CORE LABORATORIES UK LTD.
Petroleum Reservoir Engineering
ABERDEEN, SCOTLAND

RESERVOIR FLUID STUDY

for

Esso/Statoil A/S

Well: 15/8-1

North Sea, Norway.

NOV 1982
REGISTRERT

CORE LABORATORIES UK LTD.
Petroleum Reservoir Engineering
ABERDEEN, SCOTLAND

25th October 1982

Esso/Statoil
Forus
P.O. Box 300
N-4001 Stavanger
NORWAY

Subject: Reservoir Fluid Study
Well: 15/8-1
North Sea, Norway.
Our File: RFLA 820178

Mr. Arne Martinsen.

Gentlemen,

On the 29th December 1981 samples of separator liquid and gas were collected from the subject well and forwarded to our Aberdeen laboratory. The results of our analyses as requested by Esso/Statoil are presented in the following report.

On arrival in the laboratory the hydrocarbon composition to decanes plus of the separator gas was determined by gas chromatography and of the separator liquid by low and high temperature fractional distillation. We were requested by Esso/ Statoil to recombine these separator products to a producing gas-liquid ratio of 1648 standard metres^3 of gas per metre^3 of primary separator liquid at 4.14 MPa(G) to 289 K. Using this ratio in conjunction with the experimentally measured hydrocarbon compositions of these separator products, a wellstream composition was calculated and is presented in terms of mol percent on page two of this report, and weight percent on page three.

A portion of the reservoir fluid was then subjected to a constant composition expansion at the reservoir temperature of 391 K, during this expansion a retrograde dew point was observed at 33.37 MPa(G). The results of the pressure-volume relations and the deviation factor measurements at the dew point pressure and above may be found on page four of this report.

A large quantity of reservoir fluid was then subjected to a constant volume depletion at the reservoir temperature. This depletion consists of a series of expansions and constant pressure displacments terminating at the original saturated volume, this has the effect of maintaining a constant reservoir volume. After determining the sample volume at 33.37 MPa(G), a series of expansions and constant pressure displacments were made. Each displacement wellstream charged to low temperature fractional distillation equipment and the following data were measured; hydrocarbon composition, deviation factor and produced percent. These data may be found on page five of this report and are graphically represented on pages ten and eleven.

Continued Over/.....

The volume of the retrograde condensation was determined visually during the constant volume depletion and at several points during the constant volume expansion. The maximum retrograde volume observed was 7.4% of the hydrocarbon pore space. The results of the liquid-volume measurements are tabulated on page eight and are graphically represented on page fourteen.

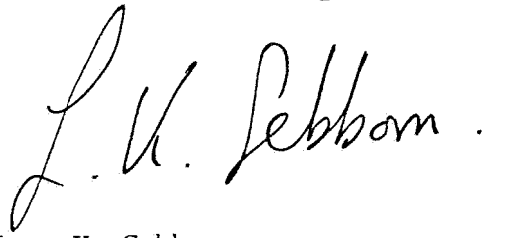
The smooth wellstream compositions were then used in conjunction with the correlation of Carr, Kobayashi and Burrows to calculate the viscosity of the wellstream during the depletion at 391 K. The results of these calculations may be found on page seven and are graphically represented on page thirteen.

The smooth wellstream compositions were also used in conjunction with literature derived equilibrium ratios, to calculate the surface recoveries that may be expected as the reservoir pressure declines. These data may be found on page six of this report and are graphically represented on page twelve.

It has been a pleasure to be of service to Esso/Statoil A/S. Should any questions arise concerning data presented in this report, or if we can be of any further assistance, please do not hesitate to contact us.

Very truly yours

Core Laboratories UK Limited
Reservoir Fluid Analysis



LKS/DIM/stb
10cc/Addressee

Les. K. Sebborn
Laboratory Manager

CORE LABORATORIES UK LTD.
Petroleum Reservoir Engineering
ABERDEEN, SCOTLAND

File RFLA 820178

Company Esso/Statoil A/S — Date Sampled 29th December 1981

Well 15/8-1 — County North Sea

Field — State Norway

FORMATION CHARACTERISTICS

Formation Name	
Date First Well Completed	, 19
Original Reservoir Pressure	MPa(G)@ M.
Original Produced Gas-Liquid Ratio	SCF/Bbl
Production Rate	Bbls/Day
Separator Pressure and Temperature	MPa(G) K.
Liquid Gravity at 289 K	°API
Datum	M. Subsea

WELL CHARACTERISTICS

Elevation	M.
Total Depth	M.
Producing Interval	3463 to 3653 M.
Tubing Size and Depth	In. to M.
Open Flow Potential	MMSCF/Day
Last Reservoir Pressure	44.61 MPa(G) @ 3648 M.
Date	, 19
* Reservoir Temperature	391 K. @ M.
Status of Well	
Pressure Gauge	

SAMPLING CONDITIONS

Flowing Tubing Pressure		10.79 MPa(G)
Flowing Bottom Hole Pressure		MPa(G)
Primary Separator Pressure		4.14 MPa(G)
Primary Separator Temperature		289 K.
Secondary Separator Pressure		MPa(G)
Secondary Separator Temperature		K.
Field Stock Tank Liquid Gravity		°API @ 60°F.
Primary Separator Gas Production Rate		MSCF/Day
Pressure Base	101.325 KPa(G)	
Temperature Base	289 K.	
Compressibility Factor (F_{pv})		
Gas Gravity (Laboratory)		
Gas Gravity Factor (F_g)		
Liquid Production Rate @ 289 K		Bbls/Day
Primary Separator Gas/ Separator Liquid Ratio		1648 SM^3/M^3
	or	607 $M^3/M^3 \times 10^6$
Sampled by		

REMARKS: *Requested analysis temperature.

