ELARK No.: 98597000016246(1)

CORE LAB

CORE LABORATORIES (U.K.) LIMITED
Advanced Technology Centre

W.A.T. v's Bubble Point Study

for

Den Norske Stats Oljeselskap a.s.

Our File : RFLA 980020

Well : 15/9-19A

CORE LAB

CORE LABORATORIES (U.K.) LIMITED

Advanced Technology Centre

26th March 1998

Den Norske Stats Ojleselskap a.s.
N-4035
Stavanger
NORWAY

Subject	: Asphaltene Study
Well	: 15/9-19A
Contract	: DTJ017535
Our File	: RFLA 980020

Attention : Ms. Bodil Somme

Dear Madam,

Core Laboratories have recently completed a study to determine the Wax Appearance Temperature relationship as a function of bubble point on fluids from well 15/9-19A, the results of which are presented in this report.

A summary of the laboratory analyses is presented in pages 1 and 2. The compositions of separator products and calculated wellstream data are presented in Appendix 1 while the W.A.T. v's bubble point data is presented in Appendix 2.

We trust that our service has met with your approval and look forward to the opportunity of working with Den Norske Stats Ojleselskap a.s. again in the future.

Yours faithfully,

Core Laboratories (U.K.) Limited

Andy Williamson

Andy Williamson
Snr. Fluids Supervisor -
Exploration and Production Chemistry Group

NAMAS
TESTING
No. 1528

BSI
BS 5750 : PART 2
(ISO 9002)
Cert No. FS 23304

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W.A.T. v's Bubble Point Study

i. Background

A set of separator samples, cylinder number 50249 (gas) and 20273 (liquid) were forwarded to the laboratory for analysis.

The compositions of the separator products were determined and the resultant wellstream composition calculated from the producing gas oil ratio supplied.

The fluids were physical recombined to produce a wellstream fluid to conduct the study.

The objective of the study was to ascertain the relationship of wax appearance temperature as a function of bubble point using selected bubble point pressures between the reservoir fluid and atmospheric oil.

A summary of the samples received is presented in Table 1.

ii. Compositional Analysis of Separator Products and Calculated Wellstream Composition

The compositions of the separator oil and gas were measured through decanes plus. The gas was analysed by gas chromatography using a GPA 2286 method. Prior to analysis, the gas sample was heated to a temperature 10°C in excess of the reported separator temperature of 58°C.

The liquid was analysed using a combination of flash separation and gas chromatography.

The mathematical wellstream composition was calculated using a producing GOR of 65.5 Sm^3/m^3.

After approval of the mathematical wellstream composition by Statoil, the separator products were physically recombined using a producing GOR of 65.5 Sm^3/m^3.

The separator product compositions and calculated wellstream composition are presented in Appendix 1.

iii. Determination of Wax Appearance Temperature v's Bubble Point

The wax appearance temperature of the recombined reservoir fluid was determined as a function of saturation pressure between the reservoir conditioned fluid and atmospheric pressure.

This predicts how the wax appearance temperature varies through the production process as gas is liberated from the reservoir fluid. The data gives an early indication of potential waxing problems during processing and transport of processed liquids. Wax deposition is likely to occur on pipe wall surfaces or in the bulk fluids when the fluid temperature falls below the wax appearance temperature.

The wax appearance temperatures were conducted by flowing the fluid at the specified saturation pressure through a temperature programmed cooling coil and then through a 1 micron sintered filter. The flowing differential pressure across the filter was monitored as a function of temperature. A rapid and continuous increase in flowing differential pressure is indicative of filter blocking due to wax crystals of greater size than 1 micron.

Note that in some cases, a gradual increase in flowing differential pressure can be observed prior to the wax appearance temperature. This is usually more pronounced as the saturation pressure is reduced and is caused by an increase in the fluid viscosity as the fluid cools. Discontinuities in the traces coincide with a change in the direction of fluid flow after a complete volume has been displaced through the filter.

Tests were conducted at the following gas saturation conditions selected by Statoil a.s.:-

344 bar psi @ 80°C (reservoir fluid), 150 bar @ 80°C, 80 bar @ 80°C, 50 bar at 80°C, 20 bar at 80°C, 1 bar at 80°C.

The wax appearance temperatures determined at each condition are presented in Table 2 and are presented graphically in Figure 1. Plots of flowing differential pressure versus temperature are presented in Appendix 2 for reference.

iv. Discussion of Analysis Results

Wax appearance temperatures were determined ranging from 28°C for the reservoir fluid to 40°C for the atmospheric oil.

This would suggest that at lower pressures, the WAT is relatively high and there is a significant increase in the potential for wax deposition during processing and transport of liquids.

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APPENDIX 1

Summary of Samples Received

Separator Product Compositions

Calculated Wellstream Composition

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Table 1

Summary of Samples Received

Sample Number	Cylinder Number	Sample Type	Separator Pressure, bar	Separator Temp, °C
92	20273	Sep Liq	48	58.6
93	50249	Sep Gas	48	58.6

Notes

i. No further sample details provided.
ii. Samples recombined to a producing GOR of 65.5 Sm^3/m^3.

