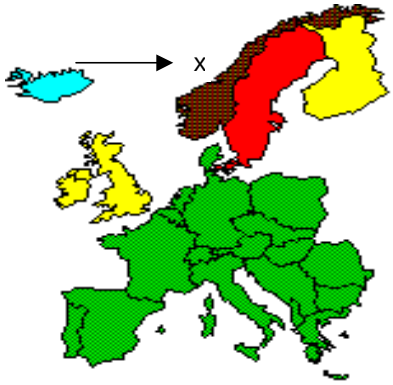
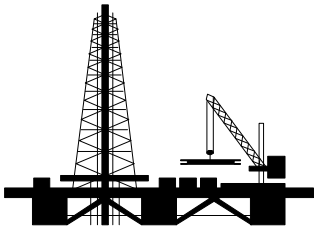
CRUDE OIL ASSAY

Draugen Crude oil





STATOIL

PRODUCT TECHNOLOGY
AND
CUSTOMER SERVICE

Crude Oil and Products
Section

DATE: 21.01.03

C O N T E N T S

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1. SAMPLE DATA

2. DISTILLATION CONDITIONS

3. ANALYTICAL RESULTS

4. ANALYTICAL METHODS

5. TBP - CURVES

1. S A M P L E D A T A

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SAMPLE:	Crude oil
DESCRIPTION:	Draugen
DATE OF SAMPLING:	07.11.02
SAMPLE VOLUME:	60 litres
SAMPLE PACKAGE:	Jerrycans
LABORATORY:	This assay was prepared by Statoil PKS

2. D I S T I L L A T I O N C O N D I T I O N S

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The following conditions according to ASTM are used:

TRUE BOILING POINT DISTILLATION

EQUIPMENT:
The distillation up to 375°C is performed according to D-2892/90, and from 375°C according to D-5236/92 (Vacuum Potstill Method)

CONDITIONS:
The cutpoints are as follows:

Atmospheric distillation:	C5 - 205°C AET
100 Torr:	205 - 240°C AET
10 Torr:	240 - 320°C AET
5 Torr:	320 - 375°C AET
From 1 to 0.1 Torr:	375 - 565°C AET

The atmospheric cutting points are corrected to 760 mmHg.

VOLUME:
Volume expansion or contraction are normalized among fractions boiling below 150°C in proportion to their yields.
(Usually the "Loss" is negative due to volume expansion)

HOLD UP:
Hold up at 375°C AET is distributed as follows: 50% on the first fraction of the Pot Still (375°C-420°C) and 50% in accordance with the mass-ratios of the fractions from 420°C AET.

LOSS:
Loss up to 375°C AET is distributed with 2/3 in the gas-fraction and 1/3 in the first liquid-fraction.

3. ANALYTICAL RESULTS

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PROJECT: CRUDE OIL ASSAY
REF.NO: 801-011

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Table 1 SAMPLE: 801-011 Draugen Crude oil

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Analysis of the whole crude:	Light ends - see tables 8a-8e	
Density at 15°C	kg/l	0.8253
Specific gravity at 60/60°F		0.8256
API gravity at 60/60°F	°API	39.9
Sulphur	mass %	0.147
Total Acid Number (TAN)	mg KOH/g	0.09
Reid Vapor Pressure (RVP)	kPa	62.3
Pour point	°C	-15
Kin. viscosity at 20°C	cSt	4.02
Kin. viscosity at 40°C	cSt	2.49
Nitrogen	mg/kg	540
Hydrogen sulphide	mass %	* ND
Vanadium (V)	mg/kg	1.1
Nickel (Ni)	mg/kg	0.9
Sodium (Na)	mg/kg	61
Wax content	mass %	<5.0
Flash point	°C	<10

* ND: not detectable

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Table 2 SAMPLE: 801-011 Draugen Crude oil