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File RFLA 820178

Well 15/8-1

HYDROCARBON ANALYSES OF SEPARATOR PRODUCTS AND CALCULATED WELL STREAM

Component	Separator Liquid * Mol Percent	Separator Gas + Mol Percent	$L^3/100M^3$	Well Stream Mol Percent
Hydrogen Sulfide	NIL	NIL		NIL
Carbon Dioxide	6.29	14.80		13.87
Nitrogen	0.04	0.51		0.46
Methane	15.55	70.08		64.14
Ethane	9.71	9.01		9.09
Propane	12.63	3.91	14.34	4.86
iso-Butane	2.80	0.40	1.75	0.66
n-Butane	7.01	0.79	3.32	1.47
iso-Pentane	2.63	0.14	0.68	0.41
n-Pentane	3.91	0.14	0.68	0.55
Hexanes	4.70	0.09	0.49	0.59
Heptanes	5.91	0.07	)	0.71
Octanes	7.06	0.04	)	0.80
Nonanes	4.41	0.01	) 0.79	0.49
Decanes plus	17.35	0.01	)	1.90
	100.00	100.00	22.05	100.00

Properties of Heptanes plus			
API gravity @ 60°F.	36.7		
Density @ 289 K (kg/M^3)	840		837
Molecular weight	161	103 (assumed)	159

Calculated separator gas gravity (air=1.000) = 0.809
Calculated gross heating value for separator gas = 38.27 MJ/M^3.
per cubic foot of dry gas @ 101.325 KPa and 289 K.

Primary separator gas collected @ 4.14 MPa and 289 K.
Primary separator liquid collected @ 4.38 MPa and 287 K.

Primary separator gas/separator liquid ratio 1640 SM^3/M^3 @ 289 K.
Primary separator gas/well stream ratio 891 $SM^3/1000\ SM^3$.

* Cylinder Number: 001-AQ
\+ Cylinder Number: 001-169

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File RFLA 820178

Well 15/8-1

HYDROCARBON ANALYSES OF SEPARATOR PRODUCTS AND CALCULATED WELL STREAM

Component	Separator Liquid * Weight Percent	Separator Gas + Wt Percent	Well Stream Wt Percent
Hydrogen Sulfide	NIL	NIL	NIL
Carbon Dioxide	3.29	27.79	20.32
Nitrogen	0.01	0.61	0.43
Methane	2.96	47.97	34.23
Ethane	3.47	11.56	9.09
Propane	6.62	7.36	7.13
iso-Butane	1.93	0.99	1.28
n-Butane	4.84	1.96	2.84
iso-Pentane	2.25	0.43	0.99
n-Pentane	3.35	0.43	1.32
Hexanes	4.79	0.33	1.69
Heptanes	6.81	0.28	2.27
Octanes	9.10	0.18	2.90
Nonanes	6.33	0.05	1.97
Decanes plus	44.25	0.06	13.54
	100.00	100.00	100.00

Properties of Heptanes plus			
API gravity @ 60°F.	36.7		
Density @ 289 K (kg/M^3)	840		837
Molecular weight	161	103 (assumed)	159

Calculated separator gas gravity (air=1.000) = 0.809

Calculated gross heating value for separator gas = 38.27 MJ/M^3. per cubic foot of dry gas @ 101.325 KPa and 289 K.

Primary separator gas collected @ 4.14 MPa and 289 K.

Primary separator liquid collected @ 4.38 MPa and 287 K.

Primary separator gas/separator liquid ratio 1648 SM^3/M^3 @ 289 K.

Primary separator gas/well stream ratio 891 SM^3/1000 SM^3.

* Cylinder Number: 001-AQ

\+ Cylinder Number: 001-169

PRESSURE-VOLUME RELATIONS AT 391 K.

Pressure MPa		Relative Volume(1)	Deviation Factor Z
48.26		0.8401	1.156
44.61	Reservoir Pressure	0.8658	1.101*
41.37		0.8956	1.056
39.99		0.9095	1.037
38.61		0.9264	1.020
37.23		0.9427	1.001
35.85		0.9610	0.983
34.47		0.9814	0.966
33.37	Saturation Pressure	1.0000	0.952**
33.09		1.0047	
32.41		1.0169	
31.72		1.0298	
31.03		1.0442	
30.34		1.0585	
29.65		1.0741	
28.96		1.0899	
28.27		1.1090	
27.58		1.1274	
26.20		1.1693	
24.82		1.2166	
23.44		1.2738	
22.06		1.3389	
20.68		1.4164	
17.93		1.6166	
15.17		1.9071	
12.41		2.3464	
9.65		3.0624	
6.89		4.3826	
4.83		6.3917	

Gas Formation Volume Factor: * 296 SM^3/M^3
** 256 SM^3/M^3

(1) Relative Volume: V/Vsat is barrels at indicated pressure per barrel at saturation pressure.

