Prøvetaking og analyse av gass og olje fra 1st trinns separator

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EMNER

- Prøvetaking
- Kondisjonering av prøver i lab før analyse.
- Gass kromatografi
- Molekylvektmåling
- Rekombinere gas og væske komposisjoner til brønnstrøm komposisjon

Prøvetaking prosedyre

Sample gass og olje samtidig, over ca 30 minutters periode. Typisk 20 liter gass flasker og 0.5 liter olje flasker. Gassflaskene fylles fra vakuum.
Stempelflasker med gylcol bak stempelet er vanlig for oljeprøver.

Jevn trykkoppbygging i gassflaskene under fylling
Glykoltrykket bak stempel i oljeflasken må sjekkes jevnlig at det er lik separator trykk under fylling.

Termisk isolering og heat tracing av ventiler og sample linjer for å hindre nedkjøling

Nedkjøling av gass under sampling gir utfelling av væske. Nedkjøling av olje kan gi utfelling av voks eller hydrater (plugging av ventiler).

Prøvertaking fra 1. trinns separator

- Første trinn har ofte høye trykk og temperaturer
- Gassen er på duggunktet
- Væsken (olje eller kondensat) er på kokepunktet
- Små endringer i P,T kan gi utfelling av væske fra gass og gass fra væske

- Carry-over av væske på gassutløp: Kan skyldes skumming eller væsketåke som følger gassen ut av separator.

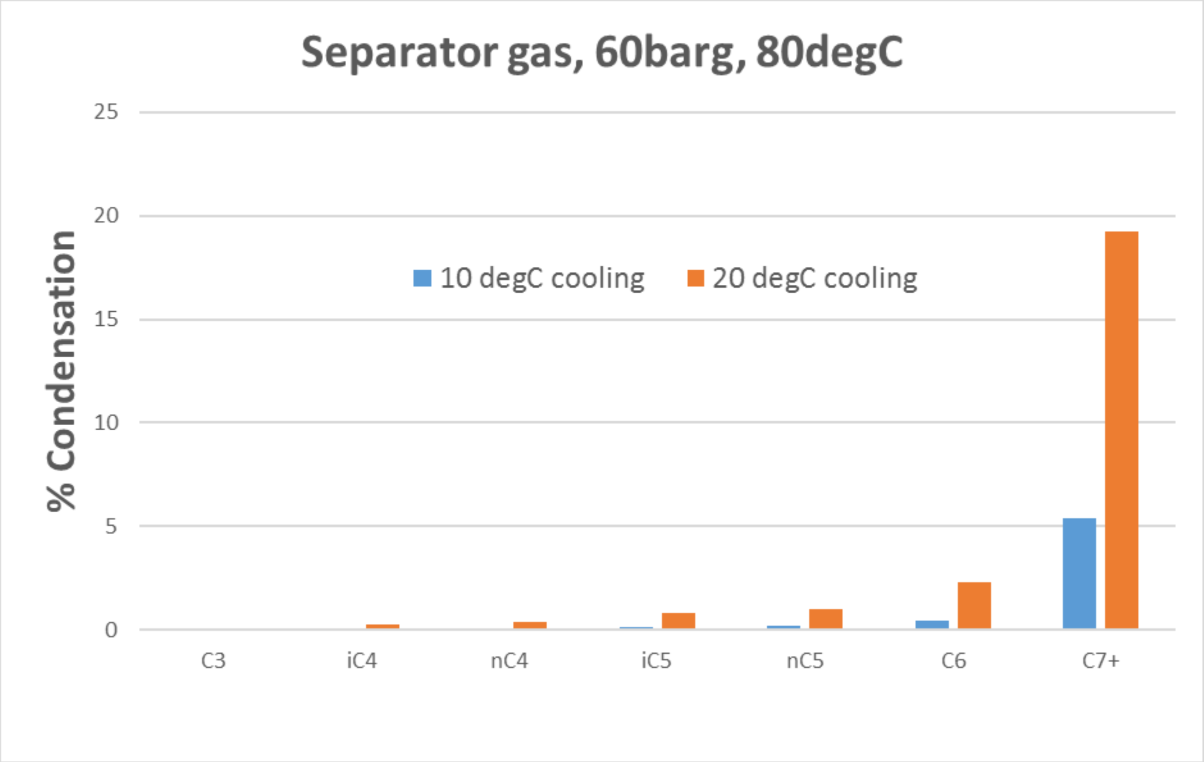
- Kan påvirke gass flow-rate måling.
- Olje i gass sample vil gi feilaktig gass komposisjon (tunge komponenter)

