GasCondOil

Process Simulation Software for Natural Gas and Oil Engineering

Version 2.3

MOST RELIABLE COMPUTATION DATA

GasCondOil-Simulation:

- composition, phase behavior and properties of reservoir natural gas and oil

- field transportation and gathering of oil and gas

- field-separation, glycol-absorption and oil-absorption processes

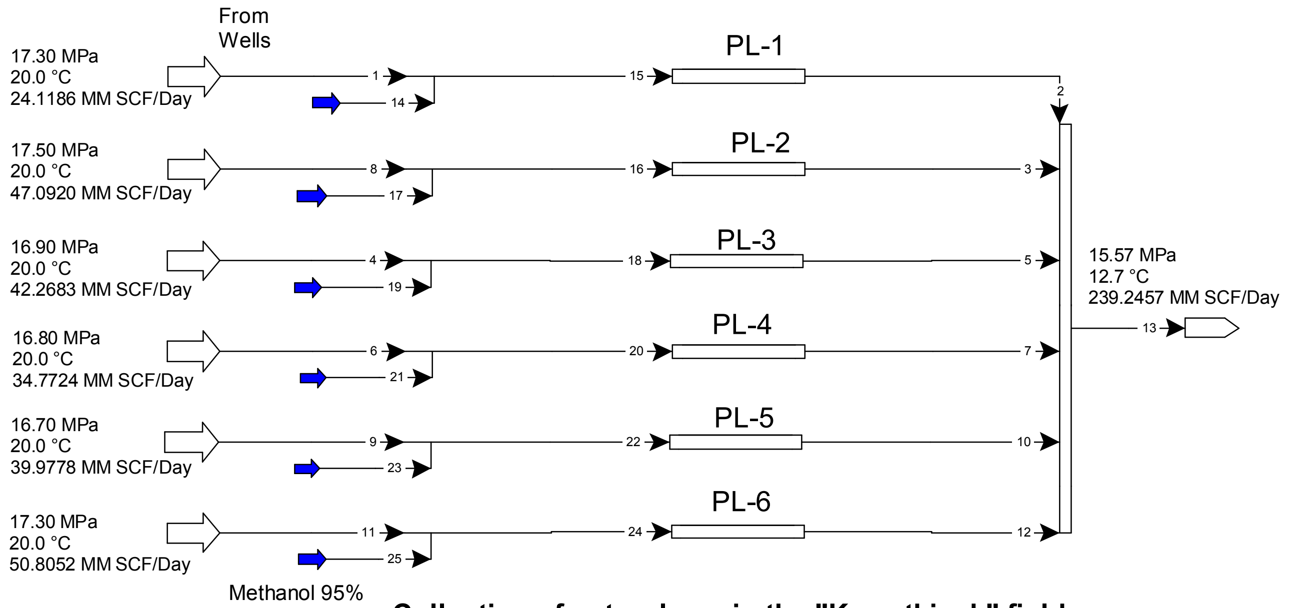
- the reconcentration of glycols and methanol

- fractional distillation

- low-temperature processing

- ice- hydrate formation conditions and inhibitors expenditure

Examples of GasCondOil-Flowsheets



Collection of natural gas in the "Kawytkinsk" field

Information about hydrate-forming in pipeline

Pipeline PL-1			
Inlet	15		
Pressure MPa	17.30		
Temperature C	19.9		
K	293.1		
Flow kmole/hr	1205.2390		
kg/hr	22772.850		

Length of pipe line	m	4300.0
Diameter of pipes on sections	mm	159.0x14.0
		159.0x14.0
Absolute roughness	mm	.10
Midline coefficient of heat transfer	W/m2/K	1.9
	kkal/m2/hr/C	1.7

\# **P R E H Y D R A T E - C O N D I T I O N**
Distance from pipeline starting .00 м

