Case – 18 Gas Analysis

Copy Right By:
Thomas T.S. Wan
（温到祥)
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Case Background:

The compressors in any of refrigeration systems are actually performing gas compression function no matter what type of refrigerant is used for the refrigeration system. The refrigerant can be halocarbons, ammonia or hydrocarbons. In most cases, the refrigerant used for refrigeration system only consists of one gas component. For example, R-290 is 100% of propane, R-1270 is 100% of propylene, etc.

Sometime, for pipe line gas compression or in some case the refrigerant used for process refrigeration system is a mixed hydrocarbon, which consists of many gas components instead of pure refrigerant.

This case is to demonstrate the method to calculate the properties of the gas mixture.

Related Technical Data and Engineering Information for the Case:

No.	Compound	Formula	Molecular weight	Boiling point °F., 14.696 psia	Vapor pressure, 100°F., psia	Freezing point, °F., 14.696 psia	Critical constants: Pressure, psia	Critical constants: Temperature, °F.	Critical constants: Volume, cu ft/lb
1	Methane	CH_4	16.043	-258.69	(5000)	-296.46[d]	667.8	-116.63	0.0991
2	Ethane	C_2H_6	30.070	-127.48	(800)	-297.89[d]	707.8	90.09	0.0788
3	Propane	C_3H_8	44.097	-43.67	190.	-305.84[d]	616.3	206.01	0.0737
4	n-Butane	C_4H_{10}	58.124	31.10	51.6	-217.05	550.7	305.65	0.0702
5	Isobutane	C_4H_{10}	58.124	10.90	72.2	-255.29	529.1	274.98	0.0724
6	n-Pentane	C_5H_{12}	72.151	96.92	15.570	-201.51	488.6	385.7	0.0675
7	Isopentane	C_5H_{12}	72.151	82.12	20.44	-255.83	490.4	369.10	0.0679
8	Neopentane	C_5H_{12}	72.151	49.10	35.9	2.17	464.0	321.13	0.0674
9	n-Hexane	C_6H_{14}	86.178	155.72	4.956	-139.58	436.9	453.7	0.0688
10	2-Methylpentane	C_6H_{14}	86.178	140.47	6.767	-244.63	436.6	435.83	0.0681
11	3-Methylpentane	C_6H_{14}	86.178	145.89	6.098	—	453.1	448.3	0.0681
12	Neohexane	C_6H_{14}	86.178	121.52	9.856	-147.72	446.8	420.13	0.0667
13	2,3-Dimethylbutane	C_6H_{14}	86.178	136.36	7.404	-199.38	453.5	440.29	0.0665
14	n-Heptane	C_7H_{16}	100.205	209.17	1.620	-131.05	396.8	512.8	0.0691
15	2-Methylhexane	C_7H_{16}	100.205	194.09	2.271	-180.89	396.5	495.00	0.0673
16	3-Methylhexane	C_7H_{16}	100.205	197.32	2.130	—	408.1	503.78	0.0646
17	3-Ethylpentane	C_7H_{16}	100.205	200.25	2.012	-181.48	419.3	513.48	0.0665
18	2,2-Dimethylpentane	C_7H_{16}	100.205	174.54	3.492	-190.86	402.2	477.23	0.0665
19	2,4-Dimethylpentane	C_7H_{16}	100.205	176.89	3.292	-182.63	396.9	475.95	0.0668
20	3,3-Dimethylpentane	C_7H_{16}	100.205	186.91	2.773	-210.01	427.2	505.85	0.0662
21	Triptane	C_7H_{16}	100.205	177.58	3.374	-12.82	428.4	496.44	0.0636
22	n-Octane	C_8H_{18}	114.232	258.22	0.537	-70.18	360.6	564.22	0.0690
23	Diisobutyl	C_8H_{18}	114.232	228.39	1.101	-132.07	360.6	530.44	0.0676
24	Isooctane	C_8H_{18}	114.232	210.63	1.708	-161.27	372.4	519.46	0.0656
