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Requested by

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Subtitle

Co-workers

Title

Corrected reservoir fluid compositions for well 15/8-1 DST 1C and 2: PVT simulations

STATOIL
EXPLORATION & PRODUCTION LABORATORY

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I. OBJECTIVES

In Core Lab.'s reservoir-fluid studies for well 15/8-1 DST 1C and 2 (reports RFL 830489 and 830490), a misinterpretation was made regarding the gas-oil ratio measured in the field separator tests (ref. 1). The composition of the samples used in Core Lab.'s constant mass expansion and constant volume depletion experiments is thus different from the actual well stream produced during the separator tests. It has therefore been decided to simulate the same type of experiments for the corrected reservoir-fluid compositions, by use of an EOS computer-simulation model. To obtain maximum reliability, Core Lab.'s exact experimental procedure has been simulated first, and the differences between the measured and simulated data have been used to correct the results from the same type of simulated experiments for the corrected reservoir-fluid compositions.

Table 1. Correct GOR values compared to those used by Core Lab.

Drill-stem test	Test-separator conditions	Gas-oil ratio, Sm3 separator gas per m3 of separator liquid	
		Used by Core Lab.	Corrected
15/8-1 DST 1C	31.1 deg C, 36.5 bara	658	1119
15/8-1 DST 2	30.8 deg C, 29.3 bara	664	847

II. COMPUTER SIMULATIONS

were made as described by K. S. Pedersen (ref. 2), using the Peng-Robinson equation of state. Liquid densities were calculated as described by Alani and Kennedy (ref. 3). The same model has previously been used in a study of the PVT properties of the reservoir fluid from the Sleipner Gamma region (ref. 4). Each simulation is based on a detailed compositional description given in the Appendix.

III. SIMULATION OF CORE LAB.'S EXPERIMENTAL PROCEDURE

Results from simulated constant mass expansion and constant volume depletion experiments based on the recombined fluid composition given by Core Lab, are shown in tables 2 to 7.

The simulated dew points agree well with the observations. The simulated z-factor values are in average 5 percent lower than the measured values. Such a trend is usually observed with the present version of the computer model (see ref. 4), and the simulations can thus be taken to confirm the reliability of the measured z-factor values. The simulated compositional data for the produced well stream during constant volume depletion agree well with the measured values.

The simulated volumes of retrograde liquid deposition at and above the first depletion pressure are significantly higher than the measured values. This trend is also usually experienced with the present version of the computer model (see ref. 4). The simulated amounts of fluid produced during constant volume depletion are slightly greater than the measured values, especially at the first depletion pressures.

TABLE 2. WELL 15/8-1 DST 1C, RECOMBINED SAMPLE:
Constant mass expansion at 135 deg C.

Comparison between measured and simulated data.

Pressure (bara)	Gas compressibility factor Measured	Simulated	Simulated gas viscosity (centipoise)
552.6	1.337	1.224	0.0589
532.7 *	1.303	1.196	0.0576
518.1	1.278	1.175	0.0566
483.6	1.221	1.126	0.0542
449.2	1.160	1.076	0.0517
414.7	1.101	1.027	0.0490
380.2	1.043	0.979	0.0462
345.7	0.985	0.931	0.0432
311.3	0.928	0.885	0.0400
290.6	0.896	0.858	0.0380
276.8	0.875	0.840	0.0366
269.9	0.864	0.831	0.0359
263.0	0.854	0.823	0.0352
256.1	0.844	0.815	0.0344
254.6 **	0.842	0.813	0.0343
251.5 ***		0.809	0.0339

*: Reservoir pressure.
**: Measured dew point.
***: Simulated dew point.

TABLE 3. WELL 15/8-1 DST 2, RECOMBINED SAMPLE:
Constant mass expansion at 127.8 deg C.

Comparison between measured and simulated data.

Pressure (bara)	Gas compressibility factor Measured	Gas compressibility factor Simulated	Simulated gas viscosity (centipoise)
474.5 *	1.218	1.136	0.0738
449.2	1.169	1.095	0.0715
414.7	1.106	1.039	0.0681
380.2	1.042	0.983	0.0646
345.7	0.980	0.927	0.0607
325.1	0.942	0.893	0.0583
311.3	0.917	0.871	0.0566
304.4	0.905	0.860	0.0557
297.5	0.893	0.849	0.0548
297.1 **		0.849	0.0547
292.4 ***	0.885		

*: Reservoir pressure.
**: Simulated dew point.
***: Measured dew point.

TABLE 4. WELL 15/8-1 DST 1C, RECOMBINED SAMPLE: CONSTANT VOLUME DEPLETION AT 135 deg C.

Comparison between measured and simulated data - mol percent of produced well stream

Component	Above dew point		207.8 bara		166.5 bara		125.1 bara	
	Meas.	Sim.	Meas.	Sim.	Meas.	Sim.	Meas.	Sim.
Carbon dioxide	8.10	8.09	8.15	8.17	8.26	8.27	8.34	8.37
Nitrogen	2.32	2.31	2.34	2.35	2.40	2.39	2.45	2.42
Methane	52.29	52.26	53.54	52.87	54.24	53.65	54.64	54.33
Ethane	10.62	10.62	10.66	10.67	10.73	10.73	10.81	10.83
Propane	12.27	12.27	12.20	12.24	12.13	12.21	12.15	12.23
iso-Butane	2.53	2.53	2.49	2.51	2.45	2.49	2.44	2.47
n-Butane	3.23	3.23	3.10	3.20	3.08	3.15	3.07	3.11
iso-Pentane	1.30	1.30	1.24	1.28	1.21	1.25	1.20	1.21
n-Pentane	1.07	1.07	0.99	1.05	0.98	1.02	0.98	0.99
Hexanes	1.26	1.28	1.17	1.24	1.10	1.18	1.06	1.11
Heptanes plus	5.01	5.04	4.12	4.42	3.42	3.66	2.86	2.94
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
C7+ molecular weight	135	136	124	127	119	120	114	115
C7+ density	0.831	0.831	0.821	0.815	0.815	0.801	0.810	0.791
Z-factor:								
Equilibrium gas	0.842	0.813	0.797	0.776	0.792	0.768	0.814	0.789
Two-phase	0.842	0.813	0.788	0.775	0.768	0.759	0.770	0.761
Well stream produced - cum. mol% of initial	0.0	0.0	12.822	13.7	28.424	29.4	46.361	47.1