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HYDROCARBON ANALYSIS OF SEPARATOR LIQUID SAMPLE BY PNA TO DECANES PLUS (CYLINDER 20273)

Component	Weight %	Mole Weight (g mole-1)	Mole %	Density (g cm-3 at 15°C)
Hydrogen	0.00	2.02	0.00	
Hydrogen sulphide	0.00	34.08	0.00	
Carbon dioxide	0.22	44.01	0.94	
Nitrogen	0.01	28.01	0.08	
Methane	1.18	16.04	13.84	
Ethane	0.75	30.07	4.69	
Propane	1.44	44.10	6.17	
i-Butane	0.31	58.12	1.00	
n-Butane	1.17	58.12	3.81	
i-Pentane	0.57	72.15	1.50	
n-Pentane	0.91	72.15	2.37	
Hexanes- Paraffins	1.25	86.18	2.74	0.663
Hexanes- Naphthenes	0.09	70.13	0.25	0.750
Hexanes Total	1.34	84.84	2.98	0.668
Heptanes- Paraffins	1.11	100.20	2.10	0.688
Heptanes- Naphthenes	1.15	89.03	2.45	0.762
Heptanes- Aromatics	0.42	78.11	1.01	0.884
Heptanes Total	2.68	91.27	5.55	0.744
Octanes- Paraffins	1.24	114.23	2.05	0.707
Octanes- Naphthenes	1.20	104.87	2.16	0.771
Octanes- Aromatics	0.60	92.14	1.23	0.871
Octanes Total	3.04	105.51	5.44	0.760
Nonanes- Paraffins	1.39	128.26	2.05	0.721
Nonanes- Naphthenes	0.71	118.04	1.13	0.791
Nonanes- Aromatics	0.81	106.17	1.44	0.873
Nonanes Total	2.91	118.88	4.62	0.775
Decanes plus	83.48	335.45	47.01	0.924
Total	100.00		100.00	

Note:- 0.00 means less than 0.005

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HYDROCARBON ANALYSIS OF SEPARATOR PRODUCTS AND CALCULATED WELLSTREAM - SAMPLE NUMBERS 92 AND 93

Component	Separator Liquid		Separator Gas	Wellstream	
	Mole %	Weight %	Mole %	Mole %	Weight %
Hydrogen	0.00	0.00	0.00	0.00	0.00
Hydrogen sulphide	0.00	0.00	0.00	0.00	0.00
Carbon dioxide	0.94	0.22	2.94	1.71	0.61
Nitrogen	0.08	0.01	1.15	0.49	0.11
Methane	13.85	1.18	80.54	39.58	5.12
Ethane	4.67	0.74	7.86	5.90	1.43
Propane	6.14	1.43	4.50	5.51	1.96
i-Butane	1.00	0.31	0.42	0.78	0.36
n-Butane	3.81	1.17	1.21	2.81	1.31
Neo-pentane	0.00	0.00	0.00	0.00	0.00
i-Pentane	1.50	0.57	0.27	1.03	0.60
n-Pentane	2.40	0.92	0.36	1.61	0.94
Hexanes	2.94	1.34	0.28	1.91	1.33
Me-Cyclo-pentane	1.03	0.46	0.06	0.66	0.44
Benzene	0.73	0.30	0.04	0.46	0.29
Cyclo-hexane	0.69	0.31	0.05	0.44	0.30
Heptanes	3.04	1.62	0.11	1.91	1.54
Me-Cyclo-hexane	0.91	0.47	0.03	0.57	0.45
Toluene	0.62	0.30	0.03	0.39	0.29
Octanes	3.75	2.27	0.06	2.33	2.14
Ethyl-benzene	0.45	0.25	0.00	0.28	0.24
Meta/Para-xylene	0.38	0.22	0.00	0.23	0.20
Ortho-xylene	0.19	0.11	0.00	0.12	0.10
Nonanes	3.43	2.33	0.03	2.12	2.19
Decanes plus	47.45	83.47	0.06	29.16	78.05
Totals	100.00	100.00	100.00	100.00	100.00

	Separator Liquid	Separator Gas	Wellstream Mole %	Wellstream
Decanes plus properties				
Molecular Weight (g mol-1)	332	142		332
Density at 15.6°C (g cm-3)	0.9279	0.7823		0.9278
Heptanes plus properties				
Mole %	62.67	0.47		38.67
Molecular Weight (g mol-1)	278	102		277
Density at 15.6°C (g cm-3)	0.9055	0.7570		0.9052
Whole fluid properties				
Average mole weight (g mol-1)	188.9	21.0		124.1
Density at separator conditions (g cm-3)	0.8327			
Grouped Fractions (mole %)				
Heptanes	5.49	0.26	3.47	
Octanes	5.28	0.12	3.29	
Nonanes	4.45	0.03	2.74	

Note : 0.00 means less than 0.005

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CALCULATED WELLSTREAM COMPOSITION BY PNA

Component	Weight %	Mole Weight (g mole-1)	Mole %	Density (g cm-3 at 15°C)
Hydrogen	0.00	2.02	0.00	
Hydrogen sulphide	0.00	34.08	0.00	
Carbon dioxide	0.61	44.01	1.72	
Nitrogen	0.11	28.01	0.49	
Methane	5.13	16.04	39.65	
Ethane	1.43	30.07	5.91	
Propane	1.97	44.10	5.52	
i-Butane	0.36	58.12	0.77	
n-Butane	1.31	58.12	2.80	
i-Pentane	0.60	72.15	1.02	
n-Pentane	0.93	72.15	1.60	
Hexanes- Paraffins	1.24	86.18	1.78	0.663
Hexanes- Naphthenes	0.09	70.13	0.16	0.750
Hexanes Total	1.33	84.87	1.94	0.668
Heptanes- Paraffins	1.06	100.20	1.32	0.688
Heptanes- Naphthenes	1.12	89.03	1.55	0.762
Heptanes- Aromatics	0.40	78.11	0.63	0.884
Heptanes Total	2.58	91.25	3.50	0.745
Octanes- Paraffins	1.18	114.23	1.28	0.707
Octanes- Naphthenes	1.14	104.87	1.34	0.771
Octanes- Aromatics	0.57	92.14	0.77	0.871
Octanes Total	2.88	105.52	3.39	0.760
Nonanes- Paraffins	1.31	128.26	1.27	0.721
Nonanes- Naphthenes	0.66	118.04	0.69	0.791
Nonanes- Aromatics	0.76	106.17	0.89	0.873
Nonanes Total	2.73	118.89	2.85	0.775
Decanes plus	78.03	335.45	28.84	0.924
Total	100.00		100.00	

