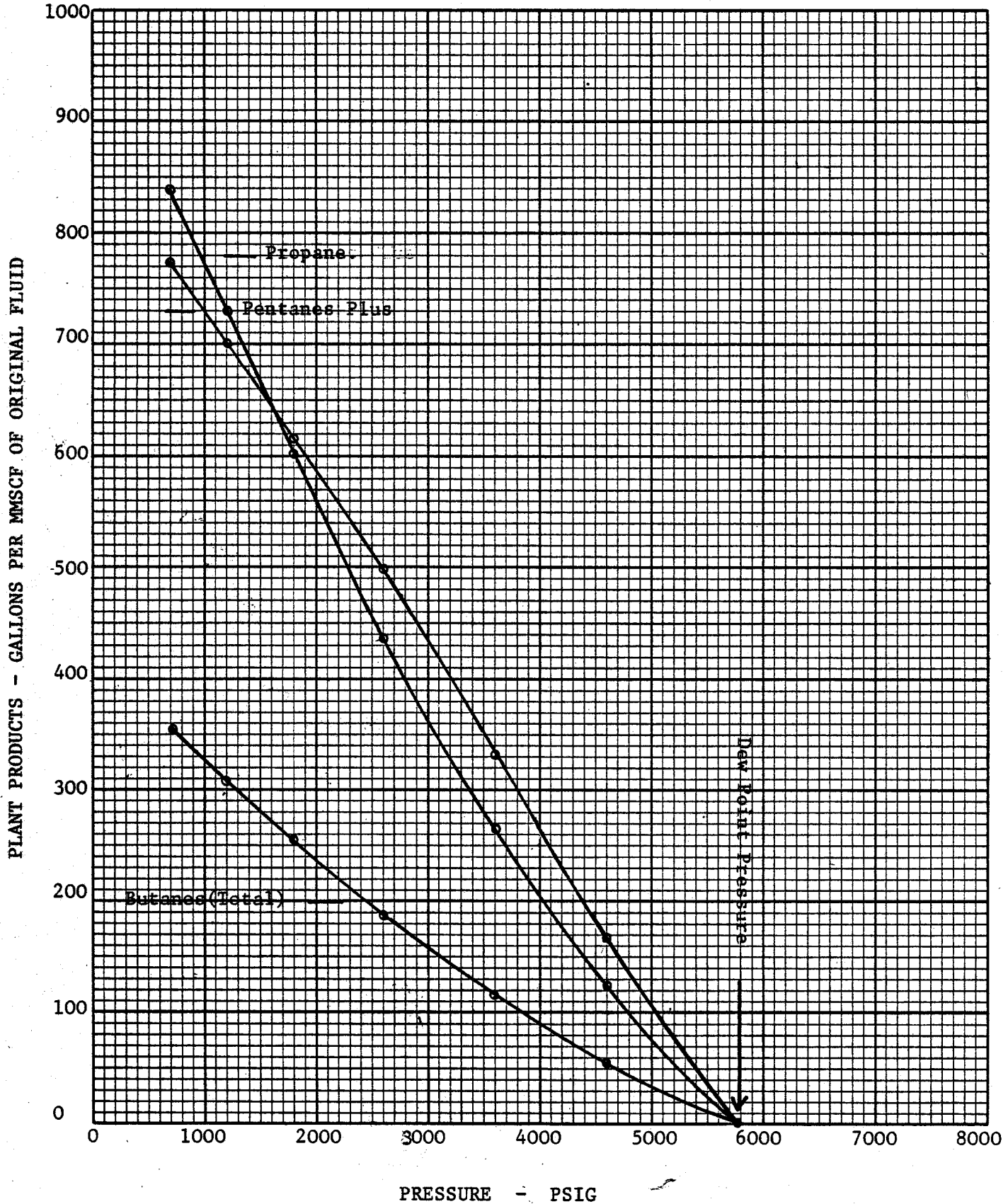
VOLUME OF WELL-STREAM PRODUCED DURING DEPLETION

Company STATOIL
Well 15/9 - 1
Field
Formation
Province
Country NORTH SEA - NORWAY