25	n-Nonane	C_9H_{20}	128.259	303.47	0.179	-64.28	332.	610.68	0.0684
26	n-Decane	$C_{10}H_{22}$	142.286	345.48	0.0597	-21.36	304.	652.1	0.0679
27	Cyclopentane	C_5H_{10}	70.135	120.65	9.914	-136.91	653.8	461.5	0.059
28	Methylcyclopentane	C_6H_{12}	84.162	161.25	4.503	-224.44	548.9	499.35	0.0607
29	Cyclohexane	C_6H_{12}	84.162	177.29	3.264	43.77	591.	536.7	0.0586
30	Methylcyclohexane	C_7H_{14}	98.189	213.68	1.609	-195.87	503.5	570.27	0.0600
31	Ethylene	C_2H_4	28.054	-154.62	—	-272.45[d]	729.8	48.58	0.0737
32	Propene	C_3H_6	42.081	-53.90	226.4	-301.45[d]	669.	196.9	0.0689
33	1-Butene	C_4H_8	56.108	20.75	63.05	-301.63[d]	583.	295.6	0.0685
34	Cis-2-Butene	C_4H_8	56.108	38.69	45.54	-218.06	610.	324.37	0.0668
35	Trans-2-Butene	C_4H_8	56.108	33.58	49.80	-157.96	595.	311.86	0.0680
36	Isobutene	C_4H_8	56.108	19.59	63.40	-220.61	580.	292.55	0.0682
37	1-Pentene	C_5H_{10}	70.135	85.93	19.115	-265.39	590.	376.93	0.0697
38	1,2-Butadiene	C_4H_6	54.092	51.53	(20.)	-213.16	(653.)	(339.)	(0.0649)
39	1,3-Butadiene	C_4H_6	54.092	24.06	(60.)	-164.02	628.	306.	0.0654
40	Isoprene	C_5H_8	68.119	93.30	16.672	-230.74	(558.4)	(412.)	(0.0650)
41	Acetylene	C_2H_2	26.038	-119[e]	—	-114.[d]	890.4	95.31	0.0695
42	Benzene	C_6H_6	78.114	176.17	3.224	41.96	710.4	552.22	0.0531
43	Toluene	C_7H_8	92.141	231.13	1.032	-138.94	595.9	605.55	0.0549
44	Ethylbenzene	C_8H_{10}	106.168	277.16	0.371	-138.91	523.5	651.24	0.0564
45	o-Xylene	C_8H_{10}	106.168	291.97	0.264	-13.30	541.4	675.0	0.0557
46	m-Xylene	C_8H_{10}	106.168	282.41	0.326	-54.12	513.6	651.02	0.0567
47	p-Xylene	C_8H_{10}	106.168	281.05	0.342	55.86	509.2	649.6	0.0572
48	Styrene	C_8H_8	104.152	293.29	(0.24)	-23.10	580.	706.0	0.0541
49	Isopropylbenzene	C_9H_{12}	120.195	306.34	0.188	-140.82	465.4	676.4	0.0570
50	Methyl Alcohol	CH_4O	32.042	148.1(2)	4.63(22)	-143.82(22)	1174.2(21)	462.97(21)	0.0589(21)
51	Ethyl Alcohol	C_2H_6O	46.069	172.92(22)	2.3(7)	-173.4(22)	925.3(21)	469.58(21)	0.0580(21)
52	Carbon Monoxide	CO	28.010	-313.6(2)	—	-340.6(2)	507.(17)	-220.(17)	0.0532(17)
53	Carbon Dioxide	CO_2	44.010	-109.3(2)	—	—	1071.(17)	87.9(23)	0.0342(23)
54	Hydrogen Sulfide	H_2S	34.076	-76.6(24)	394.0(6)	-117.2(7)	1306.(17)	212.7(17)	0.0459(24)
55	Sulfur Dioxide	SO_2	64.059	14.0(7)	88.(7)	-103.9(7)	1145.(24)	315.5(17)	0.0306(24)
56	Ammonia	NH_3	17.031	-28.2(24)	212.(7)	-107.9(2)	1636.(17)	270.3(24)	0.0681(17)
57	Air	N_2O_2	28.964	-317.6(2)	—	—	547.(2)	-221.3(2)	0.0517(3)
58	Hydrogen	H_2	2.016	-423.0(24)	—	-434.8(24)	188.1(17)	-399.8(17)	0.5167(24)
59	Oxygen	O_2	31.999	-297.4(2)	—	-361.8(24)	736.9(24)	-181.1(17)	0.0382(24)
60	Nitrogen	N_2	28.013	-320.4(2)	—	-346.0(24)	493.0(24)	-232.4(24)	0.0514(17)
61	Chlorine	Cl_2	70.906	-29.3(24)	158.(7)	-149.8(24)	1118.4(24)	291.(17)	0.0281(17)
62	Water	H_2O	18.015	212.0	0.9492(12)	32.0	3208.(17)	705.6(17)	0.0500(17)
63	Helium	He	4.003	—	—	—	—	—	—
64	Hydrogen Chloride	HCl	36.461	-121(16)	925.(7)	-173.6(16)	1198.(17)	124.5(17)	0.0208(17)