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DEPLETION STUDY AT 391 K.

Hydrocarbon Analyses of Produced Wellstream - Mol Percent

Component	Reservoir Pressure - MPa							
	33.37*	31.72	26.20	20.68	15.17	9.65	4.83	0**
Carbon Dioxide	13.87	14.03	14.11	14.28	14.44	14.33	14.14	13.98
Nitrogen	0.46	0.47	0.50	0.50	0.49	0.47	0.45	0.43
Methane	64.14	64.61	65.80	66.38	66.42	66.28	65.39	64.39
Ethane	9.09	9.02	9.06	9.09	9.23	9.34	9.53	9.68
Propane	4.86	4.78	4.72	4.69	4.70	4.89	5.33	5.59
iso-Butane	0.66	0.66	0.64	0.63	0.63	0.65	0.70	0.80
n-Butane	1.47	1.45	1.40	1.38	1.39	1.44	1.61	1.83
iso-Pentane	0.41	0.39	0.36	0.35	0.34	0.37	0.44	0.54
n-Pentane	0.55	0.53	0.49	0.46	0.46	0.49	0.60	0.68
Hexanes	0.59	0.56	0.49	0.45	0.44	0.46	0.52	0.60
Heptanes plus	3.90	3.50	2.43	1.79	1.46	1.28	1.29	1.48
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Molecular weight of heptanes plus	159	153	132	118	108	104	103	105
Density of heptanes plus (Kg/M^3)	837	833	811	797	786	782	781	783
Deviation Factor - Z								
Equilibrium gas	0.952	0.927	0.871	0.849	0.863	0.896	0.938	
Two-phase		0.933	0.880	0.845	0.829	0.822	0.785	
Wellstream produced - Cumulative percent of initial	0.000	2.966	14.943	30.024	47.593	66.236	82.128	97.528
L per 100 M^3 from Smooth Compositions								
Propane plus	66.05	61.17	49.49	43.33	40.59	40.69	44.44	49.26
Butanes plus	48.22	43.63	32.16	26.17	23.34	22.75	24.88	28.74
Pentanes plus	39.16	34.66	23.50	17.57	14.74	13.80	15.07	17.57

* Saturation Pressure
** Composition assumed to represent mid point of depletion interval (2.41 MPa)

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CALCULATED CUMULATIVE RECOVERY DURING DEPLETION

Cumulative Recovery per MMSCF of Original Fluid	Initial in Place	Reservoir Pressure - MPa						
		33.37*	31.72	26.20	20.68	15.17	9.65	4.83
Well Stream - $M^3 \times 10^2$	1000	0	29.66	149.43	300.24	475.93	662.36	821.28
Normal Temperature Separation**								
Stock Tank Liquid - Barrels M^3	36.697	0	0.954	2.504	4.739	6.822	8.804	10.578
Primary Separator Gas- $M^3 \times 10^2$	885.77	0	26.57	110.29	251.54	417.41	593.70	742.59
Stock Tank Gas - $M^3 \times 10^2$	61.94	0	1.69	5.39	11.02	16.97	23.35	29.97
Total "Plant Products" in Primary Separator Gas-M^3***								
Propane	12.152	0	0.361	1.577	3.663	6.163	8.930	11.430
Butanes (total)	3.984	0	0.120	0.561	1.337	2.286	3.342	4.278
Pentanes plus	1.751	0	0.053	0.241	0.561	0.949	1.390	1.791
Total "Plant Products" in Stock Tank Gas-M^3***								
Propane	4.954	0	0.135	0.435	0.891	1.372	1.895	2.455
Butanes (total)	3.445	0	0.097	0.335	0.707	1.115	1.566	2.051
Pentanes plus	2.783	0	0.077	0.267	0.568	0.904	1.290	1.723
Total "Plant Products" in Well Stream - M^3***								
Propane	17.833	0	0.521	2.593	5.187	8.221	11.563	14.678
Butanes (total)	9.077	0	0.267	1.310	2.593	4.104	5.762	7.326
Pentanes plus	39.155	0	1.029	3.837	6.497	9.077	11.670	14.063

* Saturation Pressure.
** Separation Basis: Primary stage 4.14 MPa at 289 K, stock tank 0 MPa at 289 K.
*** Assumes 100% plant efficiency.

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RETROGRADE CONDENSATION DURING GAS DEPLETION AT 391 K.