TABLE 4 (CONTINUED)

Comparison between measured and simulated data - mol percent of produced well stream

Component	83.7 bara Meas.	83.7 bara Sim.	49.3 bara Meas.	49.3 bara Sim.	49.3 bara * Meas.	49.3 bara * Sim.
Carbon dioxide	8.47	8.40	8.40	8.33	2.06	1.64
Nitrogen	2.43	2.42	2.39	2.36	0.20	0.16
Methane	54.38	54.47	53.63	53.68	8.47	7.77
Ethane	10.93	10.93	11.02	10.97	4.32	3.96
Propane	12.37	12.37	12.74	12.66	9.26	8.72
iso-Butane	2.49	2.49	2.60	2.59	2.92	2.77
n-Butane	3.22	3.14	3.33	3.29	4.35	4.29
iso-Pentane	1.20	1.21	1.30	1.29	2.82	2.65
n-Pentane	0.97	0.98	1.08	1.05	2.60	2.47
Hexanes	1.05	1.08	1.14	1.17	5.02	4.79
Heptanes plus	2.49	2.51	2.37	2.61	57.98	60.78
	100.00	100.00	100.00	100.00	100.00	100.00
C7+ molecular weight	110	112	109	111		
C7+ density	0.805	0.785	0.804	0.782		
Z-factor:						
Equilibrium gas	0.862	0.834	0.912	0.887		
Two-phase	0.779	0.775	0.782	0.780		
Well stream produced - cum. mol% of initial	64.494	65.2	79.130	79.7		

*: Composition of equilibrium liquid at 49.3 bara.

TABLE 5. WELL 15/8-1 DST 2, RECOMBINED SAMPLE: CONSTANT VOLUME DEPLETION AT 127.8 deg C.

Comparison between measured and simulated data - mol percent of produced well stream

Component	Above dew point		256.1 bara		207.8 bara		159.6 bara	
	Meas.	Sim.	Meas.	Sim.	Meas.	Sim.	Meas.	Sim.
Carbon dioxide	19.95	19.90	19.96	20.52	20.20	21.03	21.26	21.45
Nitrogen	1.80	1.66	1.89	1.77	1.97	1.84	2.08	1.87
Methane	45.41	45.52	47.72	47.30	49.68	48.78	50.01	49.83
Ethane	6.36	6.46	6.38	6.51	6.40	6.58	6.57	6.67
Propane	9.56	9.57	9.37	9.43	9.22	9.33	9.21	9.31
iso-Butane	2.12	2.10	1.97	2.04	1.96	1.98	1.90	1.94
n-Butane	2.93	2.90	2.74	2.79	2.70	2.68	2.60	2.61
iso-Pentane	1.18	1.17	1.12	1.10	1.08	1.04	1.03	0.98
n-Pentane	1.34	1.34	1.22	1.26	1.18	1.17	1.14	1.10
Hexanes	1.63	1.66	1.55	1.52	1.40	1.37	1.25	1.22
Heptanes plus	7.72	7.72	6.08	5.76	4.21	4.20	2.95	3.02
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
C7+ molecular weight	159	153	132	137	123	125	116	117
C7+ density	0.828	0.828	0.802	0.807	0.793	0.789	0.785	0.777
Z-factor:								
Equilibrium gas	0.885	0.842	0.824	0.801	0.795	0.774	0.808	0.778
Two-phase	0.885	0.842	0.831	0.808	0.785	0.768	0.754	0.740
Well stream produced - cum. mol% of initial	0.0	0.0	6.921	9.5	19.669	22.7	36.061	38.4

TABLE 5 (CONTINUED)

Comparison between measured and simulated data - mol percent of produced well stream

Component	118.2 bara Meas.	118.2 bara Sim.	83.7 bara Meas.	83.7 bara Sim.	49.3 bara Meas.	49.3 bara Sim.	49.3 bara * Meas.	49.3 bara * Sim.
Carbon dioxide	21.49	21.68	21.70	21.71	22.10	21.38	5.35	4.51
Nitrogen	2.08	1.86	1.98	1.82	1.81	1.72	0.15	0.13
Methane	50.26	50.23	49.76	49.88	47.70	48.41	6.98	7.50
Ethane	6.66	6.78	6.82	6.92	6.96	7.07	2.93	2.78
Propane	9.38	9.43	9.73	9.75	10.45	10.44	8.29	7.94
iso-Butane	1.94	1.95	2.11	2.01	2.26	2.22	2.82	2.67
n-Butane	2.63	2.60	2.75	2.69	3.02	3.01	4.60	4.41
iso-Pentane	1.02	0.95	1.02	0.98	1.05	1.11	2.51	2.62
n-Pentane	1.12	1.06	1.12	1.08	1.16	1.23	3.26	3.32
Hexanes	1.15	1.12	1.10	1.11	1.20	1.25	5.62	6.02
Heptanes plus	2.27	2.34	1.91	2.05	2.29	2.16	57.49	58.10
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
C7+ molecular weight	112	113	108	110	105	109		
C7+ density	0.782	0.771	0.776	0.767	0.774	0.764		
Z-factor:								
Equilibrium gas	0.835	0.805	0.875	0.841	0.921	0.889		
Two-phase	0.742	0.722	0.723	0.699	0.674	0.643		
Well stream produced - cum. mol% of initial	51.865	53.2	64.995	65.8	77.940	78.1		

*: Composition of equilibrium liquid at 49.3 bara.

TABLE 6. WELL 15/8-1 DST 1C, RECOMBINED SAMPLE:
Constant volume depletion at 135 deg C
- retrograde condensation and gas viscosity.