Figure 18-1 Physical Constants of Various Hydrocarbons

°F	H_2	N_2	O_2	CO	CO_2	H_2O	H_2S	SO_2	SO_3	CH_4	C_2H_2	°F
-300	6.93	6.94	6.95	6.95	7.00					7.95		-300
-290	6.83	6.94	6.95	6.95	7.01					7.95		-290
-280	6.73	6.94	6.95	6.95	7.02					7.95		-280
-270	6.64	6.94	6.95	6.95	7.04					7.95		-270
-260	6.57	6.95	6.95	6.95	7.06					7.95		-260
-250	6.51	6.95	6.95	6.95	7.08					7.95		-250
-240	6.46	6.95	6.95	6.95	7.10					7.95		-240
-230	6.42	6.95	6.95	6.95	7.12					7.95		-230
-220	6.38	6.95	6.95	6.95	7.15					7.95		-220
-210	6.36	6.95	6.95	6.95	7.17					7.95		-210
-200	6.35	6.95	6.95	6.95	7.20		7.88	8.10	9.00	7.95		-200
-190	6.34	6.95	6.95	6.95	7.25		7.88	8.14	9.11	7.95		-190
-180	6.35	6.95	6.95	6.95	7.28		7.90	8.20	9.22	7.95		-180
-170	6.36	6.95	6.95	6.95	7.32		7.90	8.24	9.33	7.96		-170
-160	6.39	6.95	6.95	6.95	7.37		7.91	8.30	9.45	7.96		-160
-150	6.42	6.95	6.95	6.95	7.42		7.92	8.35	9.56	7.96		-150
-140	6.44	6.95	6.95	6.95	7.47		7.93	8.40	9.67	7.96		-140
-130	6.47	6.95	6.95	6.95	7.53		7.94	8.45	9.77	7.97		-130
-120	6.50	6.95	6.96	6.95	7.59		7.95	8.50	9.90	7.98		-120
-110	6.53	6.95	6.96	6.95	7.65		7.96	8.56	10.0	7.99		-110
-100	6.56	6.95	6.96	6.95	7.71		7.97	8.61	10.1	8.00		-100
-90	6.58	6.95	6.96	6.95	7.78		7.98	8.66	10.2	8.02		-90
-80	6.61	6.95	6.96	6.95	7.84		7.99	8.71	10.3	8.04		-80
-70	6.63	6.95	6.96	6.95	7.90		8.00	8.76	10.4	8.06		-70
-60	6.66	6.95	6.96	6.95	7.97		8.02	8.81	10.6	8.08		-60
-50	6.68	6.95	6.96	6.95	8.03		8.03	8.87	10.7	8.09		-50
-40	6.70	6.95	6.97	6.95	8.11		8.04	8.91	10.8	8.12		-40
-30	6.72	6.95	6.97	6.95	8.18		8.05	8.97	10.9	8.15		-30
-20	6.75	6.95	6.97	6.95	8.25		8.06	9.01	11.0	8.17		-20
-10	6.77	6.95	6.97	6.95	8.33		8.03	9.06	11.1	8.20		-10
0	6.78	6.95	6.98	6.95	8.38	7.98	8.09	9.12	11.2	8.23	9.68	0
10	6.80	6.95	6.98	6.95	8.45	7.99	8.10	9.18	11.3	8.26	9.79	10
20	6.82	6.95	6.98	6.95	8.51	7.99	8.12	9.23	11.4	8.29	9.90	20
30	6.83	6.95	6.99	6.96	8.58	8.00	8.13	9.28	11.6	8.33	10.0	30
40	6.85	6.95	6.99	6.96	8.65	8.00	8.15	9.33	11.7	8.37	10.1	40
50	6.86	6.95	7.00	6.96	8.70	8.00	8.16	9.38	11.8	8.41	10.2	50
60	6.87	6.95	7.00	6.96	8.76	8.01	8.17	9.43	11.9	8.45	10.3	60
70	6.88	6.95	7.01	6.96	8.83	8.02	8.19	9.48	12.0	8.49	10.4	70
80	6.89	6.96	7.02	6.96	8.89	8.02	8.20	9.53	12.1	8.54	10.5	80
90	6.90	6.96	7.02	6.96	8.95	8.03	8.22	9.59	12.2	8.59	10.6	90
100	6.90	6.96	7.03	6.96	9.01	8.03	8.24	9.64	12.3	8.65	10.7	100
110	6.91	6.96	7.03	6.96	9.06	8.04	8.25	9.69	12.4	8.70	10.8	110
120	6.92	6.96	7.04	5.97	9.12	8.05	8.27	9.74	12.6	8.76	10.9	120
130	6.92	6.96	7.05	6.97	9.19	8.06	8.28	9.79	12.7	8.82	11.0	130
140	6.93	6.96	7.06	6.97	9.24	8.06	8.30	9.84	12.8	8.86	11.1	140
150	6.93	6.96	7.07	6.97	9.30	8.07	8.32	9.89	12.9	8.95	11.1	150
160	6.94	6.96	7.08	6.97	9.35	8.08	8.34	9.94	13.0	9.01	11.2	160
170	6.94	6.96	7.09	6.98	9.40	8.09	8.36	9.98	13.1	9.08	11.3	170
180	6.94	6.96	7.10	6.98	9.46	8.10	8.38	10.0	13.2	9.14	11.4	180
190	6.95	6.96	7.11	6.98	9.51	8.11	8.39	10.1	13.3	9.21	11.5	190