Note:- 0.00 means less than 0.005

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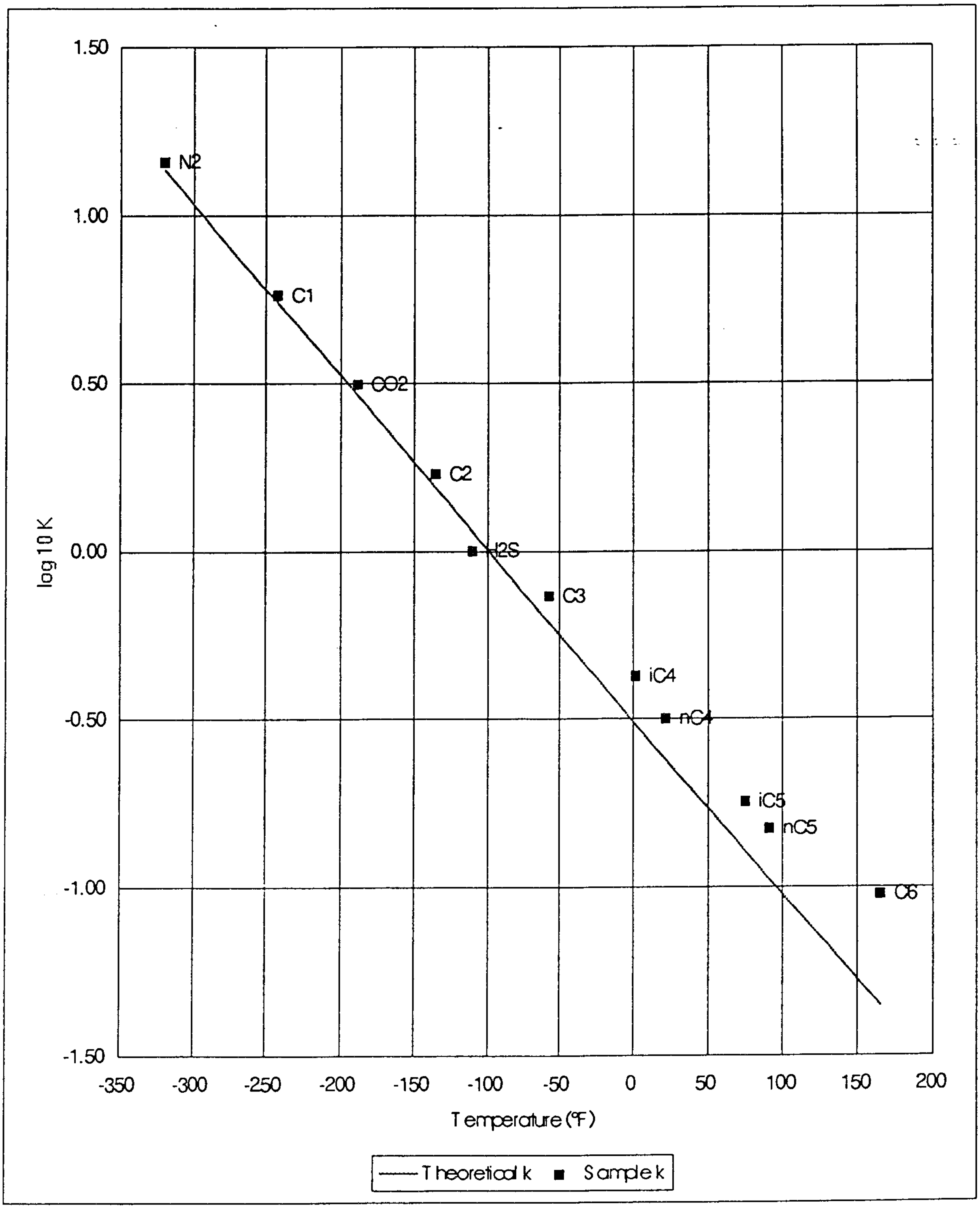
EQUILIBRIUM K PLOT



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APPENDIX 2

W.A.T. v's Bubble Point Data

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Table 2

Wax Appearance Temperatures versus Bubble Point Pressure

Saturation Pressure, bar @ 80°C	Wax Appearance Temp. °C
Reservoir Fluid	28
150	30
80	33
50	35
20	37
1	40