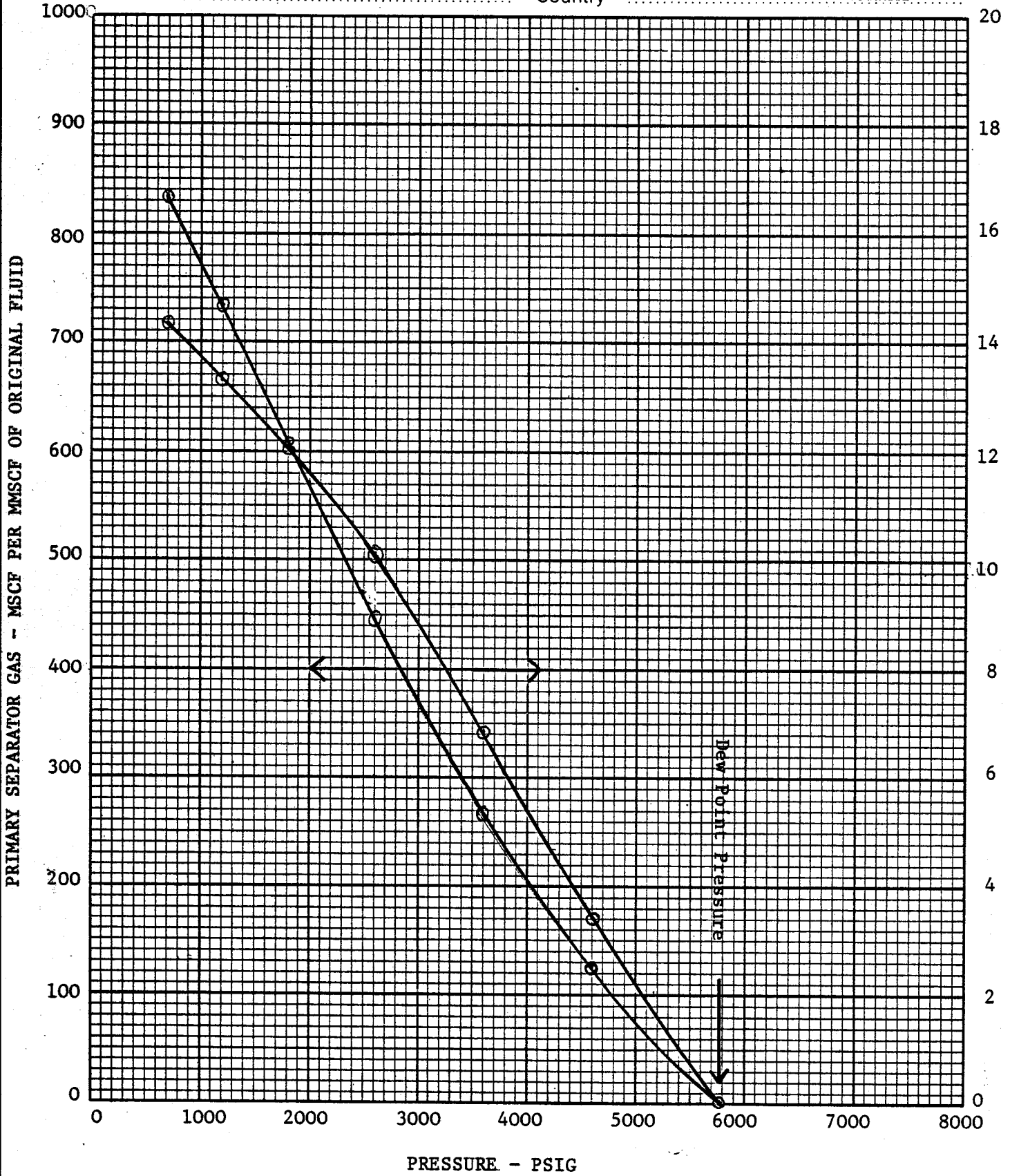
CUMULATIVE RECOVERY-"PLANT PRODUCTS" IN WELL STREAM

Company STATOIL Formation
 Well 15/9 - 1 Province
 Field Country NORTH SEA - NORWAY