Figure 18-2 Values of Various Ideal Gases Mol. Wt. Cp – Btu/Lb-Mole-°F

°F	C_2H_4	C_2H_6	C_3H_6	C_3H_8	iC_4H_8	$1C_4H_8$	iC_4H_{10}	nC_4H_{10}	iC_5H_{12}	nC_5H_{12}	nC_6H_{14}	nC_7H_{16}	°F
-300	8.13	8.51	9.17	9.45			10.5	12.6					-300
-290	8.13	8.56	9.28	9.61			10.8	12.8					-290
-280	8.13	8.60	9.37	9.80			11.1	13.0					-280
-270	8.13	8.66	9.48	9.98			11.5	13.3					-270
-260	8.13	8.71	9.60	10.2			11.8	13.5					-260
-250	8.13	8.77	9.72	10.4			12.1	13.8					-250
-240	8.13	8.84	9.85	10.5			12.5	14.1					-240
-230	8.14	8.90	10.0	10.7			12.8	14.4					-230
-220	8.14	8.98	10.1	10.9			13.1	14.7					-220
-210	8.15	9.06	10.3	11.1			13.5	15.0					-210
-200	8.15	9.14	10.4	11.3			13.8	15.2					-200
-190	8.16	9.23	10.6	11.5			14.2	15.5					-190
-180	8.17	9.32	10.7	11.7			14.5	15.8					-180
-170	8.19	9.41	10.9	11.9			14.8	16.1					-170
-160	8.20	9.51	11.0	12.1			15.2	16.4					-160
-150	8.22	9.61	11.2	12.3			15.5	16.7					-150
-140	8.24	9.72	11.4	12.5			15.8	17.0					-140
-130	8.26	9.82	11.5	12.7			16.2	17.3					-130
-120	8.29	9.94	11.7	12.9			16.5	17.7					-120
-110	8.33	10.0	11.9	13.1			16.8	18.0					-110
-100	8.37	10.2	12.0	13.3	15.8	15.2	17.2	18.3	19.9	20.6	25.1	29.2	-100
-90	8.42	10.3	12.2	13.6	16.1	15.4	17.5	18.6	20.4	21.1	25.6	29.8	-90
-80	8.48	10.4	12.4	13.8	16.4	15.6	17.8	18.9	20.9	21.5	26.1	30.4	-80
-70	8.55	10.5	12.5	14.0	16.7	15.9	18.1	19.2	21.4	22.0	26.6	30.9	-70
-60	8.64	10.6	12.7	14.2	17.1	16.1	18.4	19.5	21.9	22.5	27.1	31.5	-60
-50	8.72	10.8	12.9	14.5	17.4	16.4	18.7	19.8	22.3	22.9	27.7	32.1	-50
-40	8.82	10.9	13.1	14.7	17.7	16.7	19.0	20.1	22.8	23.4	28.2	32.7	-40
-30	8.93	11.1	13.2	14.9	18.0	17.0	19.4	20.4	23.3	23.8	28.7	33.3	-30
-20	9.04	11.2	13.4	15.2	18.3	17.3	19.7	20.7	23.8	24.3	29.2	33.9	-20
-10	9.17	11.3	13.6	15.4	18.6	17.6	20.1	21.0	24.3	24.8	29.7	34.5	-10
0	9.32	11.4	13.7	15.6	18.9	18.0	20.4	21.3	24.8	25.2	30.2	35.1	0
10	9.46	11.6	13.8	15.9	19.2	18.3	20.7	21.5	25.2	25.7	30.7	35.7	10
20	9.60	11.7	14.1	16.1	19.5	18.6	21.1	21.8	25.7	26.2	31.3	36.3	20
