VOLUMETRIC BEHAVIOR OF PROPENE

AND

THREE MIXTURES OF PROPENE AND 1-BUTENE

Thesis by

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ABSTRACT

The volumetric behavior of propene was investigated at temperatures from 40° to 460° F. and pressures from 10,000 pounds per square inch absolute to values well below vapor pressure at 40° F. The results are tabulated and are compared graphically with the data of other investigators.

Three mixtures of propene and 1-butene were subjected to volumetric study at temperatures from 40° to 280° F. in the pressure range from 10,000 to about 100 pounds per square inch absolute. The results are tabulated separately for the single-phase and two-phase regions of each mixture. Variations of actual behavior from that of ideal solutions are shown graphically.

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A. VOLUMETRIC BEHAVIOR OF PROPENE

I. INTRODUCTION

Information concerning the vapor pressure and volumetric behavior of propene is of value in industrial practice since this hydrocarbon can serve as the starting point in the preparation of a relatively large number of compounds. Experimental data pertaining to this substance are scattered and incomplete except for the recent studies of Vaughan and Graves (7). Their work covered the influence of pressure and temperature upon the specific volume of propene at pressures up to approximately 1200 pounds per square inch absolute for temperatures between 32° and 573° F. The measurements were carried out in glass over mercury, and contributed the most complete data available for this olefin. Limited information concerning the vapor pressure of this hydrocarbon was presented by Gilliland and Scheeline (2). The specific weight of the bubble-point liquid and dew-point gas near the critical temperature was studied by Winkler and Maass (8). Seibert and Burrell (6) determined the critical constants and vapor pressure of propene, whereas Powell and Giauque (3) established the heat capacity, the specific volume at atmospheric pressure, and certain other physical properties of this compound. The specific volume at atmospheric pressure was also determined by Batuecas (1) and Roper (4).

II. METHODS AND APPARATUS

The equipment employed in the volumetric studies reported was described earlier (5). In principle it consisted of a stainless steel chamber whose effective volume could be varied by introducing or withdrawing mercury. This chamber was submerged in an agitated oil bath, the temperature of which was controlled within 0.03° F. of the desired value. In order to extend this work to temperatures below 100° F., a cooling unit was added. Kerosene was withdrawn from the chamber oil bath, passed over freon-cooled coils, and returned to the oil bath. Mechanical agitation of the contents of the chamber was provided by a cylindrical cage of vertical rods activated by means of an electromagnet rotating about the outside of the chamber. The samples of propene were introduced into the apparatus in accordance with a weighing bomb technique that has been described (5). The uncertainty in the weight of the material added was probably less than 0.1%. After introducing the propene the pressure within the equipment was raised to the desired upper value by injecting mercury. The oil bath was maintained at a predetermined temperature and after equilibrium had been attained as indicated by the constancy of pressure with respect to time, the total volume occupied by the hydrocarbon was determined. The pressure was then decreased somewhat and the process repeated. From these measurements a series of corresponding equilibrium values of pressure and total volume were obtained for each of several temperatures. The same procedures were employed in the gas, liquid, and heterogeneous regions.

III. MATERIALS

The propene employed in this investigation was obtained from the Phillips Petroleum Company and a special analysis of the sample submitted indicated that it contained less than 0.005 mole fraction of material other than propene. The hydrocarbon as received was subjected to fractionation at atmospheric pressure in a column packed with small glass helices. The reflux ratio was approximately 40 to 1 and the first tenth and last fifth of the material were discarded in the course of each fractionation. At 100° F. the purified material showed 0.6 pound per square inch change in vapor pressure from bubble point to dew point. Two separate purifications were carried out in order to obtain an adequate supply for investigating the volumetric behavior of this compound. The material after purification was stored in a steel bomb until it was transferred to the volumetric equipment.