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Fraction	°C	C5-65	65-90	90-150
Yield on crude	mass %	5.47	5.48	13.08
Yield on crude	vol %	6.77	6.12	13.90
Density at 15°C	kg/l	0.6445	0.7151	0.7516
Specific gravity at 60/60°F		0.6445	0.7152	0.7518
API gravity at 60/60°F	°API	88.0	66.3	56.7
Sulphur	mass %		<0.001	0.006
Mercaptan sulphur	mg/kg	<3	<3	<3
n-Paraffins	mass %	50.1	26.7	15.8
i-Paraffins	mass %	43.8	24.6	23.6
Naphthenes	mass %	5.8	48.1	52.4
Aromatics (incl. benzene)	mass %	0.3	0.6	8.3
Benzene	mass %		0.3	0.0
n-Paraffins	vol %	50.8	28.7	17.1
i-Paraffins	vol %	44.0	26.0	24.8
Naphthenes	vol %	4.9	44.8	50.9
Aromatics (incl. benzene)	vol %	0.2	0.5	7.2
Benzene	vol %		0.3	0.0
Vapor Pressure (DVPE)	kPa	103.5	30.6	
Flash point	°C			<10
Research Octane Number (RON)		73.4	66.4	
Motor Octane Number (MON)		69.7	65.8	
Nitrogen	mg/kg		<1	<1

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Table 3 SAMPLE: 801-011 Draugen Crude oil

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Fraction	°C	150-180	180-240	240-320	320-375
Yield on crude	mass %	5.19	9.89	17.31	10.38
Yield on crude	vol %	5.41	9.90	16.68	9.68
Density at 15°C	kg/l	0.7906	0.8244	0.8566	0.8843
Specific gravity at 60/60°F		0.7909	0.8247	0.8570	0.8848
API gravity at 60/60°F	°API	47.4	40.1	33.6	28.4
Sulphur	mass %	0.040	0.047	0.075	0.185
Mercaptan sulphur	mg/kg	6.1	12.7		
Copper corrosion		1a	1a		
Total Acid Number (TAN)	mg KOH/g	<0.01	0.03	<0.01	0.07
n-Paraffins	mass %	5.5			
i-Paraffins	mass %	30.0			
Naphthenes	mass %	45.6			
Aromatics	mass %	18.8			
n-Paraffins	vol %	6.1			
i-Paraffins	vol %	31.8			
Naphthenes	vol %	45.0			
Aromatics	vol %	17.1			
Aromatics (HPLC)					
Total	mass %	17.4	19.2	25.4	29.6
Mono-Aromatics	mass %	17.4	16.8	16.4	18.4
Di-Aromatics	mass %	<0.1	2.4	8.9	8.4
Polycyclic Aromatics	mass %	<0.1	<0.1	0.1	2.8
Naphtalenes	vol %	0.01	1.58		
Aniline point	°C	48.8	54.5	67.0	75.4
Smoke point	mm	23.5	21.0		
Watson K-factor					11.7
Flash point	°C	35.0			
Freezing point	°C	<-60	<-60		
Cloud point	°C		<-41	-22	7
Cold Filter Plugging Point (CFPP)	°C		<-38	-23	7
Pour point	°C		<-39	-21	6
Cetane number			38.6	49.6	54.9
Cetane index (D-976)		26.8	37.1	46.5	47.2
CCI (D-4737)		31.4	37.3	48.8	56.2
Conradson Carbon Residue (CCR)	mass %				<0.10
Kin. viscosity at 20°C	cSt	1.10	1.95	5.57	20.8
Kin. viscosity at 50°C	cSt	0.78	1.23	2.74	7.14
Kin. viscosity at 100°C	cSt				2.48
Nitrogen	mg/kg	<1	<1	12	135
Basic nitrogen	mass %			0.001	0.006
Refractive index at 67°C					1.472
Distillation D-86 (50%)	°C	158.4	204.8	273.7	336.4

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Table 4 SAMPLE: 801-011 Draugen Crude oil