30	9.74	11.9	14.3	16.4	19.9	19.0	21.5	22.1	26.2	26.6	31.8	36.9	30
40	9.88	12.0	14.5	16.6	20.2	19.3	21.8	22.4	26.6	27.0	32.3	37.5	40
50	10.0	12.2	14.7	16.9	20.5	19.6	22.2	22.6	27.1	27.5	32.8	38.1	50
60	10.2	12.3	14.9	17.1	20.8	19.9	22.5	22.9	27.6	27.9	33.3	38.7	60
70	10.3	12.5	15.1	17.4	21.1	20.2	22.9	23.2	28.0	28.4	33.8	39.3	70
80	10.4	12.6	15.3	17.6	21.4	20.5	23.2	23.4	28.5	28.8	34.4	39.8	80
90	10.6	12.8	15.5	17.9	21.6	20.9	23.6	23.7	28.9	29.3	34.9	40.4	90
100	10.7	13.0	15.8	18.2	22.0	21.2	24.0	24.1	29.4	29.7	35.4	41.1	100
110	10.9	13.1	16.0	18.4	22.2	21.5	24.3	24.4	29.8	30.1	35.9	41.7	110
120	11.0	13.3	16.2	18.7	22.5	21.8	24.7	24.8	30.3	30.6	36.4	42.2	120
130	11.1	13.4	16.4	19.0	22.8	22.1	25.0	25.1	30.8	31.0	37.0	42.8	130
140	11.3	13.6	16.6	19.2	23.1	22.4	25.4	25.5	31.2	31.5	37.5	43.4	140
150	11.4	13.8	16.8	19.5	23.4	22.7	25.8	25.8	31.7	31.9	38.0	44.0	150
160	11.5	13.9	17.0	19.8	23.7	23.0	26.1	26.1	32.1	32.3	38.5	44.6	160
170	11.7	14.1	17.2	20.1	24.0	23.3	26.5	26.5	32.6	32.7	39.0	45.2	170
180	11.8	14.3	17.4	20.4	24.3	23.6	26.9	26.8	33.0	33.2	39.5	45.8	180
190	11.9	14.5	17.6	20.6	24.6	24.0	27.2	27.2	33.4	33.6	40.0	46.4	190

Figure 18-3 Values of Various Ideal Gases Mol. Wt. Cp – Btu/Lb-Mole-°F

Cogitation

When making gas compression calculation, the gas physical properties such as molecular weight, critical pressure, critical temperature and the Mol. Wt. Cp. of a gas mixture required are required. If the gas is a mixture of various hydrocarbons, a calculation shall be made to find out the properties of the gas mixture. Each components of the gas mixture must be given either by percent of moles or percent of weight. If the percentages are given by percents weight, it shall be converted to percents.

The Figure 18-1 is the physical properties table for molecular weight, critical pressure, critical temperature for most of the hydrocarbon gases. The Figure 18-2 and 18-2 are the Mol. Wt. Cp at various temperatures for the hydrocarbon gases.