IV. EXPERIMENTAL RESULTS

Of the three samples of propene employed, the largest weighed approximately 0.22 pound and was used in the study of the condensed-liquid and single-phase regions at the higher pressures. An intermediate sample weighing approximately 0.06 pound was employed for investigations in the critical region and for studies at intermediate pressures at the higher temperatures. A small sample of about 0.015 pound was used for the study of the low-pressure, gaseous region and provided information concerning the specific volume at dew point for 40°, 70°, and 100° F. Dew-point data at temperatures from 130° to 190° F. were obtained from the measurements with the sample of intermediate size. The range of specific volumes investigated with a given filling of the apparatus was such that it overlapped those measured with another sample.

Upon completing a series of measurements covering twelve temperatures between 40° and 460° F. a redetermination of total volumes at 100° F. as a function of pressure was made in order to detect occurrence of any change in the sample. In the case of the intermediate and small samples no significant change in the characteristics of the material was noted. However, in the case of the larger sample a slight diminution in the total volume of the system was detected and it was not possible to recover by conventional high-vacuum weighing bomb techniques (5) all of the sample originally introduced. Upon opening the equilibrium vessel a small quantity of an oily liquid was found. This polymerized material apparently resulted from keeping the large sample at temperatures above 400° F. for approximately 25 hours. During this interval the system was at pressures in excess of 5000 pounds per square inch for about 6 hours. At points at which the data for the large sample overlapped those for the intermediate sample the only significant discrepancy in specific volume was noted at 460° F. For these reasons the data at 460° F. and pressures above 1500 pounds per square inch may involve uncertainties of as much as 0.25% beyond those associated with the measurements at the lower pressures and temperatures. The experimental data for the three sets of measurements were compared in terms of the residual specific volume, $\underset{\sim}{V}$, and the compressibility factor, Z. The maximum difference found between the specific volumes as established from two samples was 0.43%. The average deviation of the specific volume at some 50 states taken in the regions where comparisons were possible was 0.21%. A careful review of the uncertainties in the absolute values of the pressure, temperature, total volume, and weight of sample indicates that the recorded specific volume at a particular pressure and temperature probably does not involve an uncertainty greater than 0.3%.

The vapor pressure of propene at 100° F. was also determined in another apparatus which utilized an independent set of temperature and pressure measuring instruments. The value so obtained was 227.1 pounds per square inch, which agrees well with the vapor pressure of 227.3 pounds per square inch as found in this investigation.

For the gaseous region from infinite attenuation to about 500 pounds per square inch (or dew point at temperatures below 180° F.) the smoothing of experimental data was accomplished by means of the residual specific volume. Smooth curves of the compressibility factor were most useful for the intermediate pressure range above 600 pounds per square inch; the upper pressure limit varied from 2000 pounds per square inch at 220° F. to 6000 pounds per square inch at 460° F. All other data were correlated by means of the specific volume. In all cases the values of the functions mentioned were smoothed with respect to pressure and temperature.

The specific volume and compressibility factor are recorded in Table I for even values of the pressure at each of the temperatures experimentally studied. In the vicinity of the critical state, an added uncertainty of as much as 0.1% is to be expected. The values of the specific volume at bubble point and dew point and of the two-phase pressure are also recorded in Table I for temperatures below 190° F.

The vapor pressure of propene has been measured by other investigators (2, 6, 7). Figure 1 presents comparative values of the residual vapor pressure as a function of temperature. For this comparison the residual vapor pressure is used to magnify divergences and is defined by the following two equations:

$$\underset{\sim}{P}'' = P_r'' - P'' \qquad (1)$$

$$\log_{10} P_r'' = 5.48144 - \frac{1747.6}{T} \qquad (2)$$

The divergence of the earlier measurements of Seibert and Burrell (6) from the later results of Vaughan and Graves (7) and from the present ones is clearly evident. The measurements of Gilliland and Scheeline (2) also differ markedly from the present data. The values of vapor pressure recorded in Table I were obtained from the smooth curve of Figure 1 and Equations 1 and 2.

The critical temperature has been observed by several investigators (6, 8) and the data are in reasonable agreement. From a review of available data, 197.0° F. was chosen as the critical temperature of propene, whereas 196.5° F. was established by Vaughan and Graves (7). Extrapolation of the relation of vapor pressure to temperature from 190° F. to the critical temperature gave a value of 668 pounds per square inch. This compares with a value of 667 pounds per square inch reported by Vaughan and Graves (7). It is believed that this value is within 3 pounds per square inch of the true critical pressure. An extrapolation of the average of the specific weights of the dew-point gas and bubble-point liquid from 190° F. to 197° F. gave a value for the specific volume at the critical state of 0.06944 cubic feet per pound.