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Fraction	°C	375-420	420-525	525-565
Yield on crude	mass %	6.29	14.21	2.71
Yield on crude	vol %	5.76	12.81	2.37
Density at 15°C	kg/l	0.9011	0.9155	0.9409
Specific gravity at 60/60°F		0.9016	0.9160	0.9415
API gravity at 60/60°F	°API	25.4	23.0	18.8
Sulphur	mass %	0.224	0.283	0.435
Total Acid Number (TAN)	mg KOH/g	0.10	0.15	0.15
Aniline point	°C	85.4	92.2	96.4
Watson K-factor		11.8	11.9	11.9
Pour point	°C	27	39	>45
Conradson Carbon Residue (CCR)	mass %	<0.10	0.14	2.2
Kin. viscosity at 50°C	cSt	20.3	58.6	
Kin. viscosity at 80°C	cSt			70.7
Kin. viscosity at 100°C	cSt	4.95	9.71	31.9
Vanadium (V)	mg/kg	<0.1	<0.1	<0.1
Nickel (Ni)	mg/kg	<0.1	<0.1	0.5
Nitrogen	mg/kg	460	1000	2230
Basic nitrogen	mass %	0.016	0.032	0.061
Refractive index at 67°C		1.480	1.490	1.506

Table 5 SAMPLE: 801-011 Draugen Crude oil

Fraction	°C	375+	525+	565+
Yield on crude	mass %	29.59	9.09	6.39
Yield on crude	vol %	26.38	7.81	5.44
Density at 15°C	kg/l	0.9258	0.9602	0.9687 (1)
Specific gravity at 60/60°F		0.9263	0.9608	0.9693
API gravity at 60/60°F	°API	21.3	15.8	14.5
Sulphur	mass %	0.356	0.557	0.609
Total Acid Number (TAN)	mg KOH/g	0.18		
Aniline point	°C	91.1	93.7	93.8
Watson K-factor		11.9	11.9	12.0
Pour point	°C	42	>45	45
Conradson Carbon Residue (CCR)	mass %	3.4	11.3	15.1
Asphaltenes	mass %	<0.50	0.71	1.09
n-Pentane insolubles	mass %	1.0	3.9	5.3
Ash	mass %	0.013	0.090	0.144
Kin. viscosity at 50°C	cSt	133		
Kin. viscosity at 80°C	cSt		694	
Kin. viscosity at 100°C	cSt	16.8	217	681
Kin. viscosity at 135°C	cSt			118
Vanadium (V)	mg/kg	3.4	12	16
Nickel (Ni)	mg/kg	4.0	13	17
Nitrogen	mg/kg	1850	4030	4780
Basic nitrogen	mass %	0.050	0.111	0.158
Penetration at 25°C	0.1mm		225	90
Refractive index at 67°C		1.502		

(1): Calculated density for 525+ and 565+ fractions.

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Table 6 SAMPLE: 801-011 Draugen Crude oil

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DISTILLATION

YIELD MASS-%

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Date:	05.12.02	
Intake:	23160.0	g
Density at 15°C:	0.8253	kg/l

FRACTION	Mass g	Yield mass %	Cumul. yield mass %	Temperature °C
Loss	0.0	0.00	0.00	
Gases	838.1	3.62	3.62	15
C5-65	1266.0	5.47	9.09	65
65-90	1269.2	5.48	14.57	90
90-150	3029.1	13.08	27.64	150
150-180	1201.0	5.19	32.83	180
180-205	776.7	3.35	36.18	205
205-240	1514.7	6.54	42.72	240
240-320	4009.7	17.31	60.04	320
320-375	2403.0	10.38	70.41	375
375-420	1455.8	6.29	76.70	420
420-525	3291.1	14.21	90.91	525
525-565	626.6	2.71	93.61	565
565+	1479.0	6.39	100.00	

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Table 7 SAMPLE: 801-011 Draugen Crude oil

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DISTILLATION

YIELD VOL-% AND DENSITY

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Date:	05.12.02
Intake:	23160.0 g
Density at 15°C:	0.8253 kg/l

FRACTION	Density at 15°C (kg/l)	Yield vol %	Cumul. yield vol %	Temperature °C
Loss		0.00	0.00	
Gases	0.5617	5.14	5.14	15
C5-65	0.6445	6.77	11.92	65
65-90	0.7151	6.12	18.04	90
90-150	0.7516	13.90	31.94	150
150-180	0.7906	5.41	37.35	180
180-240	0.8244	9.90	47.25	240
240-320	0.8566	16.68	63.94	320
320-375	0.8843	9.68	73.62	375
375-420	0.9011	5.76	79.38	420
420-525	0.9155	12.81	92.19	525
525-565	0.9409	2.37	94.56	565
565+	0.9687	5.44	100.00	