Comparison between measured and simulated data.

Pressure (bara)	Retrograde liquid deposition, percent of dew-point volume		Simulated gas viscosity (centipoise)
	Measured	Simulated	
254.6 *	0.0		0.0343
251.5 **		0.0	0.0339
249.2	0.1	0.2	
242.3	0.2	0.7	
232.0	0.4	1.4	
218.2	0.7	2.4	
207.8 ***	1.6	3.1	0.0277
166.5	5.7	5.5	0.0232
125.1	7.2	6.5	0.0200
83.7	7.1	6.2	0.0180
49.3	6.1	5.3	0.0167

*: Measured dew point.
**: Simulated dew point.
***: First depletion pressure.

TABLE 7. WELL 15/8-1 DST 2, RECOMBINED SAMPLE:
Constant volume depletion at 127.8 deg C
- retrograde condensation and gas viscosity.

Comparison between measured and simulated data.

Pressure (bara)		Retrograde liquid deposition, percent of dew-point volume		Simulated gas viscosity (centipoise)
		Measured	Simulated	
297.1	*		0.0	0.0547
292.4	**	0.0	4.2	
287.1		0.2	7.6	
280.2		0.5	10.7	
269.9		3.2	14.0	
256.1	***	8.9	16.9	0.0405
207.8		16.6	20.7	0.0307
159.6		18.6	20.9	0.0244
118.2		18.0	19.6	0.0209
83.7		16.9	18.0	0.0189
49.3		15.5	15.9	0.0173

*: Simulated dew point.
**: Measured dew point.
***: First depletion pressure.

IV. SIMULATED PVT DATA FOR CORRECTED COMPOSITIONS

The corrected reservoir fluid compositions are shown in tables 8 and 9. On the basis of these compositions, a simulated flash of reservoir fluid to test-separator conditions yielded separator gas and liquid compositions which agree reasonably well with the compositional measurements. However, the difference between the simulated and measured separator gas-oil ratio for DST 1C is relatively large.

The results from simulated constant mass expansion and constant volume depletion experiments are shown in tables 10 to 15.

1. The simulated dew points have been corrected by multiplying the results from the simulations by the ratio of measured and simulated dew points for the Core Lab. experiments, tables 2 and 3. Judged from the shape of the phase envelopes (figures 1 and 2), the additional uncertainty introduced by calculating the dew points of the corrected reservoir fluid compositions are probably not greater than the normal uncertainty for a dew-point measurement caused by sampling factors (about ± 10 bar).

2. The z-factor values in tables 10 to 13 have been corrected in a similar manner, by multiplying the results from the simulations by the ratio of the measured and simulated z-factor value at the same pressure for the Core Lab. experiments, see tables 2 to 5. Simulated z-factor values corrected in this manner have been experienced to be correct within about ± 4 percent.

3. The simulated values for the retrograde liquid deposition were adjusted down at the first depletion pressures (tables 14 and 15), because the computer model has been experienced to give too high values at these points (see tables 6 and 7 and ref. 4). The relative uncertainty in the given liquid volumes is probably about 20 percent.

4. The simulated amounts and compositions of the produced well stream during constant volume depletion (tables 12 and 13) have not been corrected. The error in the given amounts of cumulative produced well stream at each depletion stage is probably within 3 mol percent of the total reservoir fluid (see tables 4 and 5 and ref. 4).

   The errors in the simulated well-stream compositions (tables 12 and 13) are probably of the same order of magnitude as the discrepancies between simulated and measured data in tables 4, 5, 8 and 9. These errors are probably not greater than the normal experimental uncertainty due to sampling factors.

TABLE 8. WELL 15/8-1 DST 1C, CORRECTED COMPOSITION:
Flash of reservoir fluid to test separator conditions (31.1 deg C, 36.5 bara)

Comparison between measured and simulated compositions - mol percent.

Component	Separator gas		Separator liquid		Reservoir fluid composition
	Measured	Simulated	Measured	Simulated	Calculated, GOR = 1119
Carbon dioxide	9.40	9.35	4.10	3.05	8.54
Nitrogen	2.99	2.90	0.24	0.17	2.55
Methane	64.93	63.39	13.61	11.21	56.65
Ethane	10.70	10.97	10.38	8.46	10.65
Propane	8.78	9.57	22.92	21.11	11.06
iso-Butane	1.24	1.43	6.47	6.45	2.08
n-Butane	1.29	1.54	9.14	9.48	2.56
iso-Pentane	0.30	0.37	4.35	4.86	0.95
n-Pentane	0.19	0.25	3.75	4.25	0.77
Hexanes	0.11	0.14	4.84	5.82	0.87
Heptanes	0.05	0.05	4.22	5.22	0.72
Octanes	0.02	0.03	5.37	6.64	0.88
Nonanes	Trace	0.01	3.20	3.99	0.52
Decanes plus	Trace	0.00	7.41	9.29	1.20
	100.00	100.00	100.00	100.00	100.00

Gas-oil ratio, Sm3 of separator gas per m3 of separator liquid:
Measured: 1119. Simulated: 1470.

TABLE 9. WELL 15/8-1 DST 2, CORRECTED COMPOSITION:
Flash of reservoir fluid to test separator conditions (30.8 deg C, 29.3 bara)

Comparison between measured and simulated compositions - mol percent.

Component	Separator gas		Separator liquid		Reservoir fluid composition
	Measured	Simulated	Measured	Simulated	Calculated, GOR = 847
Carbon dioxide	23.42	23.56	7.21	6.18	20.52
Nitrogen	2.10	2.09	0.09	0.09	1.74
Methane	56.17	55.85	7.24	7.68	47.42
Ethane	6.98	6.98	4.57	4.54	6.55
Propane	7.88	7.93	15.67	15.60	9.27
iso-Butane	1.30	1.26	4.96	5.25	1.96
n-Butane	1.39	1.43	8.32	8.30	2.63
iso-Pentane	0.34	0.33	4.15	4.26	1.02
n-Pentane	0.22	0.31	5.38	5.07	1.14
Hexanes	0.12	0.16	7.19	7.17	1.39
Heptanes	0.06	0.06	6.12	6.24	1.14
Octanes	0.02	0.03	7.69	7.80	1.39
Nonanes	Trace	0.01	5.89	5.96	1.05
Decanes plus	Trace	0.00	15.52	15.86	2.78
	100.00	100.00	100.00	100.00	100.00

Gas-oil ratio, Sm3 of separator gas per m3 of separator liquid:
Measured: 847. Simulated: 881.