Two other published values (7, 8) for the critical specific volume are 0.0687 and 0.06916 cubic foot per pound respectively.

In the interest of convenience in the utilization of data the compressibility factor and specific volume for the dew-point gas and bubble-point liquid and the two-phase temperature have been recorded for a series of even values of pressure in Table II. The values of the two-phase temperature were obtained from a plot of $\mathbf{P}''$ versus pressure and equations 1 and 2. It is believed that the uncertainty in the two-phase temperatures cited is not greater than 0.07° F.

The volumetric behavior of propene is similar to that of other hydrocarbons when compared on a reduced basis. The volumetric data submitted in Table I supplemented by values of the heat capacity as a function of temperature (3) afford sufficient information to permit the thermodynamic properties of this hydrocarbon to be established. As an application of the data of Table I, the Clapeyron equation was used to obtain values of the latent heat of vaporization for several temperatures. The results are contained in Table III. For comparison, values obtained by Vaughan and Graves (7) are included in this tabulation.

B. VOLUMETRIC BEHAVIOR OF THREE MIXTURES OF PROPENE AND 1-BUTENE

I. INTRODUCTION

Although information concerning the volumetric behavior of mixtures of saturated hydrocarbons is constantly increasing in amount, combinations of unsaturated compounds have received little attention. In connection with the propene-1-butene system, volumetric data for 1-butene (9) and for propene (Part A) are available; however, no published data for mixtures were found.

Previous investigation (9) indicated that 1-butene deteriorates markedly at temperatures above 300° F. For this reason it was necessary to restrict the temperature range of the present work to a maximum of 280° F.

II. METHODS AND APPARATUS

The apparatus and procedure described in Part A were employed for this work. Samples were made up by two additions to the equilibrium cell. The 1-butene was added first, then the propene. Change of sample size for a given mixture was accomplished by removing a portion of the sample while the temperature was high enough to insure homogeneity of the system.

III. MATERIALS

The propene used for these mixtures was part of the large quantity which was purified for the investigation of the pure substance (Part A).

The 1-butene was prepared by dehydration of n-butanol with activated alumina used as a catalyst. A detailed description of the apparatus, preparation procedure, and method of purification may be found in the literature (9). Before producing 1-butene for the third mixture, the 4-8 mesh catalyst was replaced with 8-14 mesh granular alumina. As a result the optimum flow rate of liquid n-butanol was increased from about 35 to about 65 drops per minute. When vaporized at 130° F., a portion of the purified 1-butene showed 0.7 pound per square inch change in vapor pressure between bubble point and dew point.

IV. EXPERIMENTAL RESULTS

On a molal basis the three mixtures contained 17% (17.050%), 33% (33.153%), and 69% (69.050%) 1-butene, respectively. The initial sample weight for each mixture was about 0.17 pound. After completing a series of measurements up to maximum volume of the equilibrium cell for each of the seven temperatures between 40° and 280° F., the sample weight was reduced to about one-tenth of its original value. In this way a large and a small sample were obtained for each mixture, and the entire pressure range from about 100 to 10,000 pounds per square inch was effectively covered. Although an overlap of specific volumes was achieved for each pair of sample weights, comparison of overlapping values is not as significant as in the case of propene (Part A-IV). In the regions of overlap the total volume of the reduced sample was so small that uncertainties in operation of the apparatus produced relatively large percentage errors in the values of specific volume.

As in the case of propene, a redetermination of total volumes was made at 100° F. after each series of measurements at the seven temperatures. In addition, the vapor pressure of each sample was determined immediately after reducing the sample size. No significant changes were noted in any of the check determinations.