\# **H Y D R A T E S**
Distance from pipeline starting 3260.00 м

Outlet	2		
Pressure MPa	16.82		
Temperature C	14.8		
K	288.0		

Checking on the hydrate formation of the stream 2

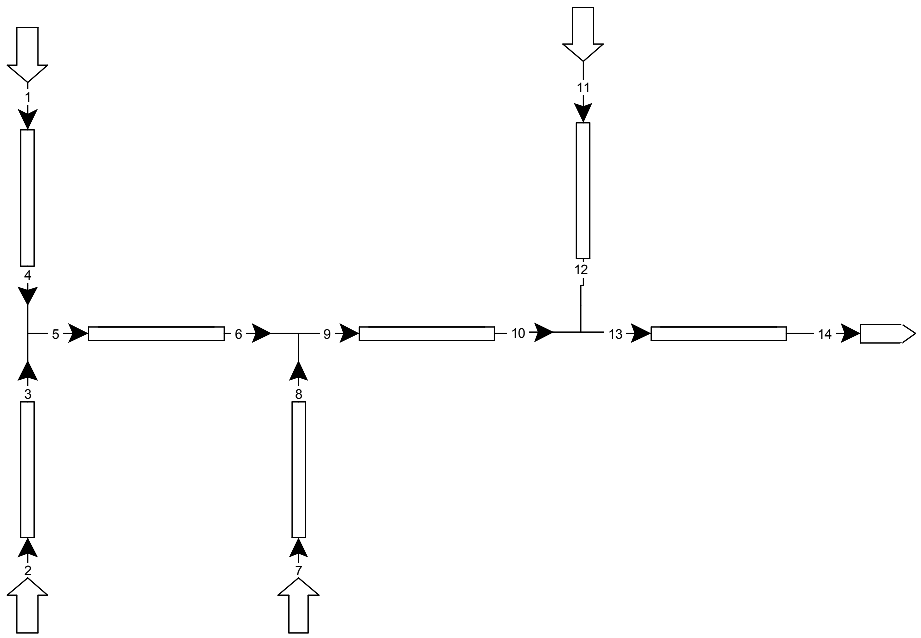
Hydrate formation t of this stream: 15.78 C

\# **H Y D R A T E S**

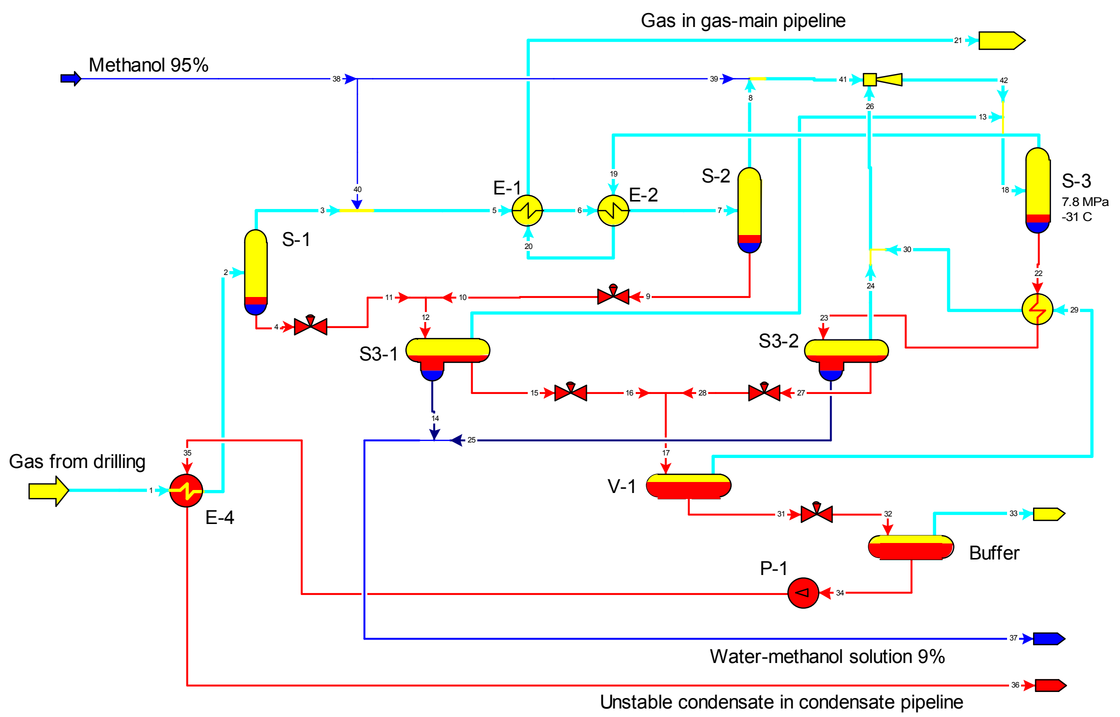
It is necessary to increase the expenditure of the inhibitor of the assigned composition on:
.151 kmole/hr or 4.65 kg/hr
hydrate formation t will comprise - 14.83 C