TABLE 10. WELL 15/8-1 DST 1C, CORRECTED COMPOSITION:
Simulated constant mass expansion at 135 deg C.

Pressure (bara)	Gas compressibility factor * Z = P V / n R T	Gas viscosity (centipoise)
552.6	1.309	0.0525
532.7 - Reservoir pressure	1.278	0.0513
518.1	1.255	0.0504
483.6	1.204	0.0483
449.2	1.149	0.0460
414.7	1.097	0.0437
380.2	1.045	0.0412
345.7	0.994	0.0386
311.3	0.945	0.0359
290.6	0.918	0.0342
276.8	0.900	0.0330
269.9	0.891	0.0325
263.0	0.882	0.0319
262.0 - Dew point *	0.881	0.0318

*: The values given here for the gas compressibility factor and the dew-point pressure have been corrected by multiplying the original simulated values by the ratio of the corresponding measured and simulated values at the same pressure for Core Lab.'s experiment (see table 2).

TABLE 11. WELL 15/8-1 DST 2, CORRECTED COMPOSITION:
Simulated constant mass expansion at 127.8 deg C.

Pressure (bara)	Gas compressibility factor * Z = P V / n R T	Gas viscosity (centipoise)
474.5 - Reservoir pressure	1.198	0.0683
449.2	1.152	0.0661
414.7	1.094	0.0628
380.2	1.034	0.0594
345.7	0.977	0.0558
325.1	0.942	0.0535
311.3	0.919	0.0518
304.4	0.908	0.0510
302.3 - Dew point *	0.905	0.0507

*: The values given here for the gas compressibility factor and the dew-point pressure have been corrected by multiplying the original simulated values by the ratio of the corresponding measured and simulated values at the same pressure for Core Lab.'s experiment (see table 3).

TABLE 12. WELL 15/8-1 DST 1C, CORRECTED COMPOSITION: SIMULATED CONSTANT VOLUME DEPLETION AT 135 deg C.

Composition of produced well stream - mol percent.

Component	Depletion pressure - bara						
	262.0	207.8	166.5	125.1	83.7	49.3	49.3*
Carbon dioxide	8.54	8.58	8.62	8.66	8.69	8.66	1.62
Nitrogen	2.55	2.57	2.59	2.60	2.60	2.58	0.16
Methane	56.65	56.93	57.26	57.57	57.69	57.37	7.81
Ethane	10.65	10.67	10.70	10.74	10.79	10.81	3.77
Propane	11.06	11.05	11.04	11.05	11.11	11.22	7.58
iso-Butane	2.08	2.07	2.06	2.06	2.07	2.10	2.23
n-Butane	2.56	2.55	2.53	2.52	2.53	2.58	3.35
iso-Pentane	0.95	0.94	0.93	0.92	0.92	0.95	1.96
n-Pentane	0.77	0.76	0.75	0.74	0.74	0.77	1.81
Hexanes	0.87	0.86	0.84	0.82	0.80	0.84	3.49
Heptanes plus	3.32	3.02	2.68	2.32	2.06	2.12	66.22
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
C7+ molecular weight	136	127	121	117	114	112	
C7+ density	0.831	0.815	0.804	0.795	0.789	0.786	
Z-factor: **							
Equilibrium gas	0.881	0.834	0.829	0.845	0.886	0.929	
Two-phase	0.881	0.826	0.810	0.818	0.835	0.857	
Well stream produced - cum. mol% of initial	0.0	16.4	32.0	49.4	67.0	81.1	

*: Composition of equilibrium liquid at 49.3 bara.
**: The Z-factor values given here have been corrected by multiplying the original simulated values by the ratio of the corresponding measured and simulated values at the same pressure for the Core Lab. experiment (see table 4).

TABLE 13. WELL 15/8-1 DST 2, CORRECTED COMPOSITION: SIMULATED CONSTANT VOLUME DEPLETION AT 127.8 deg C.

Composition of produced well stream - mol percent.

Component	Depletion pressure - bara							
	302.3	256.1	207.8	159.6	118.2	83.7	49.3	49.3*
Carbon dioxide	20.52	20.98	21.35	21.67	21.86	21.88	21.63	4.50
Nitrogen	1.74	1.82	1.87	1.90	1.89	1.86	1.79	0.13
Methane	47.42	48.76	49.80	50.62	50.97	50.74	49.61	7.56
Ethane	6.55	6.59	6.64	6.71	6.79	6.90	7.01	2.73
Propane	9.27	9.17	9.10	9.08	9.18	9.42	9.92	7.53
iso-Butane	1.96	1.92	1.88	1.85	1.85	1.90	2.06	2.48
n-Butane	2.63	2.55	2.48	2.43	2.42	2.49	2.73	4.00
iso-Pentane	1.02	0.97	0.93	0.89	0.87	0.89	0.99	2.35
n-Pentane	1.14	1.08	1.03	0.98	0.95	0.97	1.08	2.93
Hexanes	1.39	1.29	1.20	1.09	1.02	1.01	1.13	5.47
Heptanes plus	6.36	4.87	3.72	2.78	2.20	1.94	2.05	60.32
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
C7+ molecular weight	153	136	125	117	113	111	109	
C7+ density	0.828	0.806	0.790	0.786	0.778	0.767	0.765	
Z-factor: **								
Equilibrium gas	0.905	0.834	0.806	0.817	0.843	0.882	0.927	
Two-phase	0.905	0.841	0.799	0.775	0.771	0.763	0.733	
Well stream produced - cum. mol% of initial	0.0	11.6	25.0	40.8	55.5	68.0	80.1	

*: Composition of equilibrium liquid at 49.3 bara.
**: The Z-factor values given here have been corrected by multiplying the original simulated values by the ratio of the corresponding measured and simulated values at the same pressure for the Core Lab. experiment (see table 5).