- Gass i olje vil påvirke olje flow-meter

-Carry-under: Gassbobler følger oljen ut av separator (viskøs olje, for lav rentensjonstid)
-Trykkfall i oljelinjen kan frigøre gassbobler før oljemeter (flow Dp eller fallende separator-trykk)

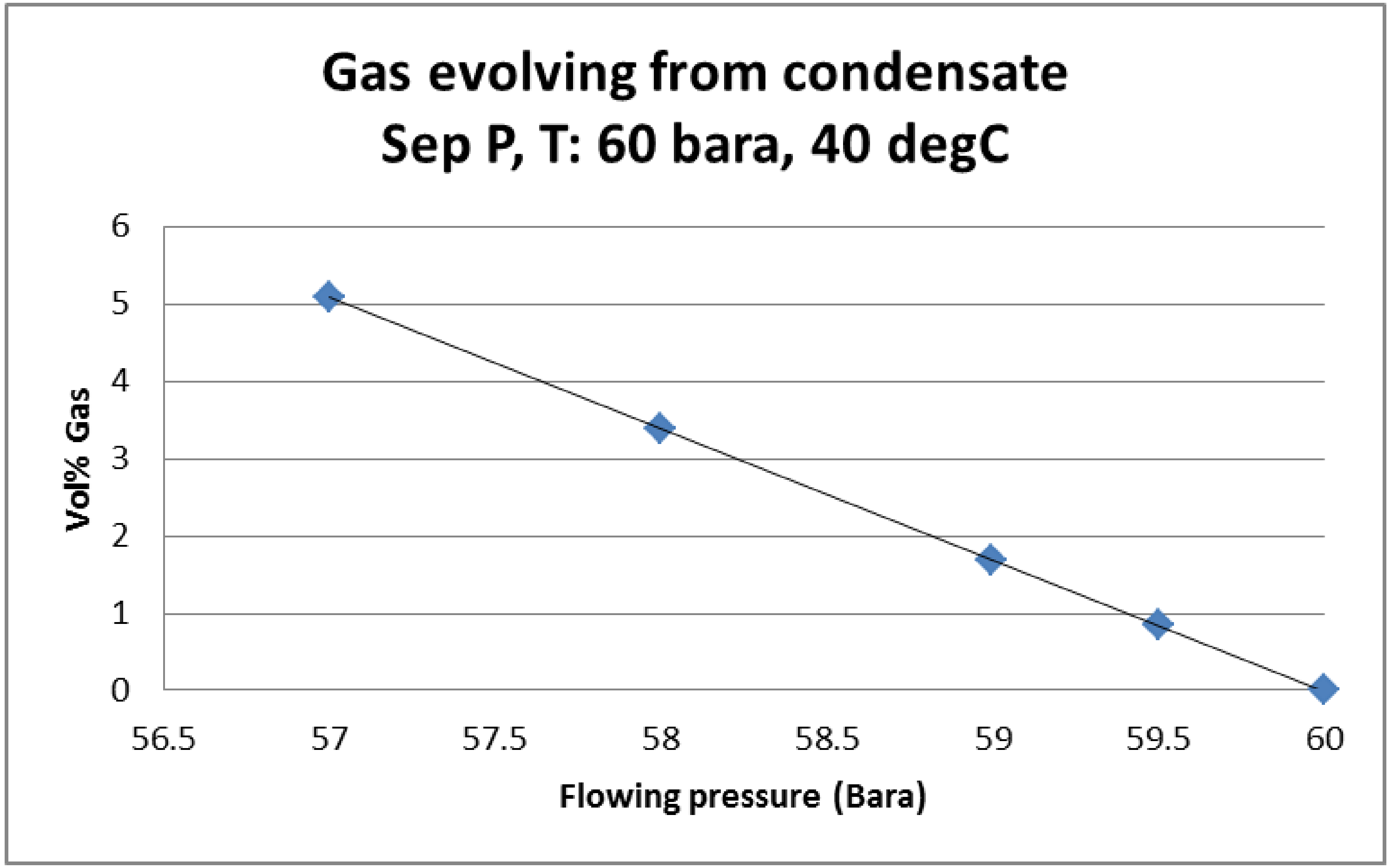
- Kan påvirke oljekomposisjon i prøveflaske

Sep Gas Condensation by Cooling



	80C	70C	60C
N2	0.966	0.966	0.967
CO2	0.962	0.962	0.963
C1	81.988	82.006	82.062
C2	7.671	7.672	7.673
C3	3.795	3.794	3.791
iC4	1.403	1.403	1.399
nC4	1.854	1.853	1.847
iC5	0.269	0.269	0.267
nC5	0.443	0.442	0.438
C6	0.407	0.405	0.397
C7+	0.242	0.229	0.195
Tot	100.0	100.0	100.0

Pressure drop in oil outlet will release gas



Gas in the oil outlet will disturb the oil rate measurement.