Composition and properties table

GasCondOil http://GasCondOil.com	Flowsheet: C:\Demo\Flowsheets\Natural gas field gathering (Kawykta).bks Date, time: 22.02.06 12:34:21			
Stream	**13**	**13 vap.**	**13 liq.**	**13 aqu.**
Pressure, MPa	15.568	15.568	15.568	15.568
Temperature, °C	12.73	12.73	12.73	12.73
Fraction(mole): gas(vapor)	0.982560	1.000000	0.000000	0.000000
hydrocarb.liquid	0.015169	0.000000	1.000000	0.000000
aqueous solution	0.002271	0.000000	0.000000	1.000000
Composition	mole fract.	mole fract.	mole fract.	mole fract.
Helium	0.0027933	0.0028381	0.0003075	0.0000121
Nitrogen	0.0158624	0.0160854	0.0037818	0.0000512
Methane	0.8954777	0.9038628	0.4856844	0.0048131
Carbon dioxide	0.0005986	0.0006000	0.0005937	0.0000233
Ethane	0.0507797	0.0505835	0.0710539	0.0002492
Propane	0.0109740	0.0107131	0.0295094	0.0000319
iso-Butane	0.0023944	0.0022909	0.0094567	0.0000008
n-Butane	0.0033920	0.0032008	0.0162854	0.0000027
iso-Pentane	0.0019953	0.0018135	0.0140717	0.0000013
n-Pentane	0.0014965	0.0013353	0.0121614	0.0000013
Methanol	0.0008085	0.0005528	0.0046688	0.0856640
Water	0.0022541	0.0001862	0.0004167	0.9091491
fr.below 55 °C	0.0003491	0.0003081	0.0030598	0.0000000
55- 85 °C	0.0030228	0.0024322	0.0417321	0.0000000
85-150 °C	0.0044894	0.0027060	0.1206828	0.0000000
150-225 °C	0.0014665	0.0003812	0.0719881	0.0000000
above 225 °C	0.0018457	0.0001101	0.1145459	0.0000000
Sum C5+	0.0146653	0.0090864	0.3782418	
Spec. content C5+, g/st.m3	68.2	35.4		
Flow , kmole/hr	11949.0	11740.6	181.3	27.1
kg/hr	225836.1	213326.9	11977.2	521.6
st.m3/hr (20°C, 0.1013 MPa)	287253.96	282244.26		
m3/hr	1355.42	1336.77	18.05	0.54
Mol. mass	18.90	18.17	66.08	19.22
Density , kg/m3	166.617	159.584	663.689	964.741
Dens. at st.cond., kg/st.m3	0.7862	0.7558		
Compressibility factor		0.7447		
Enthalpy , kJ/kmole	6059.8	6321.6	-5156.8	-32298.7
kJ/hr	72408510.0	74219700.0	-934680.0	-876508.7
Heat capacity, kJ/(kg·K)		3.625	2.188	4.030
Conductiv., W/(m·K)		0.0561	0.1230	0.5044
Dyn. viscos., mPa·s		0.0185	0.2687	1.7912
Adiabatic coefficient		2.234		
Surface tension, mN/m			8.116	68.289
High.combus.heat, kJ/kg		53136.6	48955.0	
Low.combus.heat , kJ/kg		48049.6	45260.8	



Gas-oil collection in "Peschanoozersk" field



Complex gas treatment plant of Khanchey field

Information about hydrate-forming in streams

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CONTROL FOR HYDRATES PRESENCE OF STREAM 7          ( t = -14.50 C )

Hydrate formation t of this stream:   -25.40 C
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Hydrate-free condition

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With the decrease of the expenditure of the inhibitor
of the assigned composition on:
  4.329 kmole/hr   or      133.51 kr/hr
hydrate formation t will comprise -   -14.92 C
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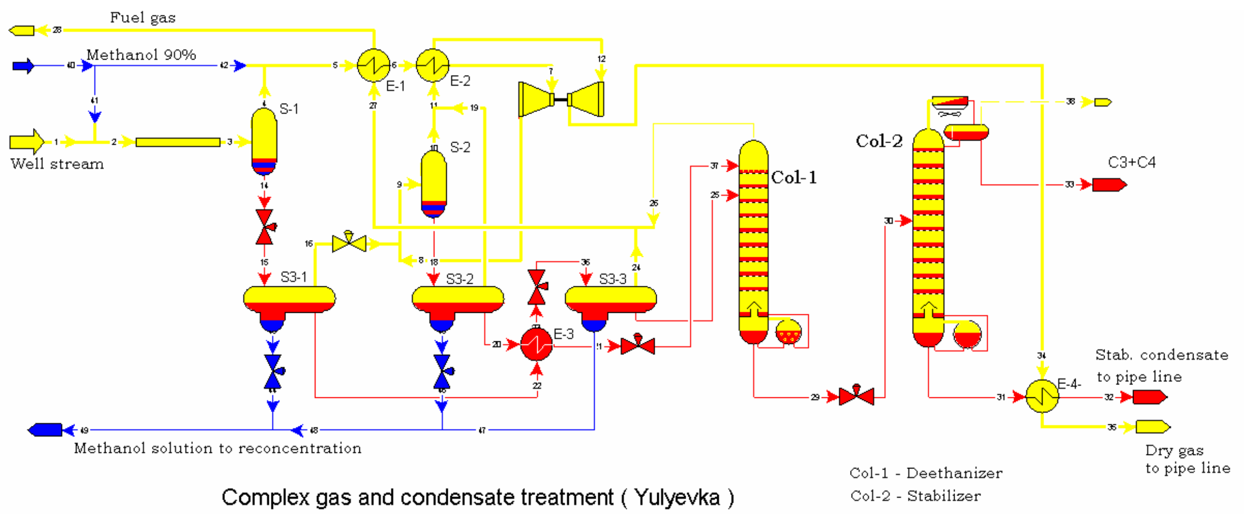
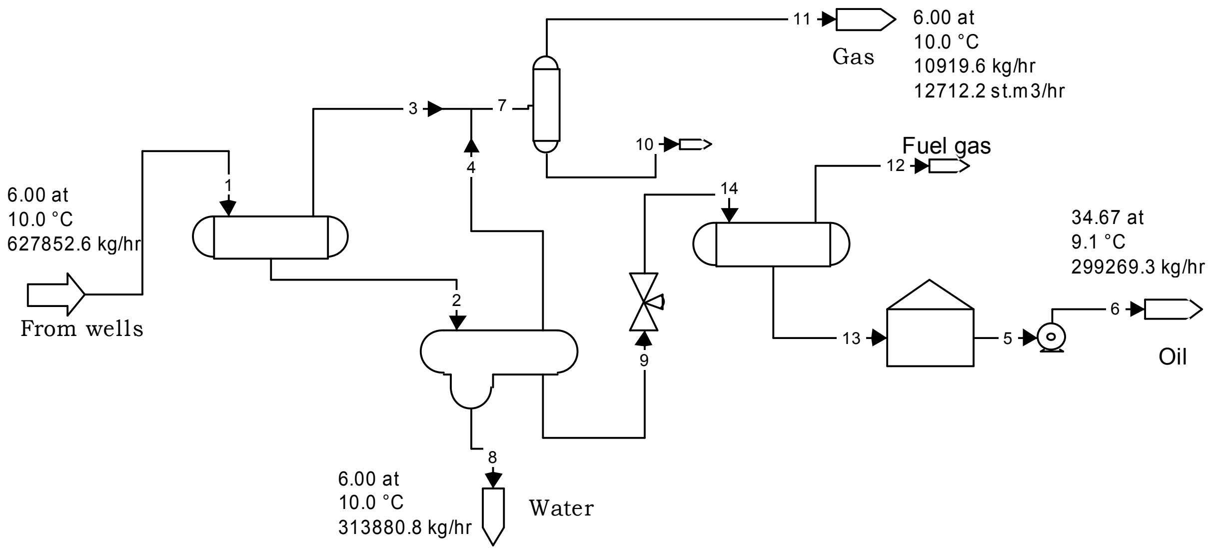