TABLE 14. WELL 15/8-1 DST 1C, CORRECTED COMPOSITION:
Simulated constant volume depletion at 135 deg C
- retrograde condensation and gas viscosity.

Pressure (bara)	Retrograde liquid deposition, percent of dew-point volume	Gas viscosity (centipoise)
262.0	0.0	0.0318
207.8	(0.8)*	0.0263
166.5	2.1	0.0228
125.1	2.7	0.0201
83.7	2.7	0.0181
49.3	2.4	0.0170

*: Estimated value. The result from the simulation, 1.2 percent, was not accepted due to the fact that the present version of the computer-simulation model has been experienced to give too large liquid volumes at the first depletion pressure (see table 6).

TABLE 15. WELL 15/8-1 DST 2, CORRECTED COMPOSITION:
Simulated constant volume depletion at 127.8 deg C
- retrograde condensation and gas viscosity.

Pressure (bara)	Retrograde liquid deposition, percent of dew-point volume	Gas viscosity (centipoise)
302.3	0.0	0.0507
256.1	(7.0)*	0.0384
207.8	(12.5)*	0.0301
159.6	15.2	0.0243
118.2	14.6	0.0210
83.7	13.5	0.0190
49.3	12.0	0.0175

*: Estimated values. The results from the simulation, 11.1 percent at 256.1 bara and 14.4 percent at 207.8 bara, were not accepted due to the fact that the present version of the computer-simulation model has been experienced to give too large liquid volumes at the highest depletion pressures (see table 7).

V. CONCLUSIONS

The errors introduced by using a computer simulation to estimate the properties of the correct reservoir fluid compositions of well 15/8-1 DST 1C and 2, seem to be within acceptable limits for most applications. However, if maximum reliability is wanted, further experiments should be carried out.

LIST OF REFERENCES

1. K. A. Grini. "PVT analyses on 15/8-1, DST no. 1C and 2". Statoil, Nov. 24th 1983.

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3. H. G. Alani, H. T. Kennedy. Petroleum Transactions, AIME 1960, 219, p. 288.

4. A. M. Martinsen, K. K. Meisingset. "PVT simulations compared to measurements on recombined reservoir fluid samples from Sleipner Gamma". Statoil, 1983.

Fig 1. Simulated Phase Envelope: Well 15/8–1 DST 1C.