Causes:

- Decreasing separator pressure

- Pressure drop in the pipe from buttom of separator to oil meter location (large flow rate and wax or deposits constricting the pipe cross-section)

Sample checks and conditioning

-Check gas bottle pressure to ensure no leakage

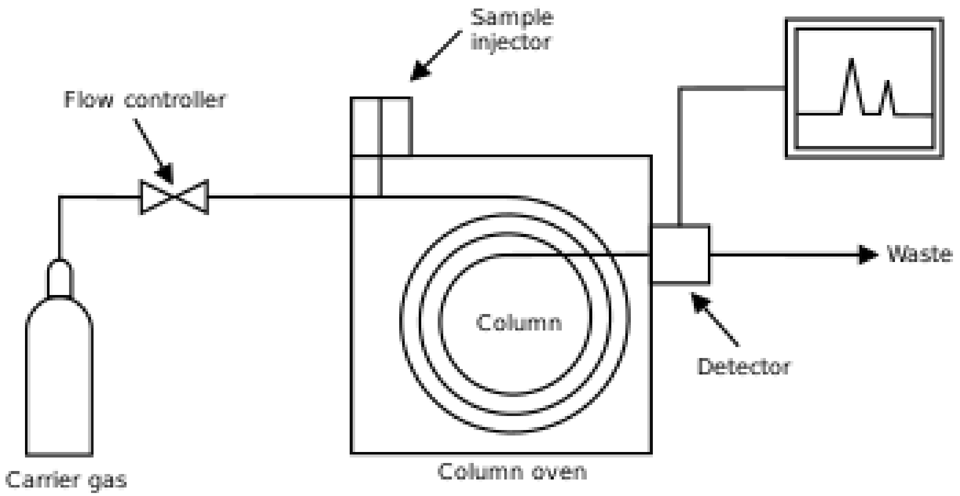
-Oil samples: Visual inspection for leakage

-Gas sample bottles are heated for at least 24 hours at T > Sep T

-Invert the bottle, rotate or roll bottle over the floor a few times during the heating process to help evaporate condensed liquid inside the bottle.

- Oil bottles are repressurized and heated to sep T and shaken (usually a mixing element inside the bottle) to homogenize before analysis.
- Check that bubble point is equal to sep pressure at sep temperature

GC working principle



Common carrier gas: He, H2

Sample inj as short «pulse» into carrier gas flow.

Different types of molecules diffuse through the column at different speeds and arrive at the detector at different times.

Common detector types: FID and TCD
FID: Flame Ionisation detector, require H2 supply.
TCD: Thermal Conductivity Detector
Used in combination.

The column oven temperature is gradually increased too gradually mobilise heavier and heavier hydrocarbons through the column.

GC

FID detector signals corresponds roughly to mass fractions in samples

TCD detector signals corresponds roughly to mole fractions in samples

Calibrated respons factors to convert signals into mass fractions and mole fractions.

Extensive and frequent calibrations required to keep uncertainty specs.

Separator gases ususally contains negligible amounts of larger molecules than c10 (MW ca 140 g/mol)

Oil can contain significant amounts of hydrocarbons > 1000 g/mol
Condensates usually only small amounts MW> 300 g/mol

GC analysis

Separator gases:
Low pressure heated gas sample is injected and analysed directly.

Separator oil:

The live oil sample is flashed to atm conditions. The flash gas volume and flash GOR is measured. A sample of the flash gas is analysed the same way as the separator gas.