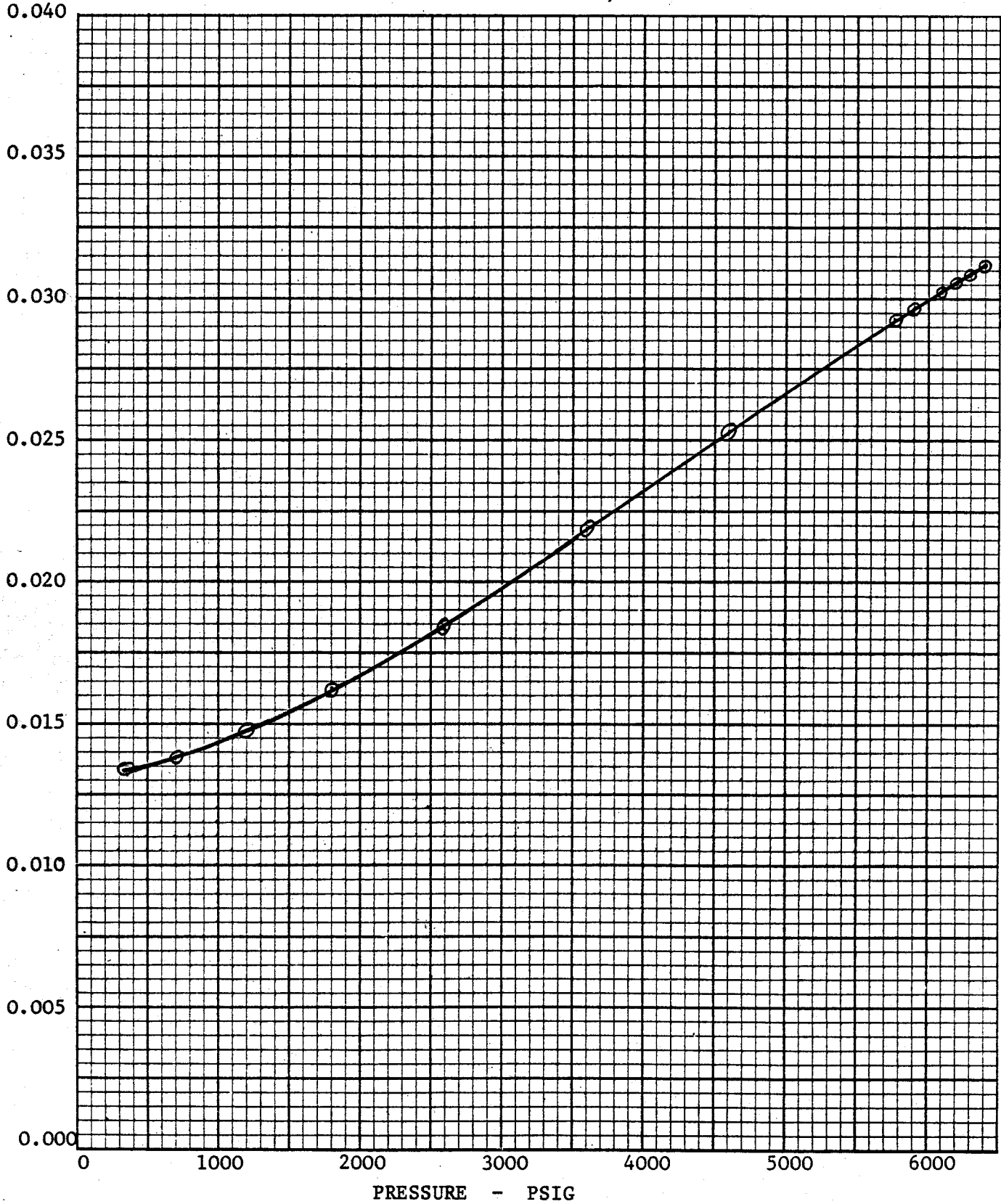
CUMULATIVE RECOVERY DURING DEPLETION

Company STATOIL Formation
 Well 15/9 - 1 Province
 Field Country NORTH SEA - NORWAY