The experimental data for the single-phase regions were correlated by smoothing residual specific volume, compressibility factor, and specific volume in respect to pressure and temperature, using each function in regions where it was most suited to accurate interpolation. Smoothing with respect to temperature was often difficult to achieve. In several instances only two or three isotherms were available for a given region, and plotting against temperature was ineffective. It is believed, therefore, that the recorded values of specific volume and compressibility factor for the 33% and 69% mixtures may involve uncertainties up to 0.35% as compared with 0.3% for propene. Experimental data for the 17% mixture were slightly more scattered than the data for the other mixtures because a small amount of water in the air chamber decreased the accuracy of the volume determinations. It appears that the probable uncertainty in the single-phase data recorded for the 17% mixture may be as great as 0.4%.

For the three mixtures, values of specific volume and compressibility factor in the single-phase regions are presented at even pressures and the experimental temperatures in Tables IV, V, and VI. Figure 2 shows the effect of increasing proportion of 1-butene on the relation of compressibility factor to pressure.

It is believed that information concerning two-phase specific volumes may be of assistance in correlating data for the complete propene-1-butene system. Isothermal curves relating compressibility factor to pressure were the most satisfactory for treating the two-phase data. It seemed inadvisable to attempt interpolation at 40° F. for any of the three mixtures because of the great rate of change of compressibility factor with pressure. Since the two-phase data could not be smoothed with respect to temperature, uncertainties in them are higher than, for example, in those for the condensed liquid region. Additional uncertainty is introduced by the fact that equilibrium is evidently not always attained in the time allowed, particularly when the large sample is about 50% vaporized. Considering the factors just mentioned, it appears that the recorded values of two-phase specific volume may involve uncertainties up to 0.5%. Tables VII, VIII, and IX present two-phase specific volumes and compressibility factors at small pressure intervals for two-phase temperatures above 70° F. Sufficient values have been recorded to permit accurate graphical interpolation. All experimentally determined bubble-point and dew-point pressures and specific volumes have been included.

As an application of the information obtained in this investigation, Figure 3 shows the deviation of the actual vapor pressures of mixtures from Raoult's law predictions at 160° F. In this case $\underset{\sim}{P}''$ is defined by equation 1 (Part A), but P_r'' is defined by the relation:

$$P_r'' = X_1 P_1'' + X_2 P_2'' \tag{3}$$

The percentage deviation of actual specific volumes from those calculated on the basis of ideal solutions is presented in Figure 4. For this figure the ordinate is defined by the equation:

$$\text{Percent Deviation} = \frac{V_{Ideal} - V}{V_{Ideal}} (100) \tag{4}$$

The values of V_{Ideal} are given by a relation analogous to equation 3. It is interesting to note that the liquid mixtures at 10,000 pounds per square inch are more nearly ideal solutions than are the gaseous mixtures at 100 pounds per square inch.

NOMENCLATURE

b = specific gas constant, R/M, (lb./sq.in.) (cu.ft./lb.)/$^{\circ}$R

Propene	$b = 0.25504$
Mixture containing 17% 1-Butene	$b = 0.24133$
Mixture containing 33% 1-Butene	$b = 0.22966$
Mixture containing 69% 1-Butene	$b = 0.20732$

P = pressure, lb./sq.in.abs.

$\underset{\sim}{P}''$ = residual vapor pressure, lb./sq.in.

P''_1 = vapor pressure of pure component 1 at a given temperature, lb./sq.in.abs.

P''_r = reference vapor pressure, lb./sq.in.abs.

T = absolute temperature, $^{\circ}$R. = ($^{\circ}$F. + 459.69)

V = specific volume, cu.ft./lb.

$\underset{\sim}{V}$ = residual volume, $(bT/P) - V$, cu.ft./lb.