Density, shrinkage and MW of the dead oil is measured.
A sample of the dead oil is analysed by GC

The dead oil composition is recombined with the flash gas composition to give the live oil composition. Here the flash GOR, measured MW, density is used to calculate the recombination factor (molar flash gas fraction)

Sep gas analysis

Table 2: Separator Gas Composition

Sample Number: [redacted]
Cylinder Number:
Well Number:

Component	mol%	wt%
N_2	2.810	3.333
H_2S	0.020	0.029
CO_2	0.854	1.592
C1	71.023	48.236
C2	10.382	13.219
C3	8.461	15.800
iC4	1.696	4.173
nC4	2.494	6.139
neo-Pentane	0.010	0.031
iC5	0.675	2.063
nC5	0.836	2.554
C6	0.538	1.962
Benzene	0.003	0.011
C7	0.165	0.699
Toluene	0.002	0.007
C8	0.029	0.138
Ethylbenzene	<0.001	0.001
m- and p- Xylenes	<0.001	0.001
o- Xylene	0.000	0.000
C9	0.002	0.012
C10	<0.001	<0.001
C11	<0.001	<0.001
C12	0.000	0.000
C13	0.000	0.000
C14	0.000	0.000
C15	0.000	0.000
Total	100.000	100.000

Molecular Weight / (g/mol)	:	23.6
Gas Gravity, (air=1.000)	:	0.815

GC Oil analysis

Table 3: Separator Liquid Composition

Sample Number: 2.01
Cylinder Number: [redacted]
Well Number: [redacted]

Component	Evolved Gas wt%	Evolved Gas mol%	Stabilised Liquid wt%	Stabilised Liquid mol%	Separator Liquid wt%	Separator Liquid mol%	Plus Fraction	Plus Fraction Composition wt%	Plus Fraction Composition mol%	Estimated Density[1] g/cm³	Molecular Weight[1] g/mol
N_2	0.675	0.784	-	-	0.003	0.029					
H_2S	0.000	0.000	-	-	0.000	0.000					
CO_2	1.082	0.800	-	-	0.004	0.029					
C1	21.350	43.298	-	-	0.086	1.577					
C2	16.959	18.346	0.054	0.548	0.122	1.197					
C3	27.838	20.534	0.285	1.973	0.395	2.650					
iC4	7.842	4.389	0.181	0.951	0.212	1.076					
nC4	12.023	6.729	0.400	2.103	0.447	2.272					
neo-Pentane	0.060	0.027	0.011	0.045	0.011	0.044					
iC5	3.982	1.795	0.305	1.293	0.320	1.312					
nC5	4.001	1.804	0.403	1.709	0.418	1.712					
C6	2.677	1.010	0.768	2.723	0.776	2.660					
Benzene	0.015	0.006	0.014	0.053	0.014	0.051	C7+	97.206	85.442	0.882	336
C7	1.297	0.421	1.336	4.073	1.336	3.940					
Toluene	0.004	0.002	0.068	0.224	0.067	0.216					
C8	0.188	0.053	1.784	4.772	1.777	4.600					
Ethylbenzene	0.000	0.000	0.056	0.160	0.056	0.155					
m- and p- Xylenes	0.000	0.000	0.099	0.286	0.099	0.276					
o- Xylene	0.000	0.000	0.070	0.200	0.069	0.193					
C9	0.006	0.002	1.620	3.860	1.614	3.719					
C10	0.001	<0.001	2.053	4.409	2.045	4.249					
C11	0.000	0.000	1.975	3.860	1.967	3.720					
C12	0.000	0.000	2.116	3.795	2.107	3.657	C12+	88.162	64.323	0.899	405
C13	0.000	0.000	2.357	3.907	2.348	3.764					
C14	0.000	0.000	2.348	3.616	2.338	3.484					
C15	0.000	0.000	2.423	3.486	2.413	3.359					
C16	-	-	2.221	2.997	2.212	2.888					
C17	-	-	2.573	3.270	2.563	3.151					
C18	-	-	2.227	2.674	2.218	2.576					
C19	-	-	1.890	2.150	1.882	2.072					
C20	-	-	2.010	2.174	2.002	2.095	C20+	70.081	39.372	0.924	526
C21	-	-	1.935	1.994	1.928	1.921					
C22	-	-	1.930	1.899	1.923	1.830					
C23	-	-	1.863	1.754	1.856	1.690					
C24	-	-	1.781	1.607	1.774	1.549					
C25	-	-	1.731	1.500	1.725	1.445					
C26	-	-	1.747	1.455	1.740	1.402					
C27	-	-	1.748	1.403	1.741	1.352					
C28	-	-	1.792	1.387	1.785	1.337					
C29	-	-	1.993	1.489	1.985	1.435					
C30	-	-	1.938	1.401	1.930	1.350					
C31	-	-	1.887	1.320	1.880	1.272					
C32	-	-	1.738	1.178	1.731	1.135					
C33	-	-	1.538	1.011	1.532	0.974					
C34	-	-	1.379	0.880	1.374	0.848					
C35	-	-	1.294	0.802	1.289	0.773					
C36+	-	-	42.059	17.609	41.886	16.964	C36+	41.886	16.964	0.949	730
Total	100.000	100.000	100.000	100.000	100.000	100.000		100.000	100.000	-	296