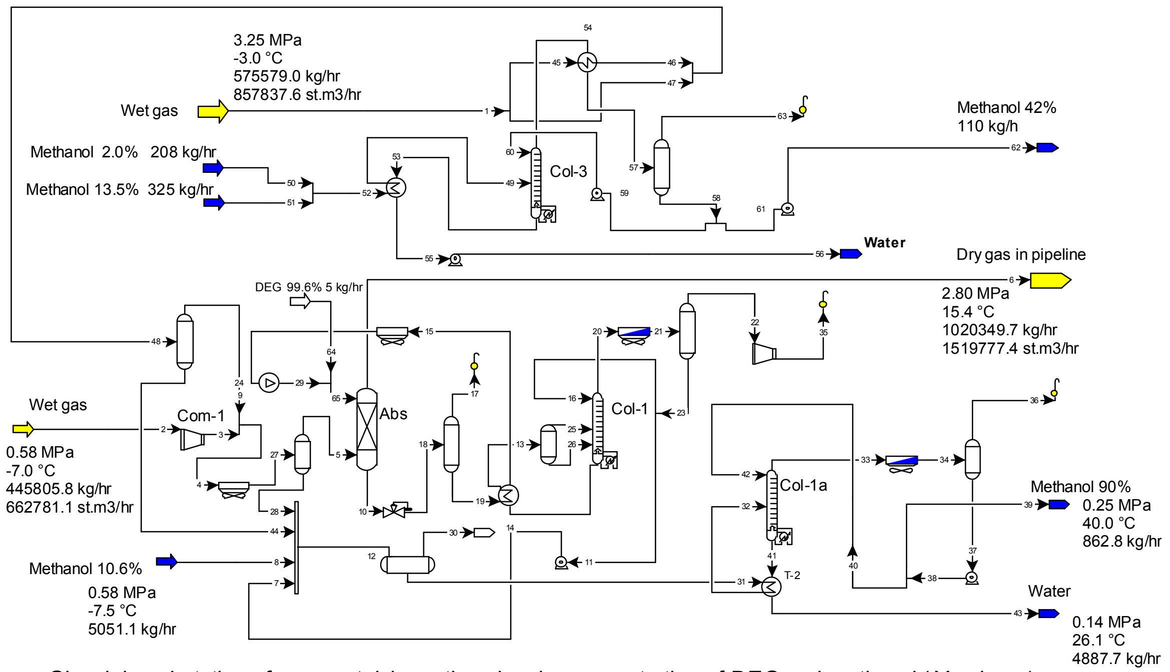
Complex gas and condensate treatment (Yulyevka)



Separation of gas-oil-water stream

GasCondOil http://GasCondOil.com		
	Flowsheet:	C:\Demo\Flowsheets\Separation of gas-oil-water.bks
	Date, time:	22.02.06 12:52:22