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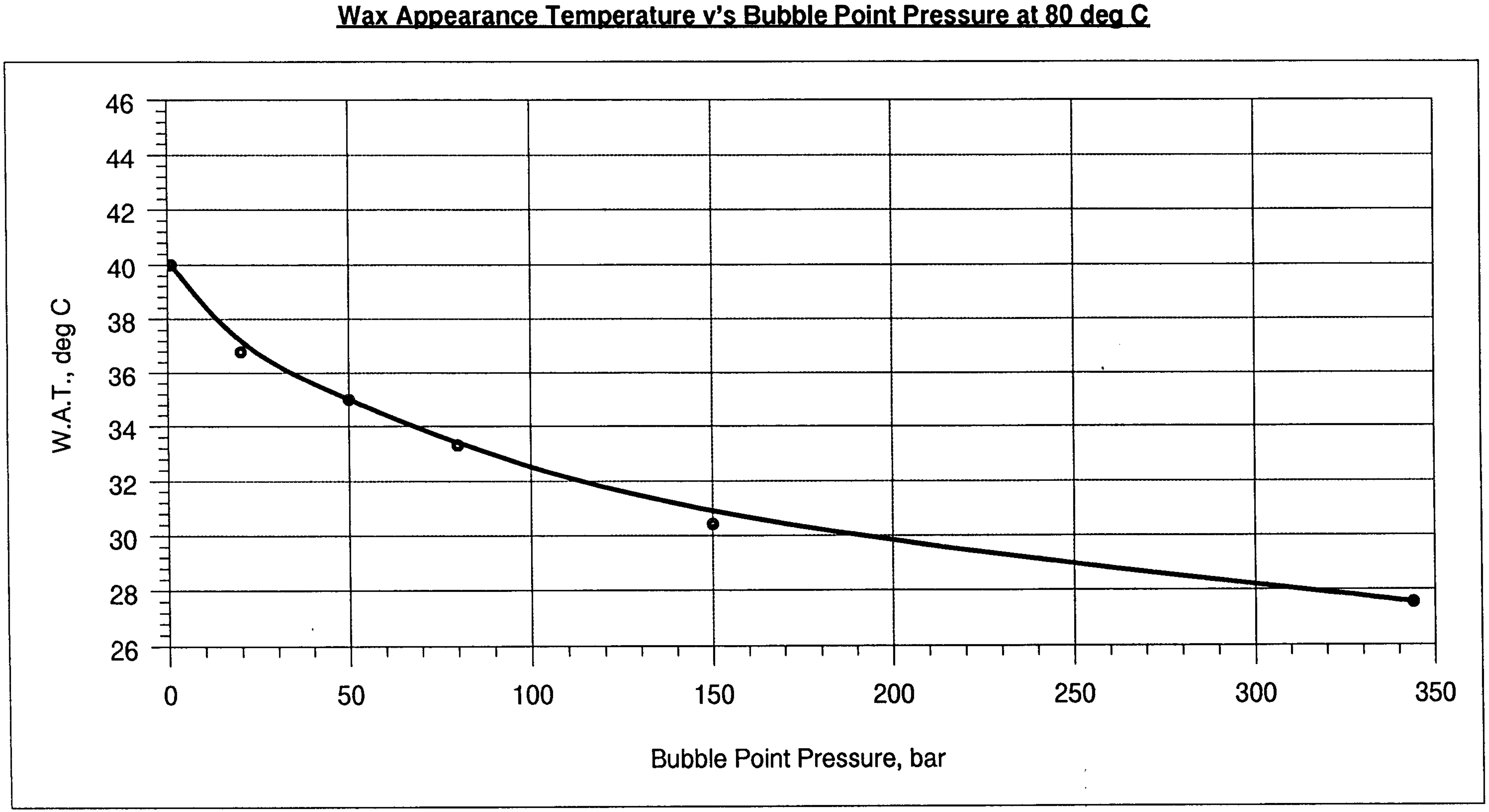