Pressure MPa(G)	Retrograde Liquid Volume Percent of Hydrocarbon Pore Space
33.37	0.0
32.41	0.5
31.72	0.9
26.20	3.7
20.68	5.7
15.17	6.9
9.65	7.4
4.83	7.3
0.00	6.9

Properties of Zero PSIG Residual Liquid

Gravity	:	32.5	°API @ 60°F
Density	:	862	Kg/M3 @ 289 K
Molecular Weight	:	189	

CALCULATED GAS VISCOSITY AT 391 K.

Pressure MPa(G)	Gas Viscosity, Pascal Second*($\times 10^{-3}$)
33.37	0.0338
31.72	0.0318
26.20	0.0263
20.68	0.0214
15.17	0.0186
9.65	0.0160
4.83	0.0138

* Calculated using the correlation of Carr, Kobayashi and Burrows, Aime Transactions, 1954, Vol 201, p264.

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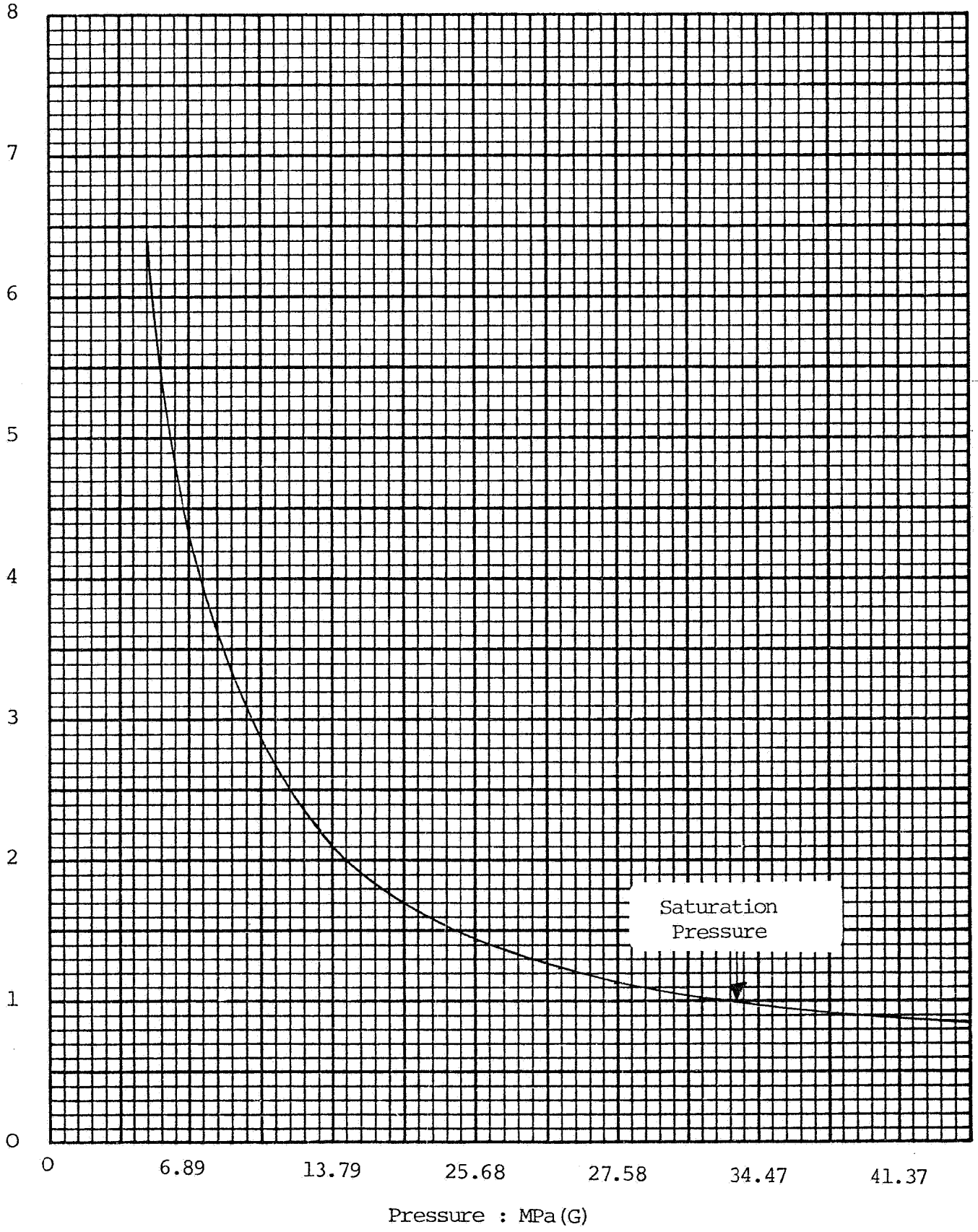
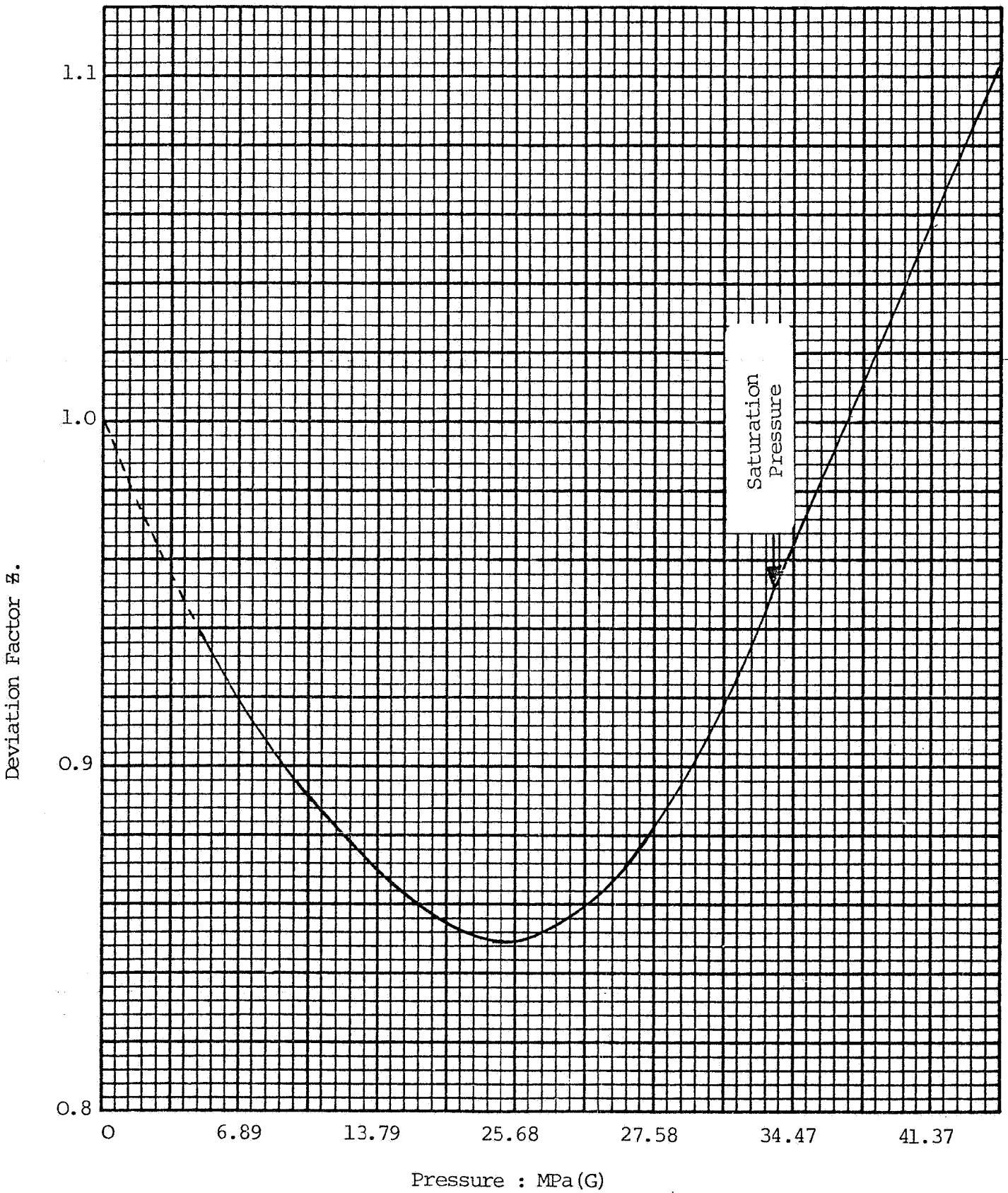
Pressure-Volume Relations of Reservoir Fluid at 391 K.