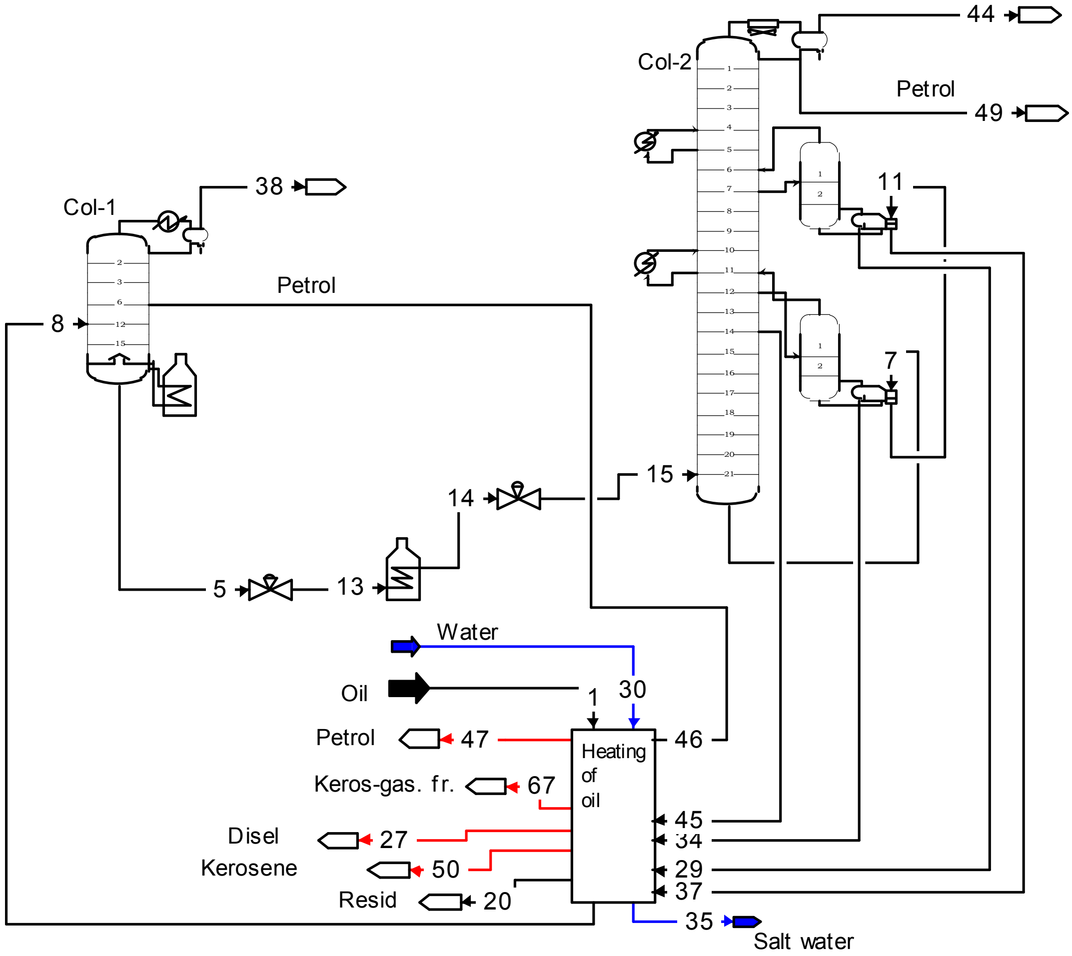
Stream	**1**	**1 vap.**	**1 liq.**	**1 aqu.**	**6**
Pressure, MPa	0.588	0.588	0.588	0.588	3.400
Temperature, °C	10.00	10.00	10.00	10.00	9.10
Fraction(mass): gas(vapor)	0.017346	1.000000	0.000000	0.000000	0.000000
hydrocarb.liquid	0.482583	0.000000	1.000000	0.000000	1.000000
aqueous solution	0.500071	0.000000	0.000000	1.000000	0.000000
Composition	mass fract.	mass fract.	mass fract.	mass fract.	mass fract.
Nitrogen	0.0004508	0.0252189	0.0000256	0.0000020	0.0000006
Methane	0.0124605	0.6422600	0.0025904	0.0001398	0.0002225
Carbon dioxide	0.0000176	0.0007239	0.0000088	0.0000017	0.0000020
Ethane	0.0015616	0.0486496	0.0014694	0.0000173	0.0005865
Propane	0.0137346	0.1838802	0.0217884	0.0000606	0.0165573
iso-Butane	0.0041649	0.0243187	0.0077555	0.0000006	0.0070118
n-Butane	0.0126092	0.0528103	0.0242255	0.0000045	0.0226540
iso-Pentane	0.0057504	0.0094063	0.0115768	0.0000012	0.0113791
n-Pentane	0.0070037	0.0084034	0.0142094	0.0000016	0.0140805
Sodium Chloride	0.0095823	0.0000000	0.0000000	0.0191618	0.0000000
Water	0.4904177	0.0018791	0.0000232	0.9806090	0.0000075
fr.below 100 °C	0.0082242	0.0012266	0.0169980	0.0000000	0.0171641
100-150 °C	0.0346597	0.0011192	0.0717808	0.0000000	0.0726252
150-200 °C	0.0349381	0.0000943	0.0723947	0.0000000	0.0732809
200-250 °C	0.0579822	0.0000089	0.1201492	0.0000000	0.1216247
250-300 °C	0.0596987	0.0000000	0.1237064	0.0000000	0.1252258
above 300 °C	0.2467439	0.0000000	0.5112977	0.0000000	0.5175776
Flow , kmole/hr	19595.9	527.6	1877.9	17190.4	1769.3
kg/hr	627852.6	10890.0	302957.7	313896.9	299269.3
STD m3/h (60°F, 14.73 psia)		12462.26			
m3/hr	2722.44	2064.45	347.64	309.97	340.22
Mol. mass	32.04	20.64	161.33	18.26	169.15
Density , kg/m3	230.621	5.275	871.474	1012.672	879.646
Dens. at st.cond., kg/st.m3		0.8586			
Enthalpy , kJ/kmole	-32952.6	10002.6	-30195.0	-34572.3	-31687.8
kJ/hr	-645736200.0	5277533.0	-56702380.0	-594311400.0	-56063680.0
Heat capacity, kJ/(kg·K)		2.037	2.134	4.223	2.125
Conductiv., W/(m·K)		0.0279	0.1542	0.5774	0.1570
Dyn. viscos., mPa·s		0.0101	10.2581	1.4205	13.1101
St.density , kg/m3			862.549		868.984
St.viscosity, mPa·s			7.9936		9.8548
cSt			9.2674		11.3406
Surface tension, mN/m			28.898	74.660	
Reid pressure of vapor, mmHg					707.8