Figure 18-1 also shows the formula each of the hydrocarbons. Sometimes, hydrocarbon gas is expressed with numerical prefix, such as C_1 for Methane, C_2 for Ethane, iC_4 fir Iso-Butane and etc, numerical prefix for gases are shown as the following:

C_n iC_n - Iso nC_n - Normal

Examples:

n		n		n		n	
1	Methane	12	Dodecane	22	Docosane	32	Dotriacontane
2	Ethane	13	Tridecane	23	Tricosane	33	Tritriacontane
3	Propane	14	Tetradecane	24	Tetracosane	40	Tetracontane
4	Butane	15	Pentadecane	25	Pentacosane	50	Pentacontane
5	Pentane	16	Hexadecane	26	Hexacosane	60	Hexacontane
6	Hexane	17	Heptadecane	27	Heptacosane	70	Heptacontane
7	Heptane	18	Octadecane	28	Octacosane	80	Octacontane
8	Octane	19	Nonadecane	29	Nonacosane	90	Nonacontane
9	Nonane	20	Eicosane	30	Triacontane	100	Hectane
10	Decane	21	Heneicosane	31	Hentriacontane	132	Dotriacontahecta
11	Undecane						

The following is the demonstration to show how to calculate the physical properties of a gas mixture:

Gas properties calculation for gas mixture when mole% is given:

1.0 Mixture of gases:

For a mixture of gas, the exact value of Mole Percent or Weight Percent must be provided for each components of the gas composition; undefined expressions such as ‘Others’, ‘Approximately’, Misc. Gases’ and etc are not allowed. Therefore, the following undefined gas composition expression is not to be used:

Methane	89%
Ethane	4%
Propane	5%
Others	2%

The following gas composition expression is acceptable:

Methane	89%
Ethane	4%
Propane	5%
Carbon.Dioxide	2%

2.0 Chemical Formula, Mole Percents and M.F. for the mixture:

		Mole%	M.F.
Methane	CH_4	89%	0.89
Ethane	C_2H_6	4%	0.04
Propane	C_3H_8	5%	0.05
Carb..Dioxide	CO_2	2%	0.02
Total		100%	1.00

The total must be exactly equal to 100% mole percent or 1.00 for M.F.

3.0 Physical constants of the each components from Figure 18-1:

Methane, CH_4
Molecular Weight = 16.043
Critical Pressure = 667.8 Psia
Critical Temp = -116.63°F
Or °R = -116.63 + 460 = 343.37°R
MWcp at 80°F = 8.54

Ethane, C_2H_6
Molecular Weight = 30.07
Critical Pressure = 707.8 Psia
Critical Temp = 90.09°F
Or °R = 90.09 + 460 = 550.1°R
MWcp at 80°F = 12.6

Propane, C_3H_8
Molecular Weight = 44.-97
Critical Pressure = 616.3 Psia
Critical Temp = 206.01°F
Or °R = 206.01 + 460 = 666.0°R
MWcp at 80°F = 17.6

Carbon Dioxide
Molecular Weight = 44.01
Critical Pressure = 1071 Psia
Critical Temp = 87.9°F
Or °R = 87.9 + 460 = 547.9°R
MWcp at 80°F = 8.89

4.0 To calculate the Molecular Weight for the Gas Mixture:

The pseudo M.W. of Methane = 16.0 x 0.89 = 14.24.
Follow the same steps to calculate the partial M.W. for other component of the gas.

Component	Formula	M.W.	Mol %	Pseudo M.W.
Methane	CH4	16.0	89%	14.24
Ethane	C2H6	30.1	4%	1.20
Propane	C3H8	44.1	5%	2.21
Carb.Dioxide	CO2	44.0	2%	0.88
Mixture Gas			100%	18.53

Therefore, the Molecular Weight of the gas mixture is 18.53

5.0 To calculate the Critical Pressure (Psia) for the gas mixture:

The Pseudo Critical Pressure of Methane = 667.8 x 0.89 = 594.34.
Follow the same steps to calculate the partial critical pressure for other component of the gas.

Component	Formula	Mol %	Critical Press.	Pseudo Critical Press.
Methane	CH4	89%	667.8	594.34
Ethane	C2H6	4%	707.8	28.31
Propane	C3H8	5%	616.3	30.82
Carb.Dioxide	CO2	2%	1071	21.42
Mixture Gas		100%		674.89

Therefore, the critical pressure of the gas mixture is 674.79 Psia

6.0 To Calculate the Critical Temperature for the Gas Mixture:

Temperature used for gas compression calculation is Rankin Temperature °R instead of °F; so change all the °F to °R to calculate the mixture critical temperature.

The Pseudo Critical Temperature of Methane = 343.37 x 0.89 = 305.60.
Follow the same steps to calculate the partial critical temperature for other component of the gas.