– not recommended for quantitative calculations –

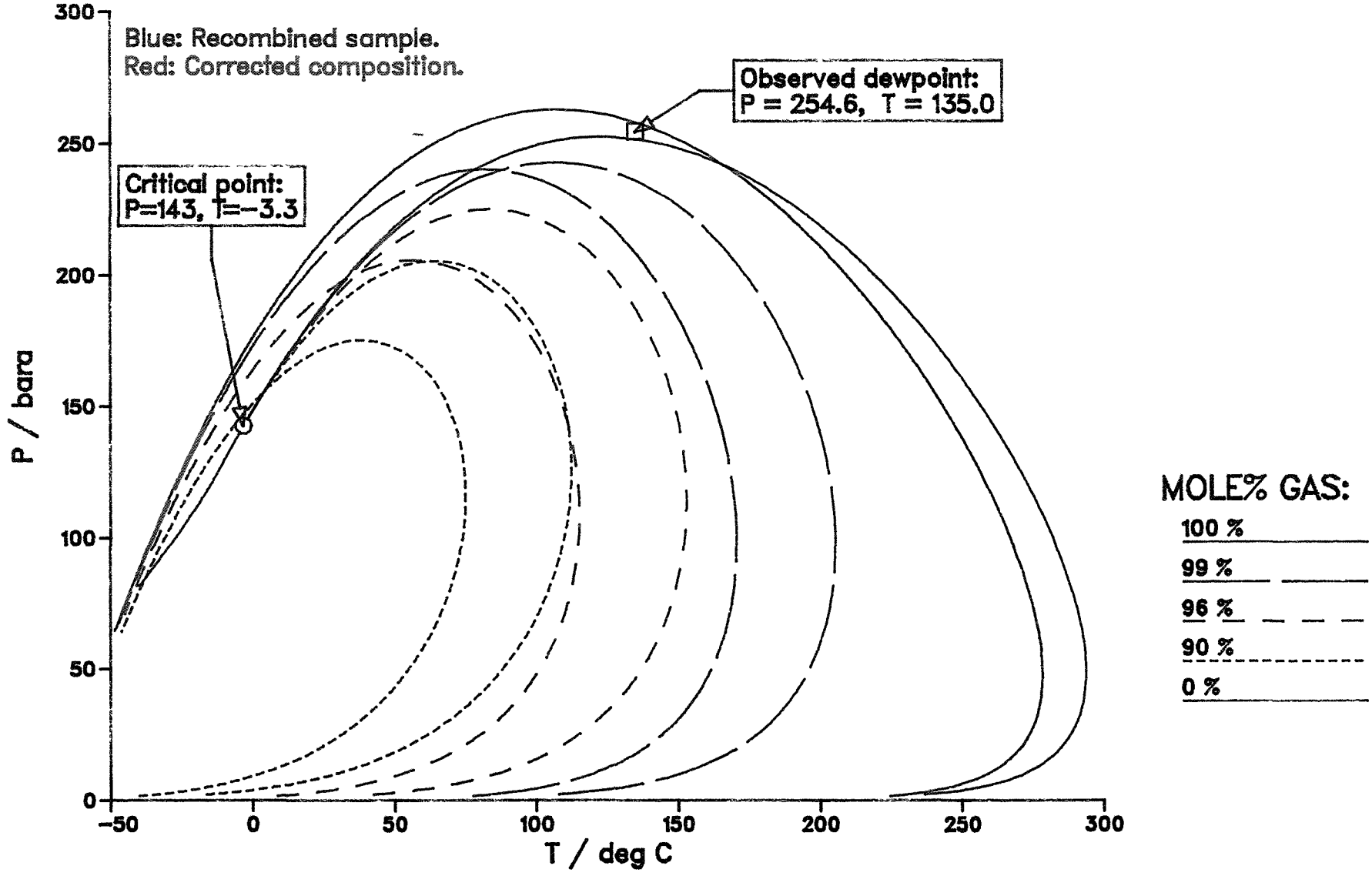
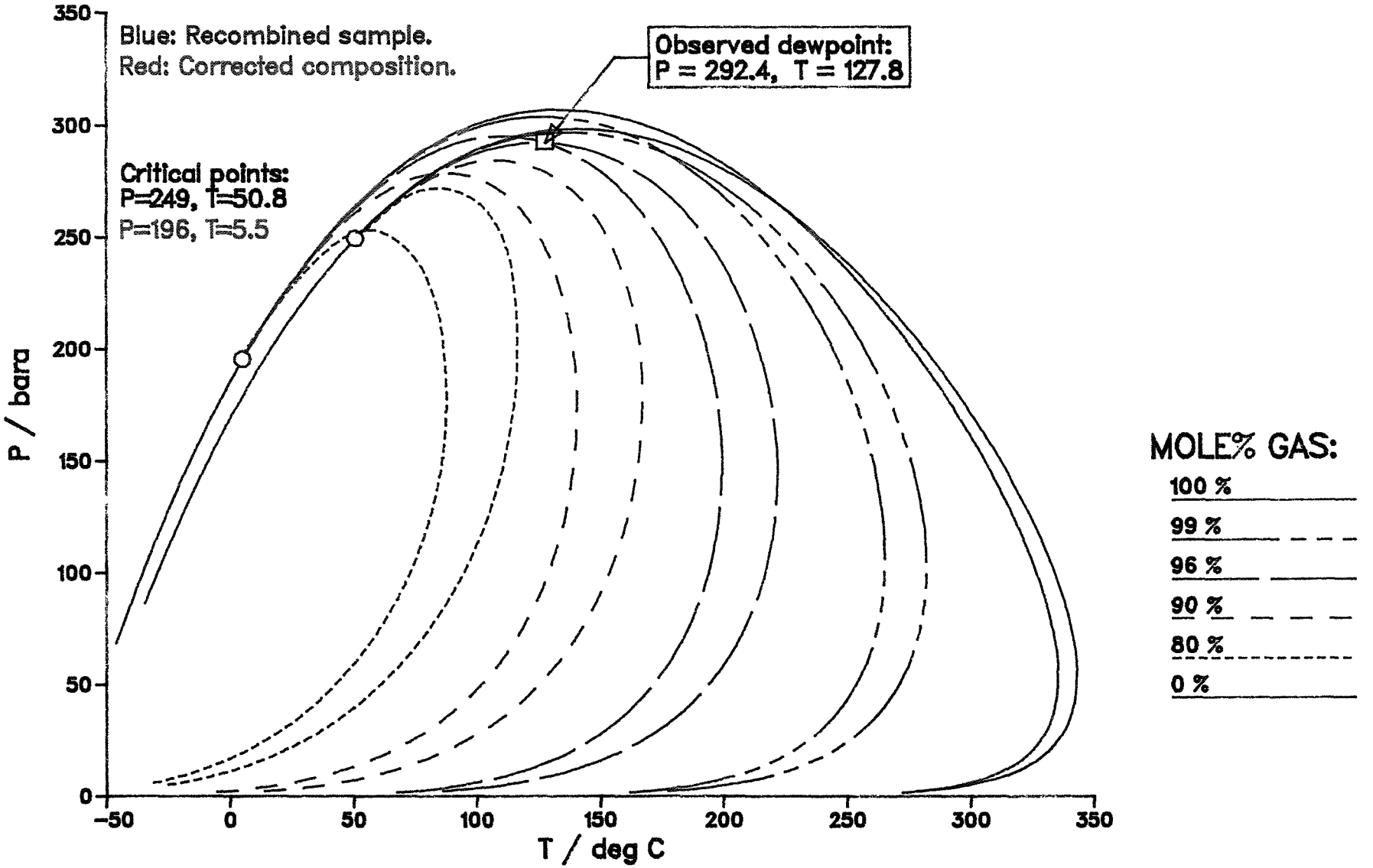


Fig 2. Simulated Phase Envelope: Well 15/8–1 DST 2.

– not recommended for quantitative calculations –



APPENDIX

The computer simulations have been made on the basis of a detailed compositional description of each sample, as shown in the following tables.

15/8-1 DST 1C: COMPOSITION BY CORE LAB

NO	COMPONENT	MOLE FRACTION	DENSITY G/CM3	MOLE WT	BOILING POINT K	TCRIT K	PCRIT ATM	ACENTRIC FACTOR	CRIT VOL (CC/GMOL)
1	N2	0.0231000		28.02		126.20	33.50	0.0400	89.5
2	CO2	0.0809000		44.01		304.20	72.80	0.2250	94.0
3	C1	0.5226000		16.04		190.60	45.40	0.0080	99.0
4	C2	0.1062000		30.07		305.40	48.20	0.0980	148.0
5	C3	0.1227000		44.09		369.80	41.90	0.1520	203.0
6	IC4	0.0253000		58.12		408.10	36.00	0.1760	263.0
7	C4	0.0323000		58.12		425.20	37.50	0.1930	255.0
8	IC5	0.0130000		72.15		460.40	33.40	0.2270	306.0
9	C5	0.0107000		72.15		469.60	33.30	0.2510	304.0
10	C6	0.0128000		86.17		507.40	29.30	0.2960	370.0
11	C7	0.0108000	0.74779	96.00	365.10	538.86	32.56	0.3560	351.4
12	C8	0.0134000	0.77611	107.00	389.90	566.77	31.54	0.4129	375.1
13	C9	0.0079000	0.80109	121.00	415.40	594.89	30.30	0.4707	402.8
C10+ - FRACTION		0.0183000	WHICH IS SPLIT UP AS FOLLOWS:						
14	C10	0.0056600	0.82344	134.00	439.00	620.78	29.13	0.5218	430.9
15	C11	0.0027700	0.84366	147.00	460.40	644.24	28.07	0.5655	458.4
16	C12	0.0015000	0.86211	161.00	481.50	666.83	26.91	0.6087	489.3
17	C13	0.0016200	0.87909	175.00	500.40	687.16	25.90	0.6445	519.1
18	C14	0.0014400	0.89481	190.00	519.60	707.21	24.77	0.6819	553.4
19	C15	0.0020300	0.91531	212.62	546.34	734.51	23.13	0.7338	607.4
20	C18	0.0013800	0.94649	248.45	584.28	773.95	21.06	0.7961	692.8
21	C22	0.0011109	0.99189	305.14	637.99	830.68	18.55	0.8287	831.5
22	C32	0.0007891	1.06935	438.55	736.76	936.79	15.27	0.9139	1117.3