Glycol-degydratation of gas containig methanol and reconcentration of DEG and methanol (Yamburg)

WATER DEW POINT

Stream number		1 Wet gas	2 Wet gas	6 Dry gas
Pressure	MPa	3.358	0.599	2.893
Temperature	°C	-3.0	-7.0	15.4
Fraction: gas(vapor)		0.99995	1.00000	1.00000
oil(condensate)		0.00000	0.00000	0.00000
aqueous solution		0.00005	0.00000	0.00000
Flow rate	kmole/hr	35683.8	27569.9	63218.7
	kg/hr	575579.06	445805.75	1020583.25
	st.m3/hr	857837.69	662781.12	1519777.88
	m3/hr	22662.62	103512.59	51199.41
Mol.mass		16.13	16.17	16.14
Density	kg/m3	25.40	4.31	19.93
		mole fract.	mole fract.	mole fract.
Nitrogen		0.0067902	0.0068071	0.0068012
Methane		0.9880080	0.9904809	0.9895854
Carbon dioxide		0.0013990	0.0014025	0.0014002
Ethane		0.0003549	0.0003558	0.0003554
Methanol		0.0001414	0.0003330	0.0000949
Water		0.0002280	0.0006207	0.0000245
Diethylenglycol		0.0000000	0.0000000	0.0000008
Hydrogen		0.0030381	0.0000000	0.0017148
Argon		0.0000404	0.0000000	0.0000228
Water dew point	°C	0.20	-7.05	-26.34



Fractional distillation of oil

Comparison of calculating data, obtaining by PRO-2, HYSYS and GasCondOil

1. Field-separation of gas-condensate (Khanchey field-plant). Actual (measurements of TyumenNIIgiprogaz) and calculating data.

Table 1.1. Actual and calculating temperature in apparatus.

Device	t act. (hourly average data, 27.05.04)	PRO-2 SRK-MPR[1]	HYSYS PR-SV[1]	GCO PR-Gas Inst.
Separator S-3	-32.0	-30.5[2]	-30.5[2]	-30.5
Segregator S3-1	20.9	19.7	19.6	19.5
Separator S-4	-9.9	-12.6	-13.7	-13.0
Buffer tank S-5	-19.2	-18.3	-19.5	-18.6

Notes: 1 - These thermodynamic models in PRO-2 and HYSYS given least deviation from actual data.

2 – Because of absence in PRO-2 and HYSYS of gas-ejection models, temperature in separator S-3 was accepted equal to temperature, calculated by means of GasCondOil.

Table 1.2. Actual and calculating product-rates.

Plant production	Factual data (hourly average data, 27.05.04)	PRO-2 SRK-MPR	HYSYS PR-SV[1]	GCO PR-Gas Inst	GCO[2] PR-Gas Inst	GCO[3] PR-Gas Inst
Gas in gas-main pipeline, MSTD m3/h	314.27	312.23	312.28	312.65	312.74	314.28
Unstable condensate, ton/h	76.40	78.23	77.71	77.67	77.45	76.36
Methanol concentration, % (weight):						
In segregator Seg3-1	4.0	2.7	5.6	6.0	6.0	6.1
In segregator Seg3-2	85.3	63.9	66.3[1]	84.5	84.5	85.8

Notes: 1 - Peng-Robinson equation of state (modif. Strijek-Vera). PR and KD (Kabadi-Danner) models give respectively 53% and 20%.