Company Esso/Statoil A/S **Formation**
Well 15/8-1 **County** North Sea
Field **State** Norway



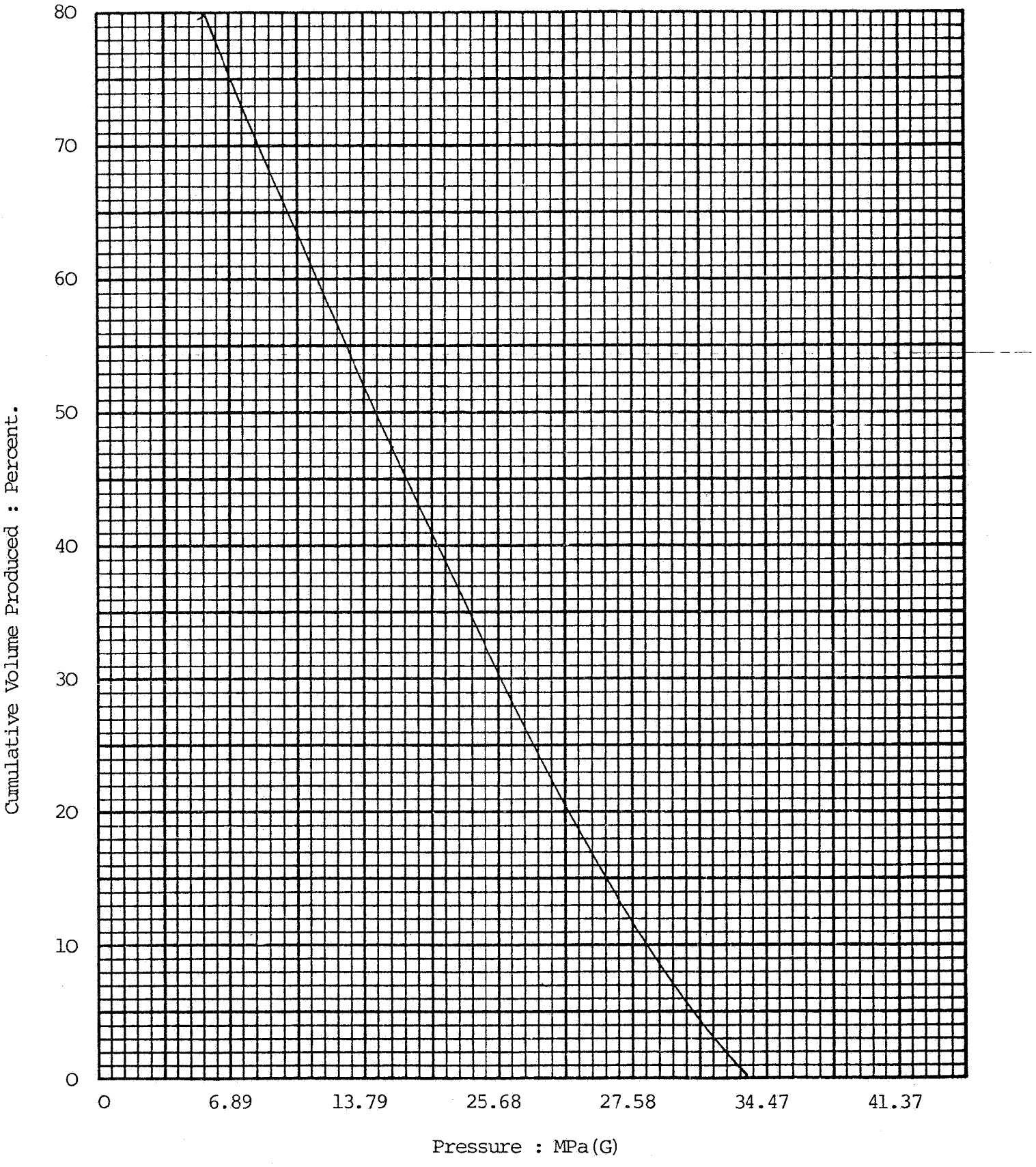
Deviation Factor Z of Wellstream During Depletion at 391 K.

Company Esso/Statoil A/S **Formation**
Well 15/8-1 **County** North Sea
Field **State** Norway



Volume of Wellstream Produced During Depletion at 391 K.