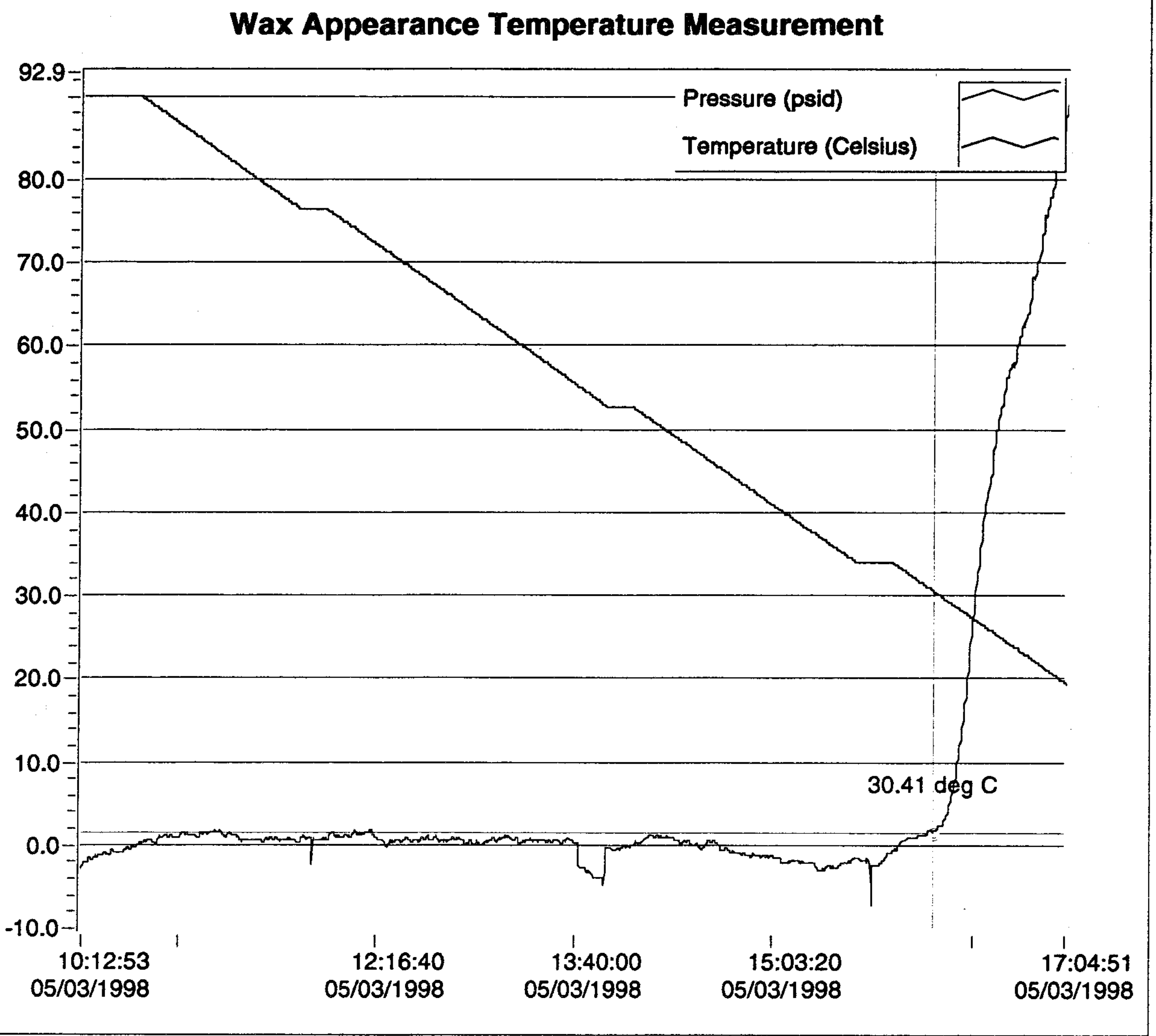
Figure 1

Company : Statoil

Well no. : 15/9-19A

Our File : RFLA 980020

Cyl. no. : Recombination



WAT 150 Bar @ 80 C (Run From 90 C , 344 Bar WP)

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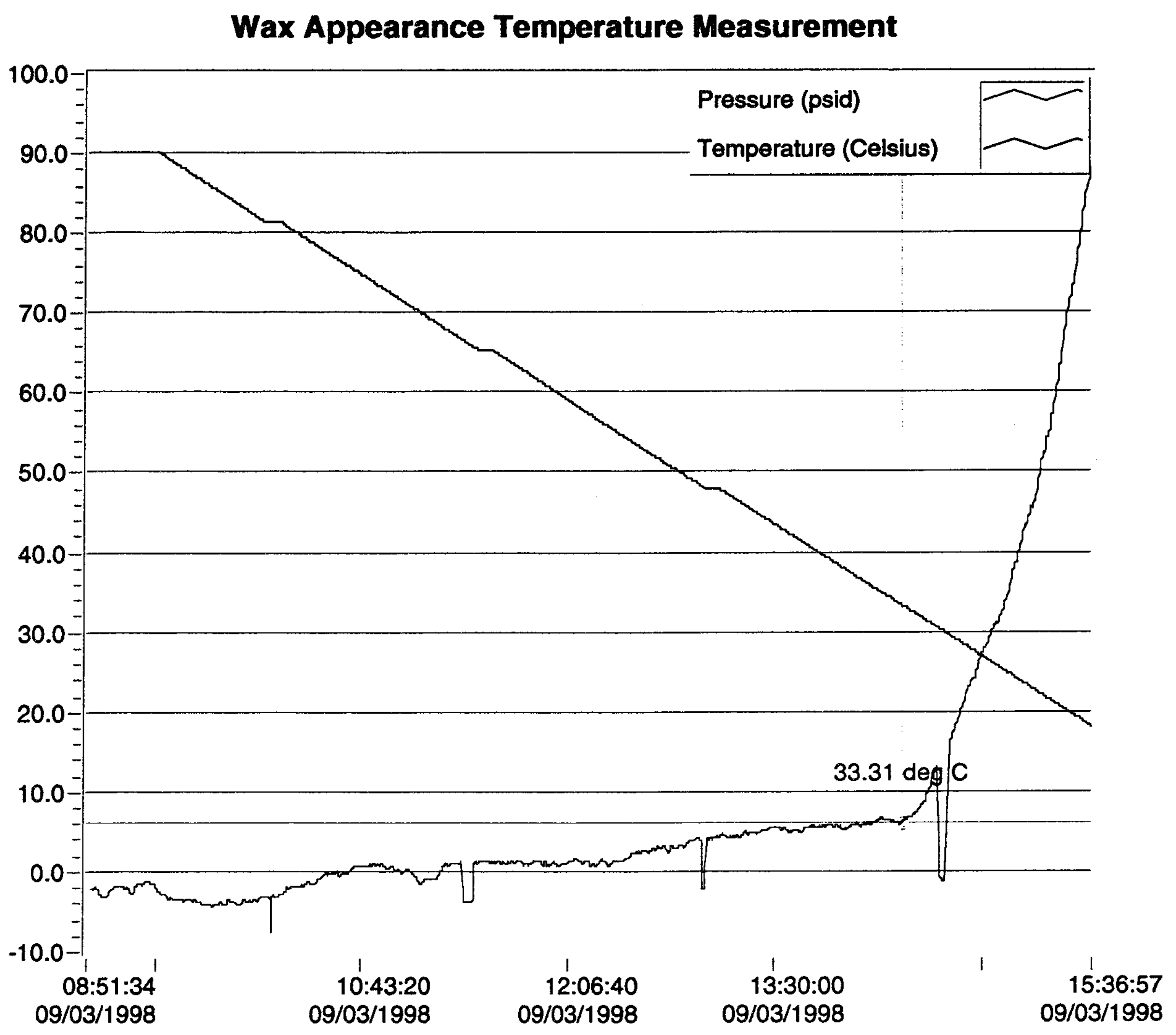
Cyl. no. : Recombination