X_1 = mole fraction of component 1

Z = compressibility factor, PV/bT

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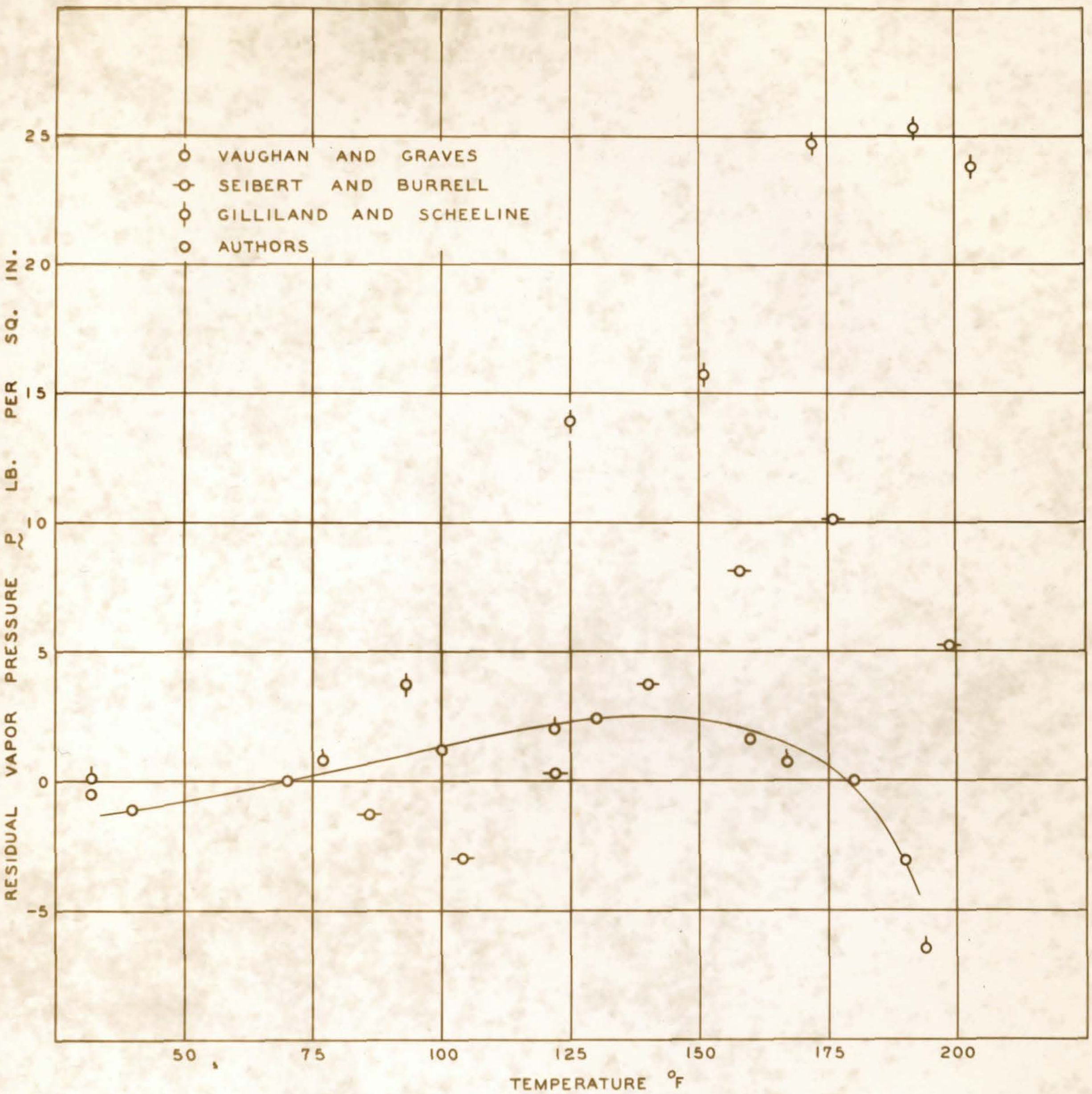