Component	Formula	Mol %	Critical Temperature	Pseudo Temp. °R
Methane	CH4	89%	(-116.63 +460) = 343.37	305.60
Ethane	C2H6	4%	(90.09 + 460) = 550.09	22.00
Propane	C3H8	5%	(206.01 + 460) = 666.01	33.30
Carb.Dioxide	CO2	2%	(87.9 + 460) = 547.90	10.96
Mixture Gas		100%		371.86

Therefore, the Critical Temperature of the Gas Mixture is 371.86°R

7.0 To Calculate the Mol. Wt. Cp for the Gas Mixture:

The MWcp is to be used for the calculation of the k factor. It is always associated with the temperature at the suction. Assuming the operating condition is 80°F, the example is to calculate the MWcp of the gas mixture at 80°F at compressor suction.

The Pseudo MWcp of Methane = 8.54 x 0.89 = 7.60.
Follow the same steps to calculate the partial MWcp for other component of the gas.

Component	Formula	Mol %.	MWcp	MWcp
Methane	CH4	89%	8.54	7.600
Ethane	C2H6	4%	12.60	0.504
Propane	C3H8	5%	17.6	0.880
Carb.Dioxide	CO2	2%	8.89	0.178
Mixture Gas		100%		9.162

Therefore, the MWcp of the Gas Mixture at 80°F is 9.162

8.0 Gas Analysis Table:

								Component	Pseudo	
Component	Formula	M.W.	Mol %	Pseudo M.W.	Critical Press.	Critical Temp.	MWcp	Press.	Temp.	MWcp
Methane	CH4	16.0	89%	14.24	668	343	8.54	595	305	7.600
Ethane	C2H6	30.1	4%	1.20	708	550	12.60	28	22	0.504
Propane	C3H8	44.1	5%	2.21	616	666	17.6	31	33	0.880
Carb.Dioxide	CO2	44.0	2%	0.88	1071	548	8.89	21	11	0.178
Mixture Gas			100%	18.53				675	371	9.162

Therefore, physical properties of the gas mixture are as the following:

MW of gas mixture:	18.53
Critical Pressure:	675 Psia
Critical Temperature:	371°R
MWcp at 80°F:	9.162

Converting Weight Percents to Mole Percent for gas mixture:

As indicated earlier, the properties calculation for gas mixture are based on Mole%, therefore, if only Wt% is given for the gas flow, the Wt% should be converted into Mol% in order to calculate the gas properties of the mixture. The steps to convert the Wt% to Mol% are as the following:

(1) Components of mixture gas, Wt% given:

Propane	C_3H_8	75.90% by weight
Methane	CH_4	8.48%
Ethane	C_2H_6	7.95%
n-Butan	$n\text{-}C_4H_{10}$	7.67%

(2) Find the molecular weight of each component of the gas:

		Molecular weight
Propane	C_3H_8	44.094
Methane	CH_4	16.042
Ethane	C_2H_6	30.068
n-Butan	$n\text{-}C_4H_{10}$	58.120

(3) Convert the Weight Percent to Mole Percent:

Calculate the Mol Gas per 100# of Mixture for Propane component:

$$= \frac{\text{Wt\%}}{\text{MW}} = \frac{75.90}{44.094} = 1.7213$$

Same step to calculate the value for other gas components and the result is as the following:

	MW	Wt%	Mol Gas Per 100# Mix.
Propane, C_3H_8	44.094	75.90	1.7213
Methane, CH_4	16.042	8.48	0.5286
Ethane , C_2H_6	30.068	7.95	0.2644
n-Butan, n-C_4H_{10}	58.120	7.67	0.1320
		100.00%	2.6463

Total Lb. Mol per 100 Lbs gas is 2.6463

$$\text{Mol\% for Propane gas} = \frac{1.7213}{2.6463} = 65.05 \text{ Mol\%}$$

Follow the same steps to calculate the Mole% for other gas component and the result is shown below:

	MW	Wt%	Mol Gas Per 100# Mix.	Mol %
Propane, C_3H_8	44.094	75.90	1.7213	65.05
Methane, CH_4	16.042	8.48	0.5286	19.98
Ethane , C_2H_6	30.068	7.95	0.2644	9.99
n-Butan, n-C_4H_{10}	58.120	7.67	0.1320	4.98
		100.00%	2.6463	100.0%

(4) Gas mixture in Mole percent:

Propane	C_3H_8	65.05% by Mole
Methane	CH_4	19.98%
Ethane	C_2H_6	9.99%
n-Butan	n-C_4H_{10}	4.98%