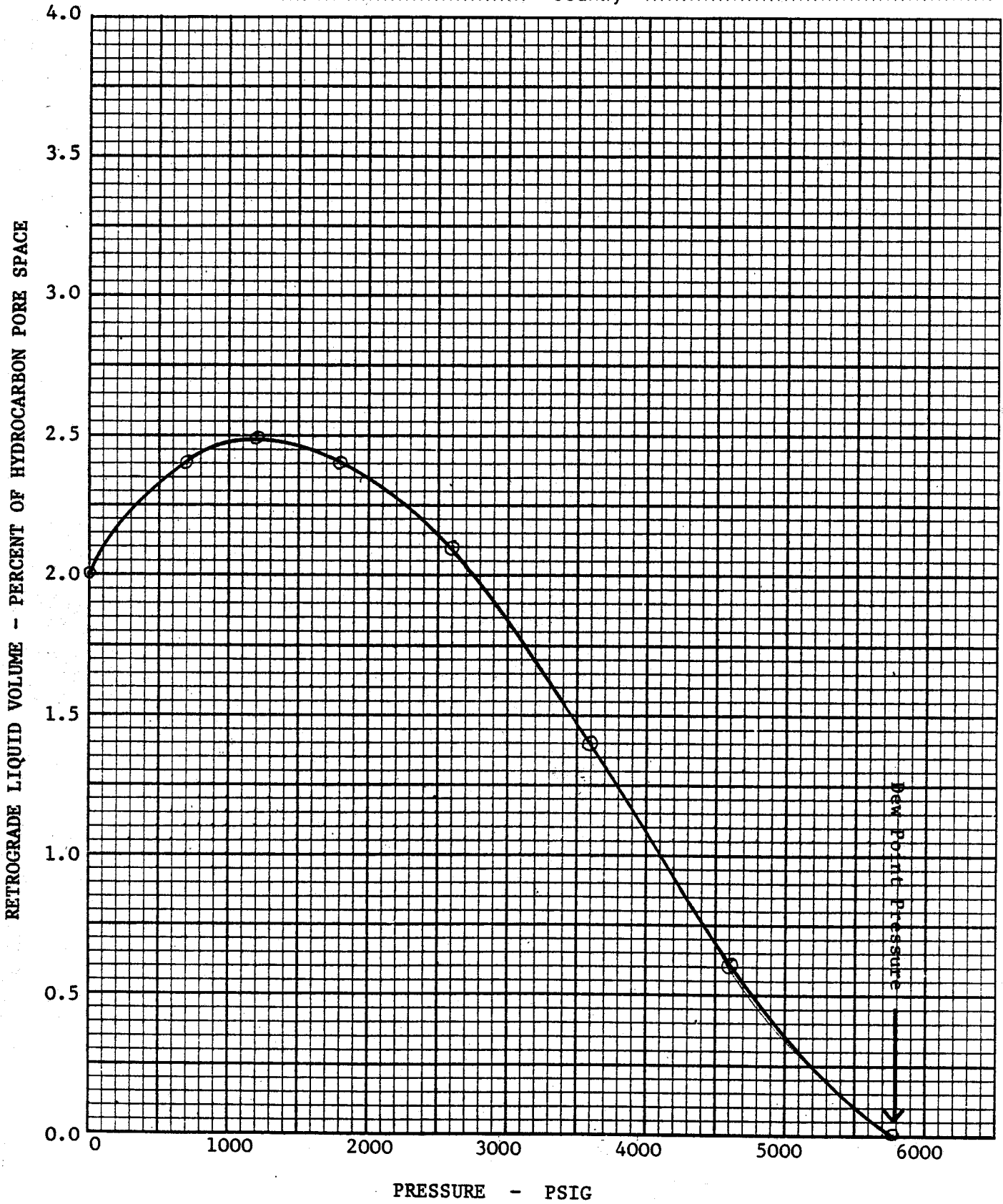
CALCULATED GAS VISCOSITY AT 241°F.