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Table 8a SAMPLE: 801-011 Draugen Crude oil

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COMPOSITIONAL ANALYSIS OF CRUDE OIL (MASS %)

NORMAL PARAFFINS:

Methane	<0.01
Ethane	0.03
Propane	0.53
Butane	1.77
Pentane	2.10
Hexane	1.68
Heptane	1.33
Octane	0.95
Nonane	0.39
Sum n-paraffins	8.78

C4 HYDROCARBONS

i-Butane	0.47

C5 HYDROCARBONS

ISO PARAFFINS:

2,2-Dimethylpropane	<0.01
i-Pentane	1.51
Sum C5 i-paraffins	1.51

NAPHTHENES:

Cyclopentane	0.19

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Table 8b SAMPLE: 801-011 Draugen Crude oil

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C6 HYDROCARBONS

ISO PARAFFINS:

2,2-Dimethylbutane	0.04
2,3-Dimethylbutane	0.12
2-Methylpentane	0.99
3-Methylpentane	0.59
Sum C6 i-paraffins	1.74

NAPHTHENES:

Methylcyclopentane (Inc. 2,2-Dimethylpentane)	1.02
Cyclohexane	1.38
Sum C6 naphthenes	2.40

AROMATICS:

Benzene	0.02

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Table 8c SAMPLE: 801-011 Draugen Crude oil

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C7 HYDROCARBONS

ISO PARAFFINS:

2,2,3-Trimethylbutane	<0.01
3,3-Dimethylpentane	0.02
2,4-Dimethylpentane	0.08
2-Methylhexane	0.60
2,3-Dimethylpentane	0.05
3-Methylhexane	0.56
Sum C7 i-paraffins	1.31

NAPHTHENES:

cis-1,3-Dimethylcyclopentane	0.25
trans-1,3-Dimethylcyclopentane	0.23
trans-1,2-Dimethylcyclopentane	0.44
Methylcyclohexane	2.52
Ethylcyclopentane	0.13
1,1-Dimethylcyclopentane	0.14
Sum C7 naphthenes	3.70

AROMATICS:

Toluene	0.31

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Table 8d SAMPLE: 801-011 Draugen Crude oil

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C8 HYDROCARBONS

ISO PARAFFINS:

2,2,4-Trimethylpentane	<0.01
2,5-Dimethylhexane	0.07
2,4-Dimethylhexane	0.09
3,4-Dimethylhexane	0.01
3,3-Dimethylhexane	0.02
2,3-Dimethylhexane	0.11
(Inc. naphthenic compound)	
2-Methyl-3-ethylpentane	0.02
2-Methylheptane	0.50
4-Methylheptane	0.17
3-Methylheptane	0.90
2,3,4-Trimethylpentane	0.01
Sum C8 i-paraffins	1.91

NAPHTHENES:

1,1,3-Trimethylcyclopentane	0.15
(Inc. 2,2-Dimethylhexane)	
trans, cis-1,2,4-Trimethylcyclopentane	0.14
trans,cis-1,2,3-Trimethylcyclopentane	0.14
trans-1,4-Dimethylcyclohexane	0.22
1,1-Dimethylcyclohexane	0.08
trans-1-Methyl-3-ethylcyclopentane	0.05
cis-1-Methyl-3-ethylcyclopentane	0.04
trans-1-Methyl-2-ethylcyclopentane	0.11
trans-1,2-Dimethylcyclohexane	0.28
2-Propylcyclopentane	0.02
cis-1,2-Dimethylcyclohexane	0.13
Ethylcyclohexane	0.67
1-Propylcyclopentane	0.19
cis,cis-1,2,4-Trimethylcyclopentane	0.02
1-Methyl-1-ethylcyclopentane	0.02
cis-1,3-Dimethylcyclohexane	<0.01
(Inc. naphthenic compound)	
Sum C8 naphthenes	2.25