2 - Equilibrium model + liquid entrainment from separators (3 cm3/std.m3).

3 - With application of a nonequilibria factor + liquid entrainment .

Table 1.3. Actual and calculation content of light hydrocarbons in commercial condensate

Components	kg/h actual	PRO-2 SRK-MPR		HYSYS PR-SV		GCO PR-Gas Inst		GCO PR-Gas Inst[1]	
		kg/hr	Deviation, %	kg/hr	Deviation, %	kg/hr	Deviation, %	kg/hr	Deviation, %
Methane	1677	2220	32.4	2170	29.4	2154	28.4	1794	7.0
Ethane	3420	5424	58.6	5218	52.6	5325	55.7	3453	1.0
Propane	7324	6625	-9.5	6750	-7.8	6817	-6.9	7190	-1.8
i-Butane	2874	2734	-4.9	2671	-7.1	2653	-7.7	2827	-1.6
n-Butane	7173	6637	-7.5	6650	-7.3	6626	-7.6	7013	-2.2
i-Pentane	3323	3263	-1.8	3222	-3.0	3198	-3.8	3314	-0.3
n-Pentane	4505	4441	-1.4	4295	-4.7	4303	-4.5	4432	-1.6

Note: 1 - With application of a nonequilibria factor

Table 1.4. Methanol-flow rate (kg/h) for non-hydrate condition of Khanchey field-plant

Actual	Theoretical	
	HYSYS	GCO
732	1250	630

2. *Experimental and calculating solubility of hydrocarbons, water, methanol and glycols .*

Table 2.1. Experimental (Katz, 1964) and calculating solubility of methane in water at 10 MPa

T, C	% (mole) methane in water				Deviation , %		
	Exp	HYSYS CEOS/A^E Mixing Rules[1]	PRO-2 SRK-MPR[1]	GCO PR-Gas Inst	HYSYS A^E	PRO-2 SRK-MPR	GCO PR Gas Inst
25	0.18	0.29	0.000025	0.183	+61.1	-100.0	-1.7
40	0.15	0.23	0.000086	0.145	+53.3	-99.9	-3.3
80	0.12	0.17	0.000670	0.119	+41.7	-99.4	-0.8
100	0.12	0.17	0.001600	0.128	+41.7	-98.6	+6.7

Note: 1 - Models PR-SV, PR, PRTwu in HYSYS give at 25 C respectively 0.0%, 0.00003 % and 0.000035%; Models PR-HV and PR in PRO-2 – 17.7% and 0.00003%.

Table 2.2. Methanol content of natural gas (95 mole % methane).

T, C	P, MPa	% (mole) methanol in gas				Deviation, %		
		Literary data (Istomin, 1987)	HYSYS A^E	PRO-2 SPK-SS	GCO PR-Gas Inst	HYSYS A^E[1]	PRO-2 SPK-SS[2]	GCO PR-Gas Inst
-20	4.9	0.052	0.046	0.050	0.052	-11.5	-3.8	0.0
	10	0.093	0.074	0.109	0.081	-20.4	+17.2	-12.9
	14.7	0.150	0.131	0.245	0.136	-12.7	+63.3	-9.3
	20	0.210	0.239	0.452	0.200	+13.8	+115.2	-4.8
20	4.9	0.49	0.48	0.511	0.487	-2.0	+4.3	-0.6
	10	0.46	0.52	0.579	0.475	+13.0	+25.9	+3.3
	14.7	0.53	0.66	0.850	0.577	+24.5	+60.4	+8.9
	20	0.60	0.90	1.280	0.726	+50.0	+113.3	+21.0

Notes: 1 - model PR-SV give deviation from +3.8% to 226%, KD from -6.1% to +103.3%, PR from +3.8% to +226.2%, SRK-Twu, PR-Twu, TST from +16% to +220%;
2 – model SRK (modif. Panad-Reid) give deviation from – 11.0% to – 44.3%, PR from – 3.8% to +115.2%.

Table 2.3. Solubility of methanol in unstable condensate, % mass. (by concentration of methanol in water 50% and molecular weight of unstable condensate 90).

T, C	Literary data (Istomin, 1987)	HYSYS (PR-SV)	PRO-2 (SRK-SS)	GCO PR-Gas Inst	Deviation, %		
					HYSYS (PR-SV)[1]	PRO-2 (SRK-SS)[2]	GCO PR-Gas Inst
-20	0.22	0.76	0.59	0.24	+245.5	+168.2	+9.1
-10	0.41	0.99	0.77	0.38	+141.5	+87.8	-7.3
0	0.63	1.25	0.99	0.57	+98.4	+57.1	-9.5
10	1.0	1.54	0.99	0.85	+54.0	-1.0	-15.0

Notes: 1 - model PR give deviation from +96 % to +450 %, KD from +290 % to +1000 %, PR-Twu, SRK-Twu, TST, CEOS/A^E – above +370%;
2 - model SRK-MPR give deviation to – 100 %, PR-MPR from +300 % to +700 %, PR - to +1100 %.