Figure 1. Comparison of Values of Residual Vapor Pressure of Propene

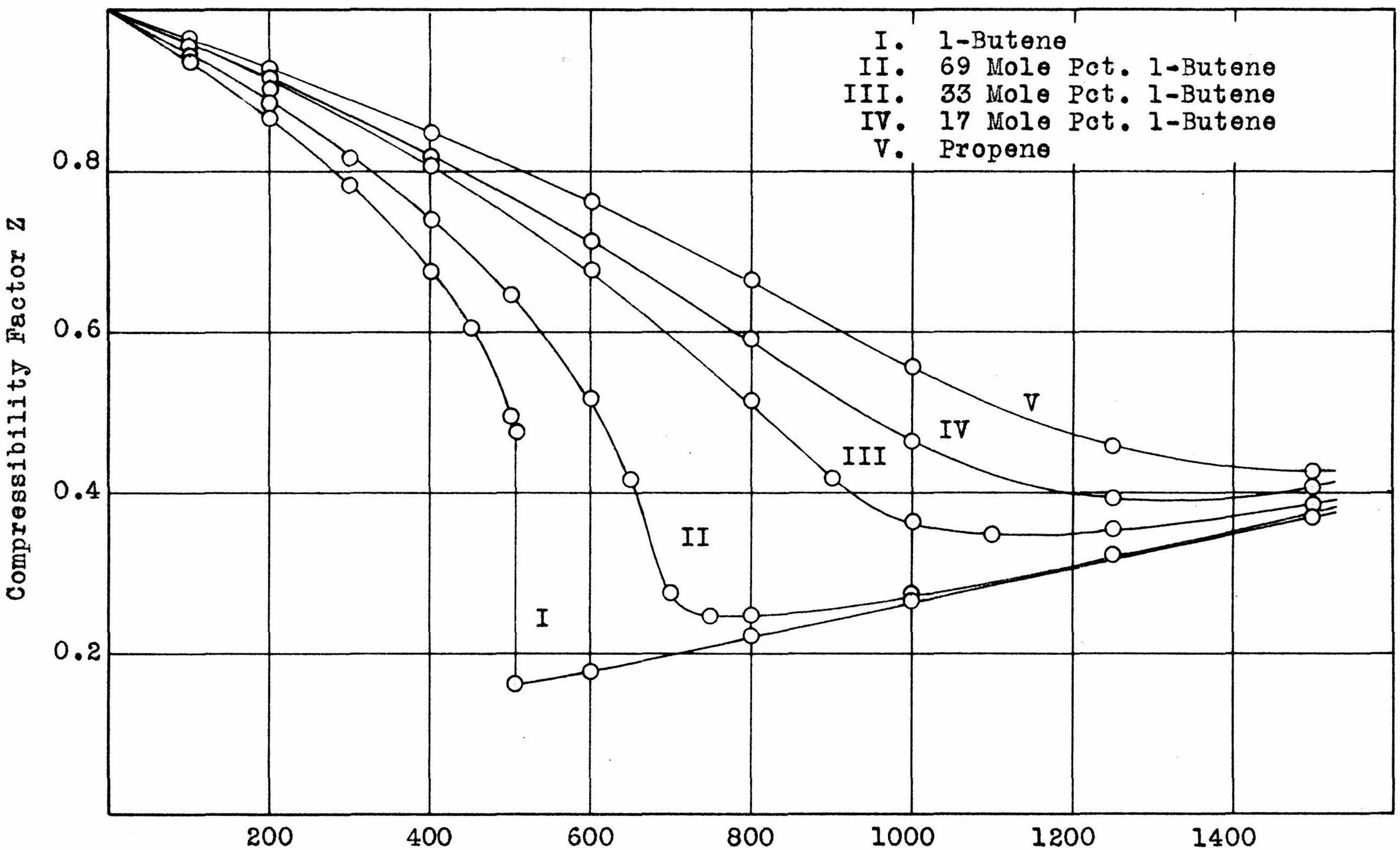

Figure 2. Compressibility Factor for the Propene-1-Butene System at 280° F.