A COMPOSITIONAL ANALYSIS IS AVAILABLE UP TO C19

A LOGARITHMIC DEPENDENCE OF MOLE FRACTION AGAINST CARBON NUMBER IS ASSUMED FOR THE C20+ - FRACTION

CALCULATED MOLECULAR WEIGHTS:

TOTAL MIXTURE = 34.2
C10+ - FRACTION = 187.1
C20+ - FRACTION = 360.6

NON-ZERO BINARY INTERACTION COEFFICIENTS:

	N2	CO2	C1	C2	C3+
N2	0.00	0.00	0.02	0.06	0.08
CO2	0.00	0.00	0.12	0.15	0.15

P N A - ANALYSIS :

NO	PARAFFINS	NAPHTHENES	AROMATES
11	0.500	0.450	0.050
12	0.300	0.430	0.270
13-22	0.300	0.400	0.300

15/8-1 DST 2: COMPOSITION BY CORE LAB

NO	COMPONENT	MOLE FRACTION	DENSITY G/CM3	MOLE WT	BOILING POINT K	TCRIT K	PCRIT ATM	ACENTRIC FACTOR	CRIT VOL (CC/GMOL)
1	N2	0.0166000		28.02		126.20	33.50	0.0400	89.5
2	CO2	0.1990000		44.01		304.20	72.80	0.2250	94.0
3	C1	0.4552000		16.04		190.60	45.40	0.0080	99.0
4	C2	0.0646000		30.07		305.40	48.20	0.0980	148.0
5	C3	0.0957000		44.09		369.80	41.90	0.1520	203.0
6	IC4	0.0210000		58.12		408.10	36.00	0.1760	263.0
7	C4	0.0290000		58.12		425.20	37.50	0.1930	255.0
8	IC5	0.0117000		72.15		460.40	33.40	0.2270	306.0
9	C5	0.0134000		72.15		469.60	33.30	0.2510	304.0
10	C6	0.0166000		86.17		507.40	29.30	0.2960	370.0
11	C7	0.0138000	0.73921	96.00	365.10	536.91	31.88	0.3637	356.8
12	C8	0.0169000	0.76174	107.00	389.90	563.12	30.37	0.4284	385.2
13	C9	0.0128000	0.78161	121.00	415.40	589.34	28.72	0.4967	418.0
C10+ - FRACTION		0.0337000	WHICH IS SPLIT UP AS FOLLOWS:						
14	C10	0.0065600	0.79939	134.00	439.00	613.36	27.22	0.5590	451.1
15	C11	0.0067800	0.82193	152.91	469.77	644.22	25.29	0.6398	499.0
16	C13	0.0031500	0.84366	175.00	500.40	674.36	23.36	0.7204	554.0
17	C14	0.0053000	0.86196	197.70	529.33	701.66	21.49	0.8006	614.5
18	C17	0.0032000	0.88369	229.12	564.35	734.17	19.34	0.8429	698.6
19	C19	0.0028900	0.90205	255.48	590.62	759.27	17.96	0.8966	767.0
20	C21	0.0019905	0.92394	288.95	622.95	789.85	16.39	0.9595	859.9
21	C25	0.0023971	0.95737	351.88	676.25	839.48	14.13	1.0445	1031.3
22	C36	0.0014324	1.01761	501.90	772.21	933.39	11.72	1.1662	1328.5

A COMPOSITIONAL ANALYSIS IS AVAILABLE UP TO C19

A LOGARITHMIC DEPENDENCE OF MOLE FRACTION AGAINST CARBON NUMBER IS ASSUMED FOR THE C20+ - FRACTION

CALCULATED MOLECULAR WEIGHTS:

TOTAL MIXTURE = 40.6
C10+ - FRACTION = 211.4
C20+ - FRACTION = 367.3

NON-ZERO BINARY INTERACTION COEFFICIENTS:

	N2	CO2	C1	C2	C3+
N2	0.00	0.00	0.02	0.06	0.08
CO2	0.00	0.00	0.12	0.15	0.15

P N A - ANALYSIS :