Table 2.4. Solubility of water in liquid hydrocarbons

System	T, C	% (mole) of water in hydrocarbon phase				Deviation, %		
		Experim. (Griswold, 1942)	HYSYS KD	PRO-2 SRK-SS	GCO PR-Gas Inst	HYSYS KD[1]	PRO-2 SRK-SS[2]	GCO PR-Gas Inst
Water-octane	10	0.056	0.022	0.031	0.055	-60.7	-44.6	-17.8
	37.8	0.2	0.084	0.1	0.19	-58.0	-50.0	-5.0
Water-heavy oil fraction (M=434)	124	2.52	1.43	2.8	2.1	-43.2	+11.1	-16.7
	189	9.53	5.8	10.8	9.4	-39.1	+13.3	-1.4

Notes: 1 – model PR give deviation from -25.4% to -60.7%, PR-SV from – 27.2% to -66.1%, PR-Twu, SRK-Twu, TST from – 60% to -90%, CEOS/A^E - up to +1000%;
2 – model SRK (modif. Panad-Reid) give deviation from +12.7% to – 44.6%, PR from – 8.2% to -50.0%.

Table 2.5. Experimental (Yokoyama, 1988) and calculating solubility of methane in DEG at t = 25 C.

P, MPa	% (mole) methane in DEG				Deviation, %		
	Exp	HYSYS TST	PRO-2 SRK-SS	GCO PR- Gas Inst	HYSYS TST[1]	PRO-2 SRK-SS[2]	GCO PR- Gas Inst
3	0,959	0,96	3,4	1,06	0.0	+254.5	+10.5
5	1,66	1,5	5,4	1,65	-9.6	+225.3	-0.6
8	2,48	2,18	7,9	2,42	-12.1	+218.5	-2.4

Notes: 1 – model PR-Twu give deviation from -7% to -18%, SRK-Twu from -12% to -21%, CEOS/A^E from +230% to +250%, PR from +230% to 260%, PR-SV from +450% to +500%,KD from +170% to +200%;

2 – model SRK (modif. Panad-Reid) give deviation from 140% to 170%, PR from – 220% to +260%.

3. Influence of reservoir mineralized water on properties of a field technological medium.

Table 3.1. Experimental (Morrison,1990) and calculating relative volatility of methanol in water – salt mixture (T = 361 K, P = 0.101 MPa).[1]

NaCl content in water, % (mole)	Methanol content in water, % (mole)	Experimental relative volatility	PRO-2 SRK-MPR	GCO PR-Gas Inst	Deviation, % (PRO-2, SRK-MPR)[2]	Deviation, % (GCO, PR-Gas Inst)
0	10.7	6.8	6.4	6.0	-5.9	-11.8
2.9	10.2	8.7	15.0	8.1	+72.4	-6.9
4.3	10.0	9.5	21.4	8.9	+125.3	-6.3
5.8	9.7	10.7	29.3	9.7	+173.8	-9.3
7.1	9.5	11.5	37.1	10.3	+222.6	-10.4

Notes: 1 – Calculation by HYSYS no possible.
2 – SRK-KD, SRK-SS etc. models give greater deviation.

Table 3.2. Literary (Katz,1959) and calculating water content in methane, g/m3 (T= 313 K).

P, MPa	% (weight) CaCl2 in water	Literary data	GCO PR-Gas Inst
1	0	5,74	5,84
	20[1]	4,85	4,5
10	0	0,81	0,81
	20[1]	0,68	0,62

Notes: 1 – Calculation by HYSYS and PRO-2 no possible.

Literature about GasCondOil

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2. Kalashnikov O.V., Budnyak S.V., Ivanov Yu.V. Adequacy questions of thermalphysic base of HYSYS, PRO-2 and GasCondOil. 2. Hydrocarbons, water, methanol, glycols and salts mixtures. Ecotechnologies and resource saving, 2000, № 1, p. 31-35.)

3. Besprozvanny A.V., Kabanov O.P., Stavitsky V.A., Zvetkov N.A., Grizishin D.N., Tipugin A.A. Perspective of valangin gas treatment (En-Yahin field). Problems of development of Urengoy-complex. M., Nedra, 2003, p. 143-149.

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Overall conclusion

1. Comparison of the GasCondOil-Program with PRO-2 and HYSYS shows similar accuracy for hydrocarbon mixtures and better results for hydrocarbons-aqueous solution systems containing methanol, glycols and salts.
2. As compared with existing analogs GasCondOil provides the most reliable results by engineering calculations of gas field-treatment systems.

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