Notes:

1. Density and Molecular Weight data for compositional fractions are calculated as per the references found in the Appendix.

Flash and recombination data

Properties of Single Stage Flash at 13.2°C

Sample Number: [redacted]
Cylinder Number:

Single Stage Flash to Stock Tank Conditions		
Gas Liquid Ratio	73.3	sm³/sm³
Gas Gravity, (air = 1.000)	1.005	
Stabilised Oil Gravity at STP	0.7662	[53.18°API]
Fluid Volume Factor (1)	1.187	
Saturation Pressure	47.24	bara
Fluid Density at Saturation Pressure	0.721	g/cm³

Data for Recombination

Sample Number : [redacted]
Cylinder Number:

Separator Gas	Field Data	Laboratory Data
Gas Gravity, sg, (air=1.000)	0.614	0.623
Fg, (sg-½)	1.276	1.267
Fpv, (Z-½)	1.066	1.066
GLR (sm³/sm³) (2)	14317.6	14221.8
CGR (10^{-6}sm³/sm³)	69.8	70.3
Correction Factor	0.993	

Data for recombination of dead oil and flash gas to live oil composition

Data for recombining separator gas and live oil to wellstream composition. Sep gas composition is used to slightly improve field data: sg, Z and GOR

Recombining gas and liquids into wellstream composition

Molar flows

Gas: $F_g = Q_{vg}/V_{mg}$

Oil: $F_o = Q_{vo}/V_{mo}$

Separator flow rates: Q_{vg} and Q_{vo}.

Gas and oil molar volumes: V_{mg}, V_{mo}

Gas molar fraction: $\alpha = F_g/(F_g+F_o)$

Gas composition: $y(i)$

Oil composition: $x(i)$

Recombined: $z(i) = \alpha y(i) + (1-\alpha)x(i)$

Recombined composition

Table 5: Calculated Recombined Fluid Composition

Sample Numbers: [redacted]
Cylinder Numbers:
Well Number:

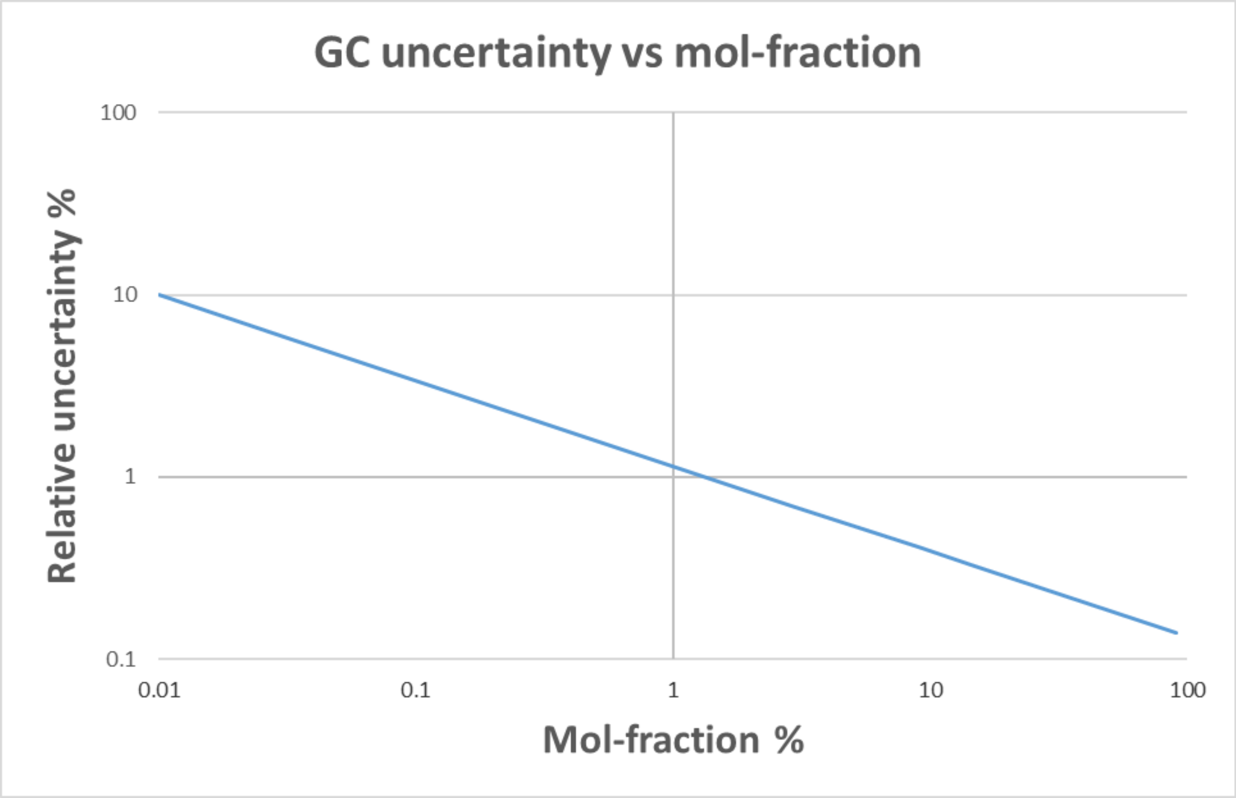
Recombination GOR xxx sm³/sep m³

Component	Calculated Fluid wt%	Calculated Fluid mol%	Plus Fraction	Plus Fraction Composition wt%	Plus Fraction Composition mol%	Estimated Density [1] g/cm³	Molecular Weight g/mol
N_2	0.081	0.674					
H_2S	0.001	0.005					
CO_2	0.042	0.221					
C1	1.221	17.690					
C2	0.430	3.328					
C3	0.758	3.998					
iC4	0.305	1.220					
nC4	0.581	2.323					
neo-Pentane	0.011	0.036					
iC5	0.361	1.164					
nC5	0.468	1.509					
C6	0.804	2.168					
Benzene	0.013	0.040	C7+	94.937	65.664	0.882	336
C7	1.321	3.064					
Toluene	0.066	0.167					
C8	1.739	3.539					
Ethylbenzene	0.054	0.119					
m- and p- Xylenes	0.097	0.212					
o- Xylene	0.068	0.148					
C9	1.576	2.857					
C10	1.997	3.263					
C11	1.920	2.857					
C12	2.058	2.809	C12+	86.086	49.398	0.899	405
C13	2.292	2.891					
C14	2.283	2.676					
C15	2.357	2.579					
C16	2.160	2.218					
C17	2.502	2.420					
C18	2.166	1.978					
C19	1.838	1.591					
C20	1.955	1.609	C20+	68.430	30.236	0.924	526
C21	1.882	1.476					
C22	1.877	1.405					
C23	1.812	1.298					
C24	1.732	1.189					
C25	1.684	1.110					
C26	1.699	1.077					
C27	1.700	1.038					
C28	1.743	1.027					
C29	1.938	1.102					
C30	1.885	1.036					
C31	1.836	0.977					
C32	1.691	0.872					
C33	1.496	0.748					
C34	1.341	0.651					
C35	1.258	0.594					
C36+	40.901	13.027	C36+	40.901	13.027	0.949	730
Total	100.000	100.000		100.000	100.000		233

Notes:

1. Density: Taken from Katz and Firoozabadi, Journal of Petroleum Tech., Nov. 1978.

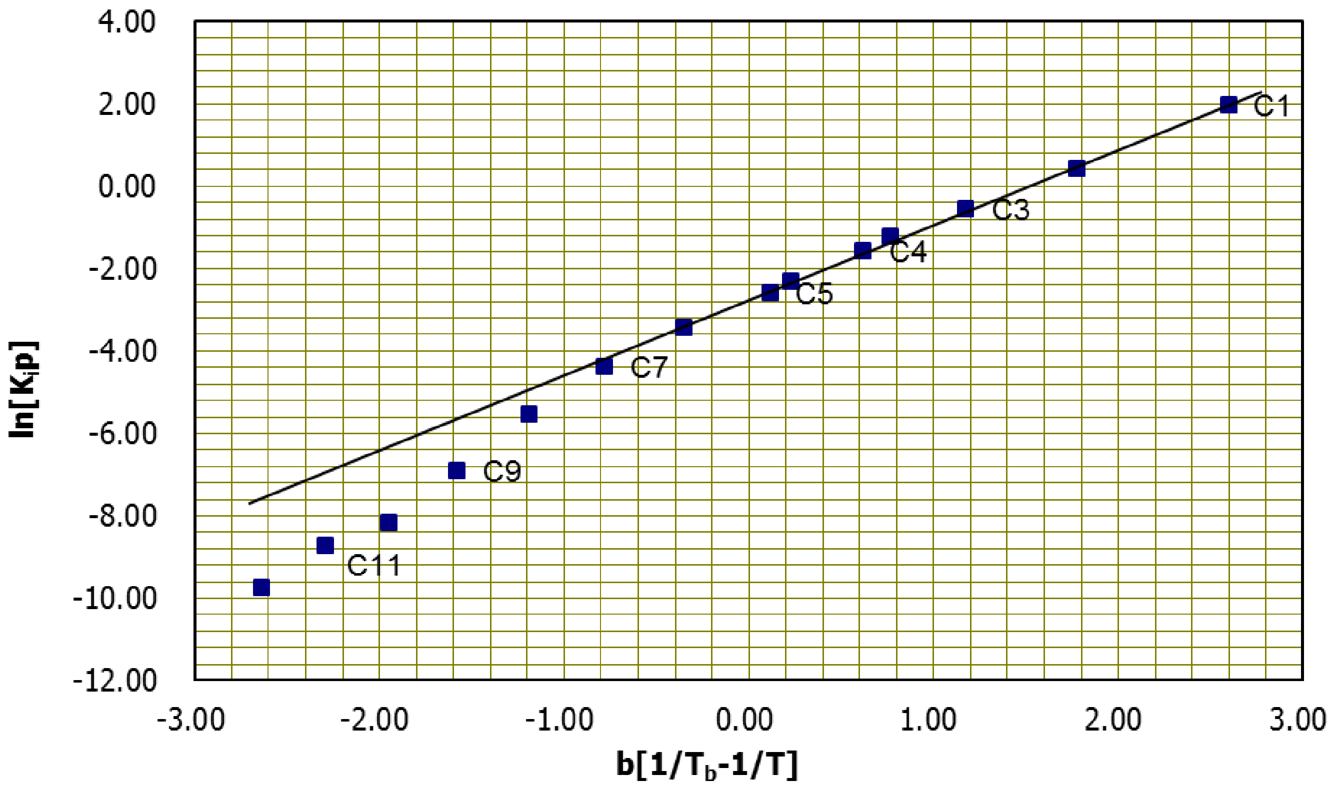
GC measurement uncertainty



Only indicative
Uncertainty also
depends on type of molecule

Kvalitetssjekk

Hoffmann Crump plott



Ki = yi/xi
P: separator pressure
Tbi: kokepunkt
T: Separator temperatur
bi: En konstant bestemt av hver komponents kritiske trykk og temperatur

Sep P: opptil 70bar
Sep T: 10-95 degC

Molecular weigth determination of oil:
Freezing point depression

Necessary when the GC cannot fully analyse the oil
The freezing point of a pure liquid is lowered when other sustances are dissolved into the liquid.

The reduction in freezing point is linear to mole fraction of dissolved substance at low molar fractions:

$\Delta T = K\beta$

K: Slovent specific constant
β: molar fraction of solute

High purity Benzene is normally used as solvent.
ΔT is measured and molar fraction β is calculated. Knowing the mass of oil (by precision weighing) that was added to known mass of Benzene, the average molecular weight of the oil is calculated.
MWo = (Mo/Mb)*β*MWb/(1- β)

List of uncertainty contributions

Uncertainties in gas and liquid flow rates

Problems during sampling

Analytical uncertainties:

Sep gas composition

Flash gas composition

Dead oil composition

Flash data and GOR

Molecular weight of dead oil

Moles and molar fractions

Molar fractions (usually as %):

80 mol% Methane in a fluid means 80% of the molecules are Methane.

Molecules are typically counted in moles:

1 mole = Avogadros number of molecules: 1 mole = 6.022E23 molecules.

Molecular weights: Water MW = 18 gram/mol. 18 gram water contains Avogadros number of water molecules.

NB: No difference between molar fractions and molecular fractions.

Molar volume : Vm = MW/Density (MW: g/mol, Density: g/ml →

Vm units: ml/mol)