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Table 8e SAMPLE: 801-011 Draugen Crude oil

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AROMATICS:

Ethylbenzene	0.14
m- & p-Dimethylbenzene (m- & p- xylene)	0.64
o-Dimethylbenzene (o-Xylene)	0.20
Sum C8 aromatics	0.98

C9 HYDROCARBONS

ISO PARAFFINS:

3,5-Dimethylheptane	0.14
4-Methyloctane	0.14
2-Methyloctane	0.19
3-Methyloctane	0.25
2,3,4-Trimethylhexane	<0.01
Unidentified paraffin	0.09
Sum C9 i-paraffins	0.82

NAPHTHENES:

1,1,3-Trimethylcyclohexane	0.19
1-Methyl-2-propylcyclopentane	0.08
1-Methyl-3-ethylcyclohexane	0.22
1-Methyl-4-ethylcyclohexane	0.15
1,1,4-Trimethylcyclohexane	0.10
Unidentified naphthenes	0.07
Sum C9 naphthenes	0.80

TOTAL IDENTIFIED	27.19
TOTAL UNIDENTIFIED	0.27
TOTAL C10+	72.54

4. ANALYTICAL METHODS

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Table 9a SAMPLE: 801-011 Draugen Crude oil

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TEST	UNITS	METHOD
Density at 15°C	kg/l	D-4052/D-5002
Specific gravity at 60/60 °F		-
Total Sulphur	mass %	D-4294
Total Sulphur	mass %	D-5453 for sulphur content less than 0,01%
Hydrogen sulphide	mass %	D-3227
Mercaptan sulphur	mg/kg	D-3227
n-Paraffins	mass %	GC
i-Paraffins	mass %	GC
Naphthenes	mass %	GC
Aromatics	mass %	GC
Benzene	mass %	GC
Aromatics - HPLC	mass %	IP-391/95
Naphthalene	vol %	D-1840
Watson K		UOP 375
Vapor Pressure (DVPE)	kPa	D-5191
Reid Vapor Pressure (RVP)	kPa	D-323
Flash point (Pensky Martens)	°C	D-93
Freezing point	°C	D-2386
Cloud point	°C	D-2500/D-5772
Pour point	°C	D-5853/D-5950
Could Filter Plugging Point	°C	IP 309
Kin. viscosity at 20°C	cSt	D-445
Kin. viscosity at 50°C	cSt	D-445
Kin. viscosity at 80°C	cSt	D-445
Kin. viscosity at 100°C	cSt	D-445
Kin. viscosity at 135°C	cSt	D-445

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Table 9b SAMPLE: 801-011 Draugen Crude oil

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TEST	UNITS	METHOD
Aniline Point	°C	D-611
Research Octane Number (RON)		D-2699/95
Motor Octane Number (MON)		D-2700/95
Cetane index		D-976
Calculated Cetane Index (CCI)		D-4737
Cetane number		D-613
Smoke point	mm	D-1322
Distillation of the whole crude up to 375°C		D-2892
Distillation of the indivudal fractions		D-86
Distillation of 375+ °C		D-5236
Total Acid Number (TAN)	mgKOH/g	D-664
Copper corrosion		D-130
Nitrogen: fractions up to 420 °C	mg/kg	D-4629
Nitrogen: fractions above 420 °C	mg/kg	D-4629 modified
Basic nitrogen	mass %	UOP 269
Vanadium (V)	mg/kg	ICP-AES
Nickel (Ni)	mg/kg	ICP-AES
Sodium (Na)	mg/kg	ICP-AES
Conradson Carbon Residue or	mass %	D-189
Carbon Residue (Micro Method)	mass %	D-4530
Asphaltenes	mass %	IP 143
n-C5 Insolubles	mass %	D-4055
Ash	mass %	D-482
Penetration at 25°C	0.1mm	D-1321
Refractive index at 67°C		Abbe refractometer
Wax content	mass %	UOP 46 (mod. acetone precip.)