Company Esso/Statoil A/S **Formation**
Well 15/8-1 **County** North Sea
Field **State** Norway



Cumulative Recovery - "Plant Products" In Primary Separator Gas

Company Esso/Statoil A/S **Formation**
Well 15/8-1 **County** North Sea
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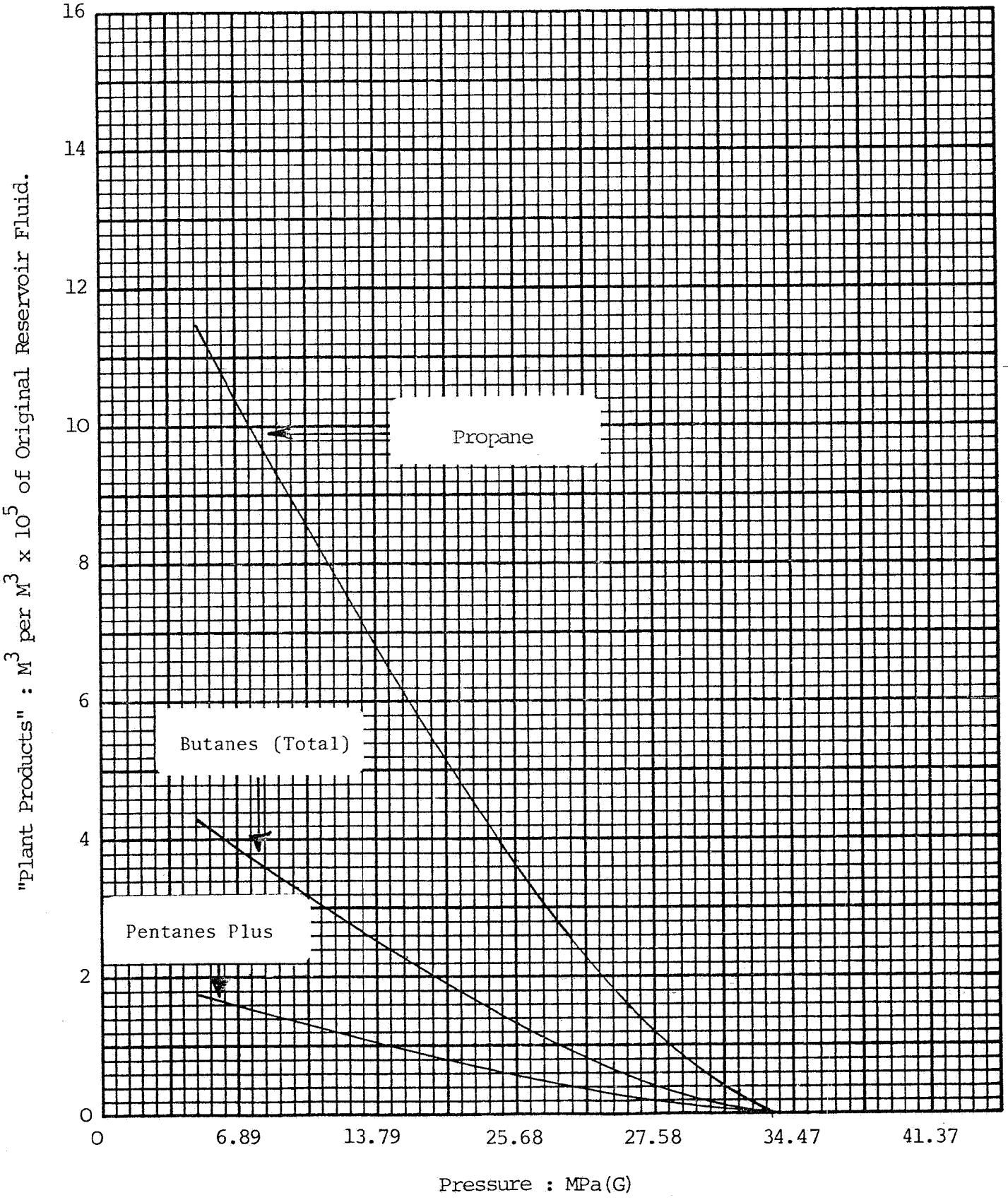