NO	PARAFFINS	NAPHTHENES	AROMATES
11	0.500	0.450	0.050
12	0.370	0.450	0.180
13-22	0.300	0.400	0.300

15/8-1 DST 1C: CORRECTED COMPOSITION

NO	COMPONENT	MOLE FRACTION	DENSITY G/CM3	MOLE WT	BOILING POINT K	TCRIT K	PCRIT ATM	ACENTRIC FACTOR	CRIT VOL (CC/GMOL)
1	N2	0.0255000		28.02		126.20	33.50	0.0400	89.5
2	CO2	0.0854000		44.01		304.20	72.80	0.2250	94.0
3	C1	0.5665000		16.04		190.60	45.40	0.0080	99.0
4	C2	0.1065000		30.07		305.40	48.20	0.0980	148.0
5	C3	0.1106000		44.09		369.80	41.90	0.1520	203.0
6	IC4	0.0208000		58.12		408.10	36.00	0.1760	263.0
7	C4	0.0256000		58.12		425.20	37.50	0.1930	255.0
8	IC5	0.0095000		72.15		460.40	33.40	0.2270	306.0
9	C5	0.0077000		72.15		469.60	33.30	0.2510	304.0
10	C6	0.0087000		86.17		507.40	29.30	0.2960	370.0
11	C7	0.0072000	0.74791	96.00	365.10	538.88	32.57	0.3559	351.4
12	C8	0.0088000	0.77634	107.00	389.90	566.83	31.55	0.4127	374.9
13	C9	0.0052000	0.80142	121.00	415.40	594.98	30.32	0.4703	402.6
C10+ - FRACTION		0.0120000	WHICH IS SPLIT UP AS FOLLOWS:						
14	C10	0.0037100	0.82385	134.00	439.00	620.91	29.16	0.5212	430.5
15	C11	0.0018200	0.84415	147.00	460.40	644.39	28.11	0.5647	458.0
16	C12	0.0009800	0.86267	161.00	481.50	667.02	26.95	0.6077	488.8
17	C13	0.0010600	0.87972	175.00	500.40	687.38	25.95	0.6433	518.5
18	C14	0.0009400	0.89550	190.00	519.60	707.46	24.81	0.6805	552.7
19	C15	0.0013300	0.91607	212.62	546.34	734.81	23.18	0.7320	606.6
20	C18	0.0009100	0.94740	248.47	584.31	774.34	21.11	0.7938	691.9
21	C22	0.0007363	0.99295	305.16	638.00	831.16	18.61	0.8262	830.2
22	C31	0.0005137	1.06832	434.11	733.32	933.58	15.37	0.9082	1108.2

A COMPOSITIONAL ANALYSIS IS AVAILABLE UP TO C19

A LOGARITHMIC DEPENDENCE OF MOLE FRACTION AGAINST CARBON NUMBER IS ASSUMED FOR THE C20+ - FRACTION

CALCULATED MOLECULAR WEIGHTS:

TOTAL MIXTURE =	30.8
C10+ - FRACTION =	186.9
C20+ - FRACTION =	358.2

NON-ZERO BINARY INTERACTION COEFFICIENTS:

	N2	CO2	C1	C2	C3+
N2	0.00	0.00	0.02	0.06	0.08
CO2	0.00	0.00	0.12	0.15	0.15

P N A - ANALYSIS :

NO	PARAFFINS	NAPHTHENES	AROMATES
11	0.500	0.450	0.050
12	0.300	0.430	0.270
13-22	0.300	0.400	0.300

15/8-1 DST 2: CORRECTED COMPOSITION

NO	COMPONENT	MOLE FRACTION	DENSITY G/CM3	MOLE WT	BOILING POINT K	TCRIT K	PCRIT ATM	ACENTRIC FACTOR	CRIT VOL (CC/GMOL)
1	N2	0.0174000		28.02		126.20	33.50	0.0400	89.5
2	CO2	0.2052000		44.01		304.20	72.80	0.2250	94.0
3	C1	0.4742000		16.04		190.60	45.40	0.0080	99.0
4	C2	0.0655000		30.07		305.40	48.20	0.0980	148.0
5	C3	0.0927000		44.09		369.80	41.90	0.1520	203.0
6	IC4	0.0196000		58.12		408.10	36.00	0.1760	263.0
7	C4	0.0263000		58.12		425.20	37.50	0.1930	255.0
8	IC5	0.0102000		72.15		460.40	33.40	0.2270	306.0
9	C5	0.0114000		72.15		469.60	33.30	0.2510	304.0
10	C6	0.0139000		86.17		507.40	29.30	0.2960	370.0
11	C7	0.0114000	0.73922	96.00	365.10	536.92	31.89	0.3637	356.8
12	C8	0.0139000	0.76177	107.00	389.90	563.13	30.37	0.4283	385.2
13	C9	0.0105000	0.78165	121.00	415.40	589.35	28.72	0.4966	417.9
C10+ - FRACTION		0.0278000	WHICH IS SPLIT UP AS FOLLOWS:						
14	C10	0.0054200	0.79944	134.00	439.00	613.38	27.22	0.5589	451.0
15	C11	0.0055900	0.82200	152.91	469.78	644.25	25.29	0.6397	499.0
16	C13	0.0026000	0.84373	175.00	500.40	674.39	23.37	0.7202	553.9
17	C14	0.0043700	0.86204	197.69	529.31	701.69	21.50	0.8004	614.3
18	C17	0.0026400	0.88377	229.10	564.33	734.19	19.34	0.8426	698.4
19	C19	0.0023800	0.90216	255.49	590.62	759.32	17.96	0.8963	766.9
20	C21	0.0016454	0.92406	288.95	622.94	789.90	16.39	0.9591	859.7
21	C25	0.0019805	0.95751	351.88	676.24	839.55	14.14	1.0441	1031.1
22	C36	0.0011740	1.01703	499.92	770.84	932.05	11.73	1.1643	1326.4

A COMPOSITIONAL ANALYSIS IS AVAILABLE UP TO C19

A LOGARITHMIC DEPENDENCE OF MOLE FRACTION AGAINST CARBON NUMBER IS ASSUMED FOR THE C20+ - FRACTION

CALCULATED MOLECULAR WEIGHTS:

TOTAL MIXTURE	38.3
C10+ - FRACTION	211.2
C20+ - FRACTION	366.5

NON-ZERO BINARY INTERACTION COEFFICIENTS:

	N2	CO2	C1	C2	C3+
N2	0.00	0.00	0.02	0.06	0.08
CO2	0.00	0.00	0.12	0.15	0.15

P N A - ANALYSIS :

NO	PARAFFINS	NAPHTHENES	AROMATES
11	0.500	0.450	0.050
12	0.370	0.450	0.180
13-22	0.300	0.400	0.300