WAT 80 Bar @ 80C (Run From 90 C , 344 Bar WP)

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Company : Statoil

Well no. : 15/9-19A

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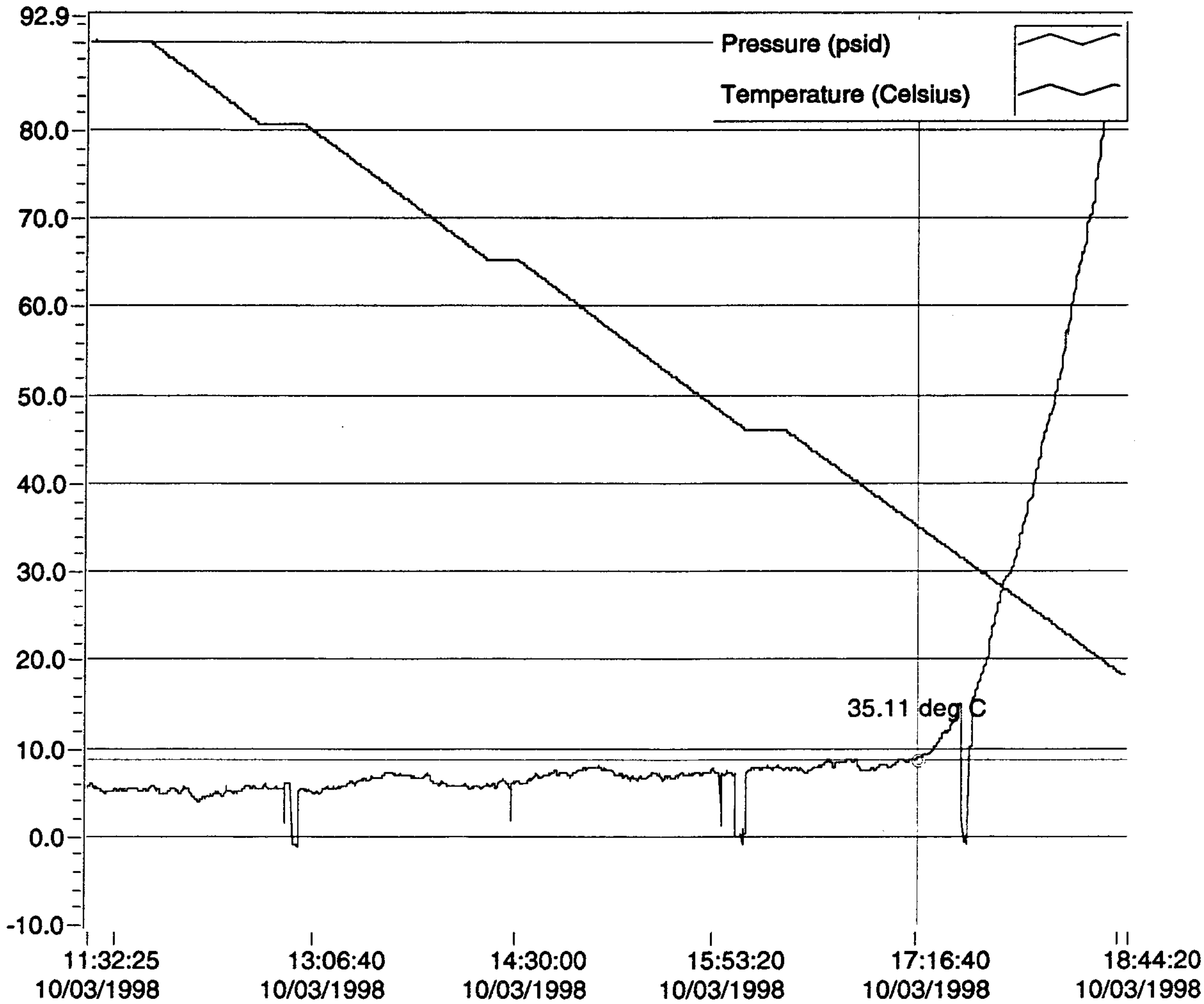
Cyl. no. : Recombination

Wax Appearance Temperature Measurement



WAT 50 Bar @ 80C (Run From 90 C , 344 Bar WP)