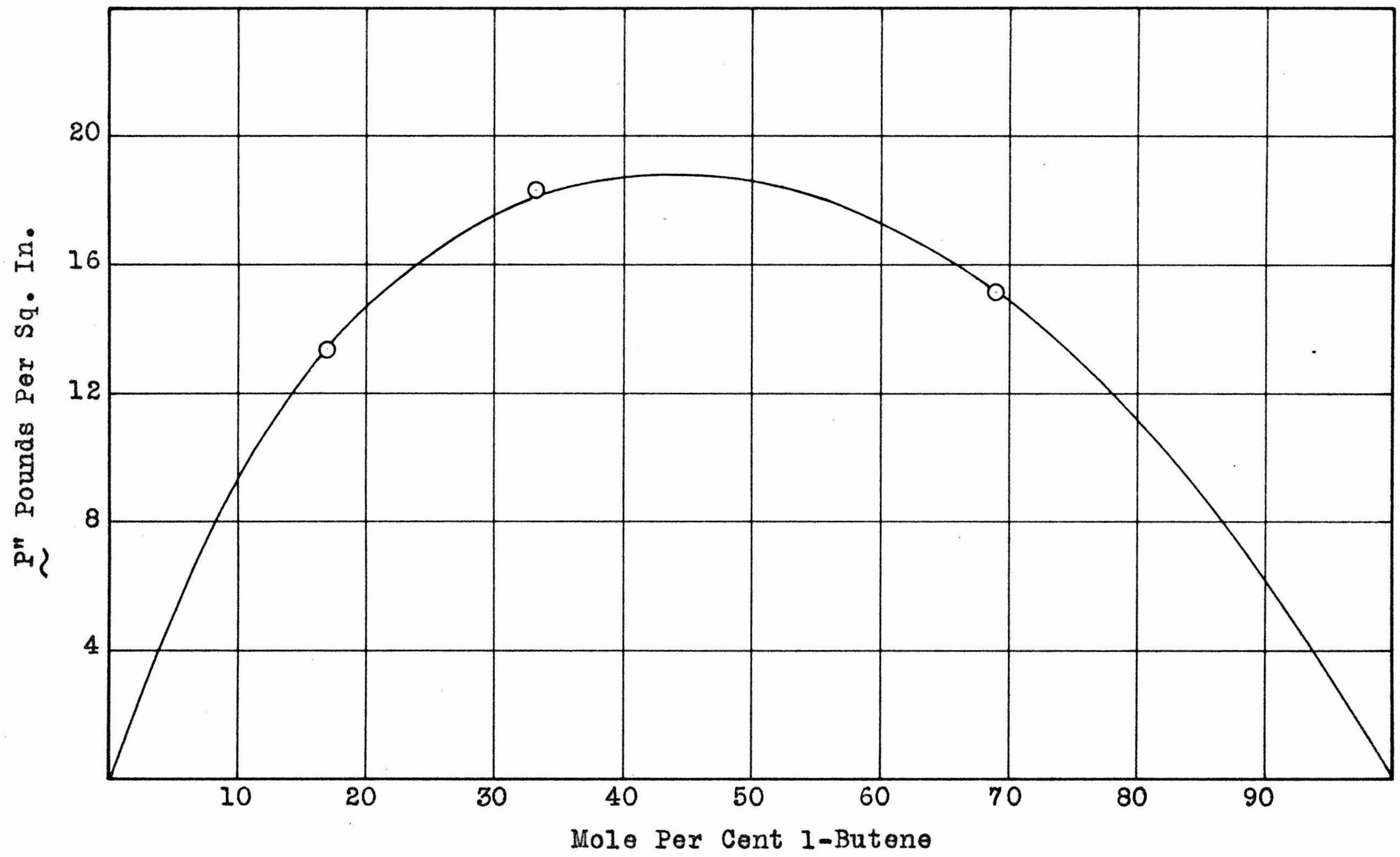

Figure 3. Deviation of Bubble-Point Pressure from Raoult's Law for Propene-1-Butene Mixtures at 160° F.