Calculated Gas Viscosity at 391 K.

Company Esso/Statoil A/S **Formation**
Well 15/8-1 **County** North Sea
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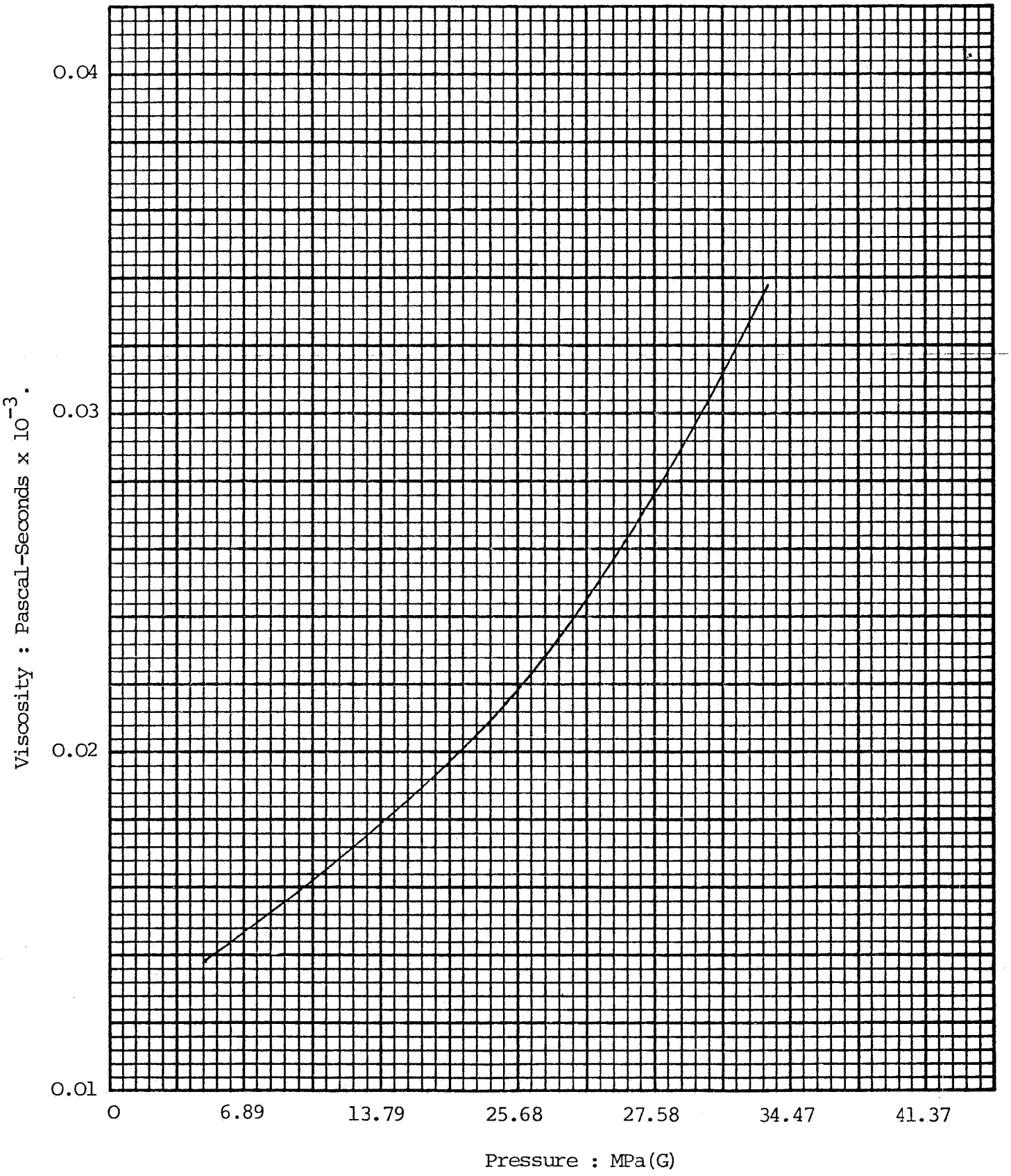
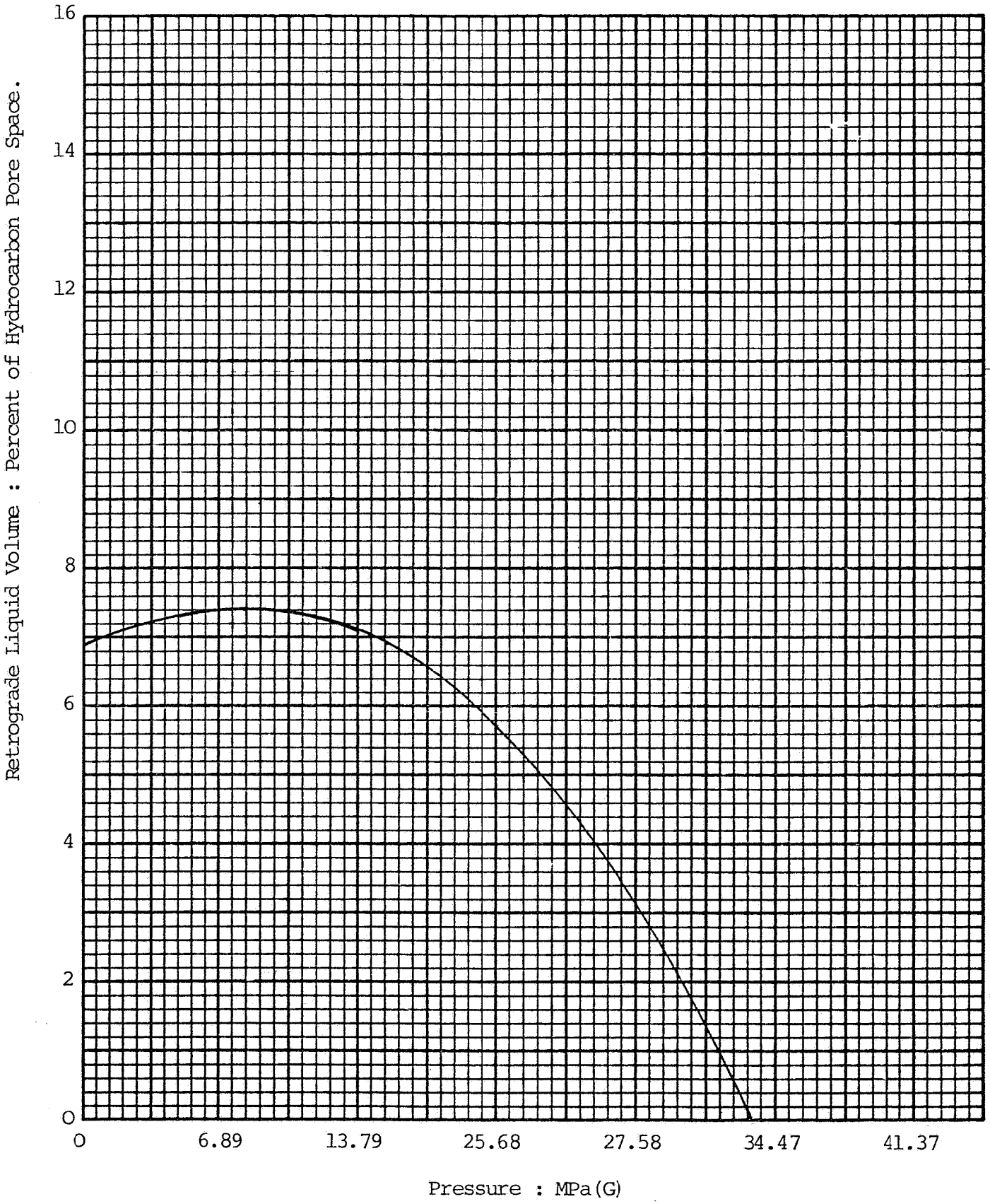


Retrograde Condensation During Depletion at 391 K.

Company Esso/Statoil A/S **Formation**
Well 15/8-1 **County** North Sea
Field **State** Norway



CORE LABORATORIES UK LTD.
Petroleum Reservoir Engineering
ABERDEEN, SCOTLAND

ESSO/STATOIL A/S
Well: 15/8-1

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Core Laboratories UK Limited
Reservoir Fluid Analysis

L. K. Sebborn

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