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Company : Statoil

Well no. : 15/9-19A

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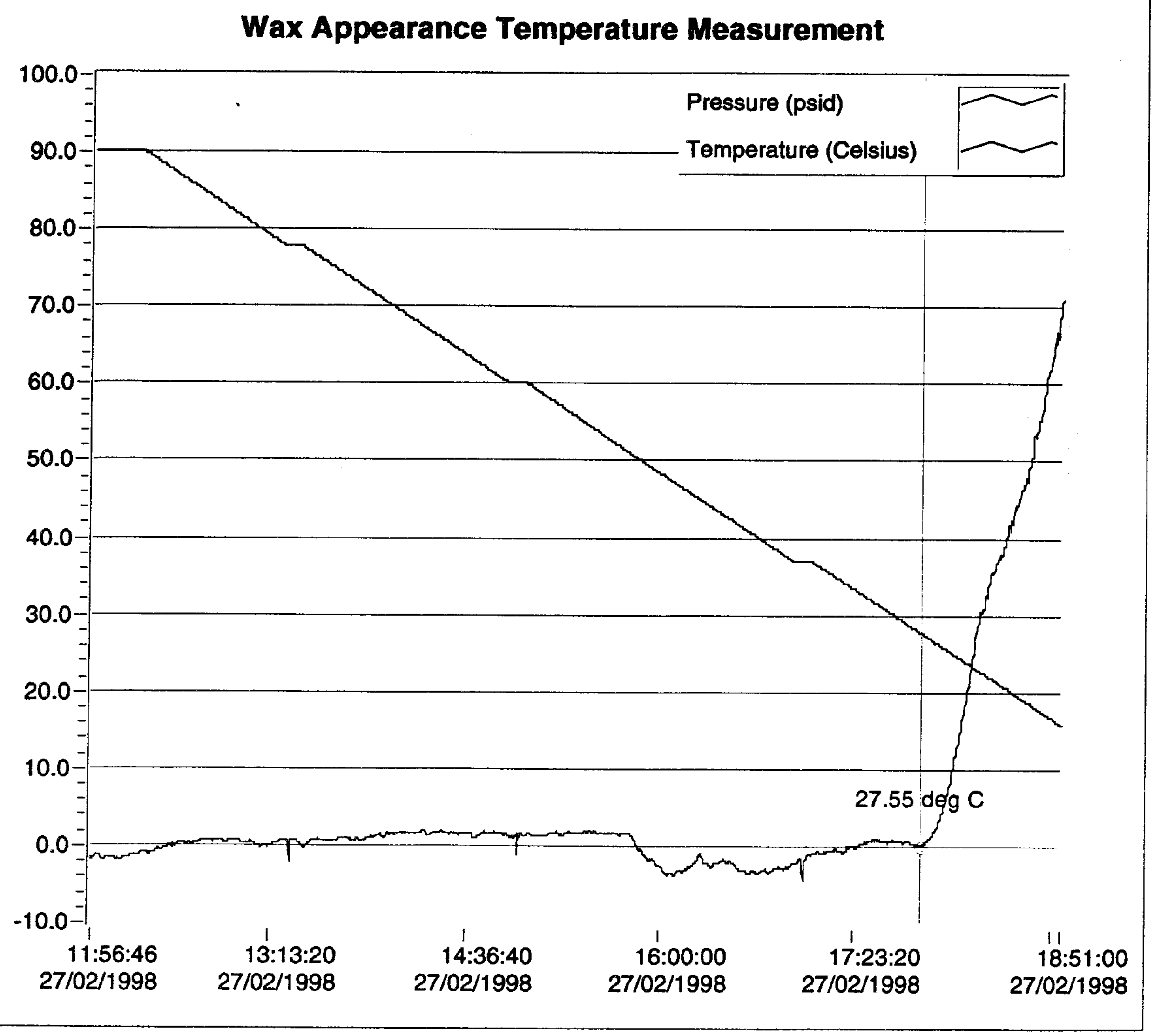
Cyl. no. : Recombination



WAT On Reservoir Fluid (Run From 90 C , 344 Bar WP)

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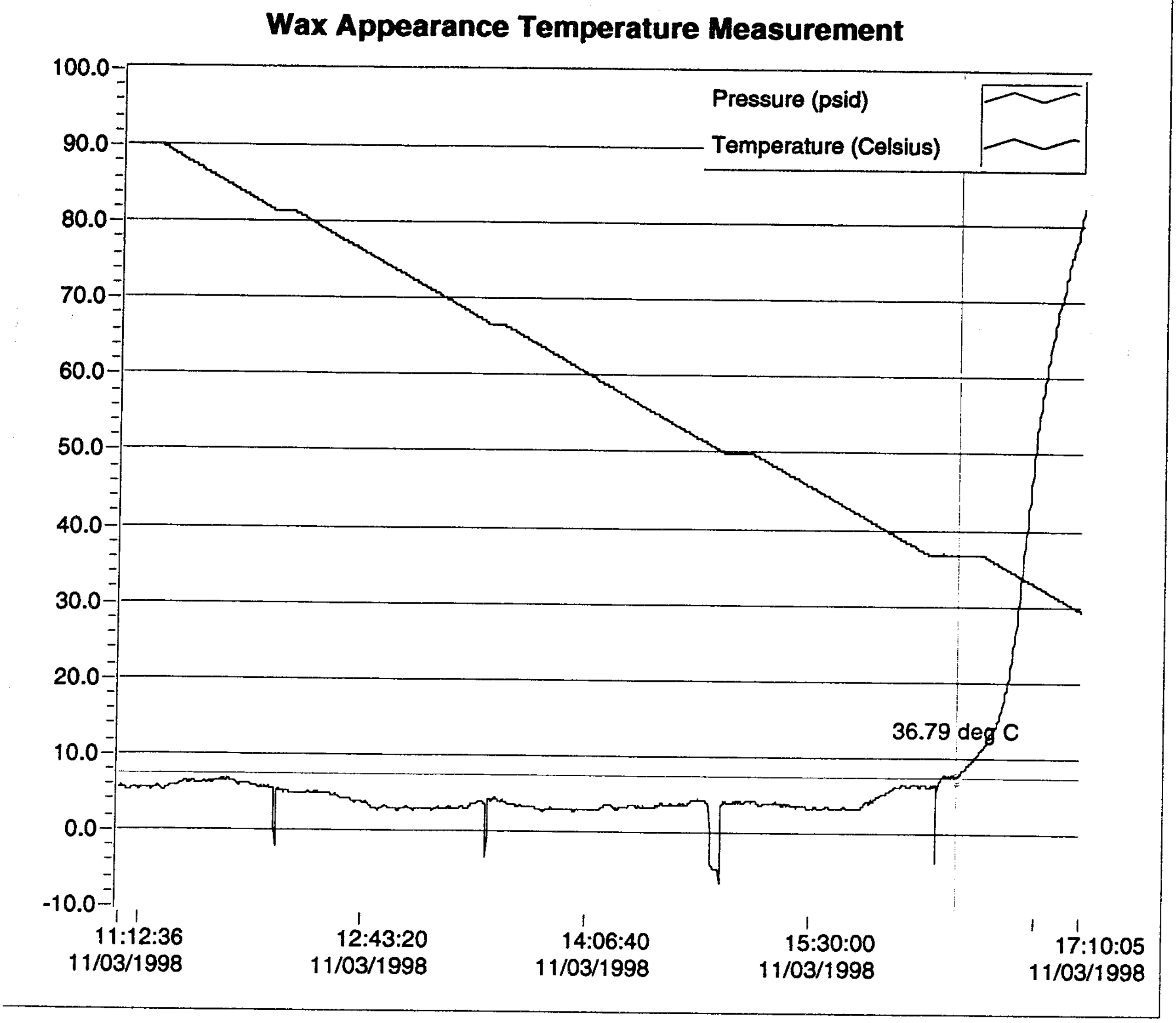
Cyl. no. : Recombination