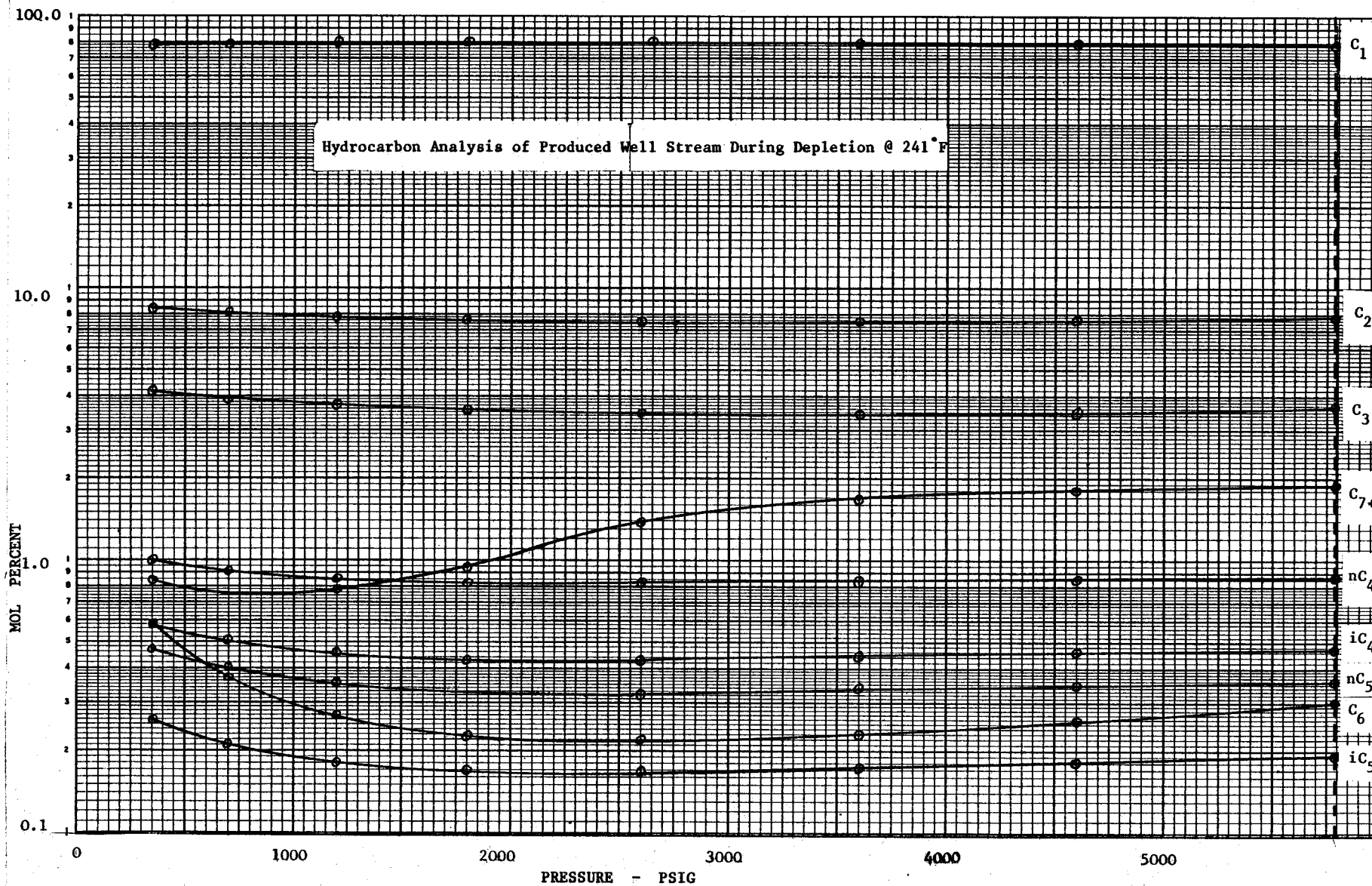
Company STATOIL Formation
Well 15/9 - 1 Province
Field Country NORTH SEA - NORWAY



RETROGRADE CONDENSATION DURING DEPLETION

Company STATOIL Formation
Well 15/9 - 1 Province
Field Country NORTH SEA - NORWAY





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