WAT 20 Bar @ 80C (Run From 90 C , 344 Bar WP)

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Company : Statoil

Well no. : 15/9-19A

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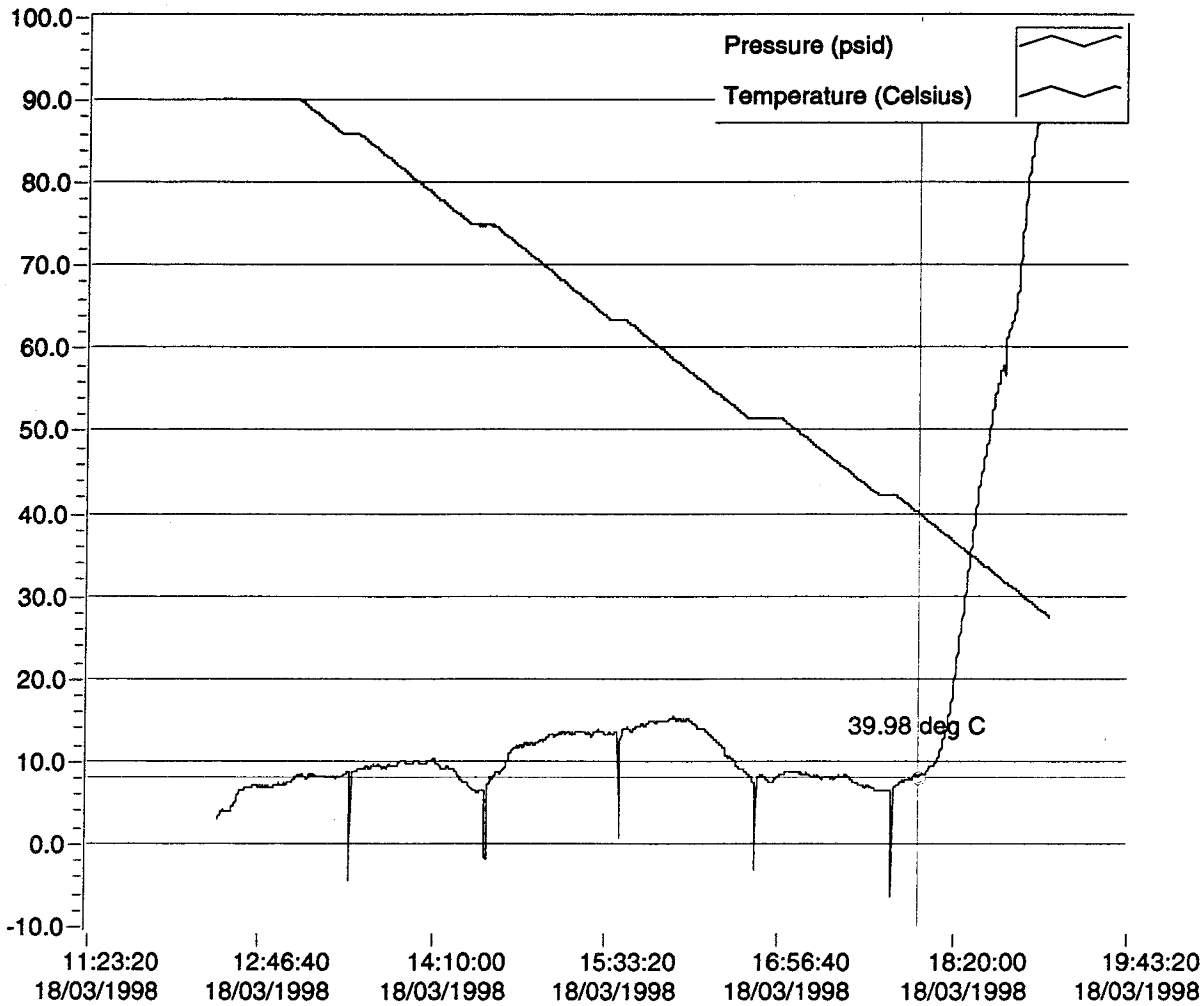
Cyl. no. : Recombination

Wax Appearance Temperature Measurement



WAT 1 Bar @ 80C (Run From 90 C , 344 Bar WP)

Kevin Dalton

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