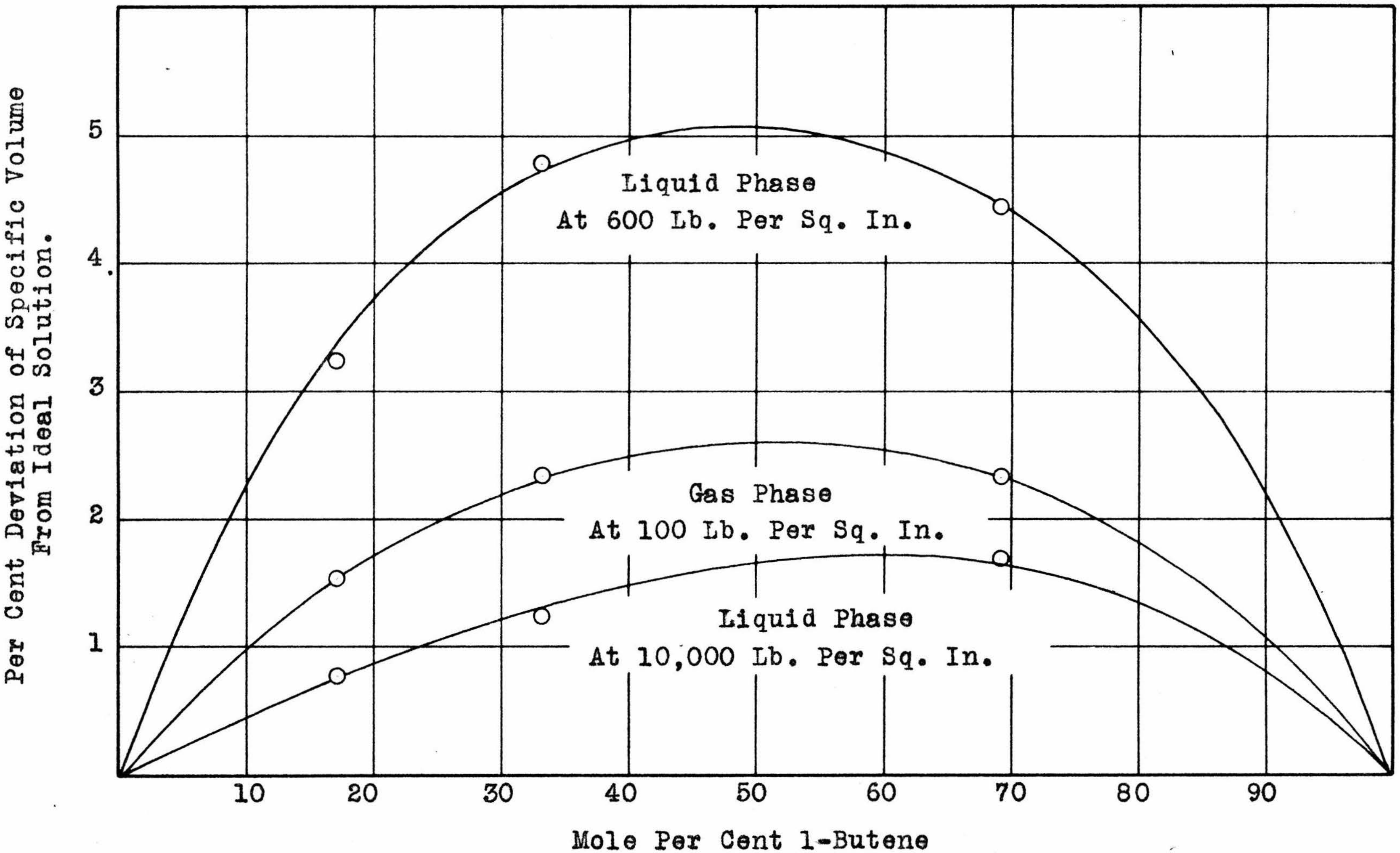

Figure 4. Percentage Deviation of Actual Specific Volume From Ideal Solution for Propene-1-Butene Mixtures at 160° F.

TABLE I.

VOLUMETRIC BEHAVIOR OF PROPENE

Pressure lb./sq.in. abs.	40° F.		70° F.		100° F.	
	V	Z	V	Z	V	Z
	(97.5)*		(152.1)		(227.3)	
Bubble Point	0.02969	0.02271	0.03121	0.03514	0.03318	0.05284
Dew Point	1.1227	0.8589	0.7207	0.8114	0.4718	0.7513
0		1.000		1.000		1.000
14.7	8.516	0.9821	9.053	0.9848	9.589	0.9873
20	6.215	0.9754	6.615	0.9793	7.013	0.9826
30	4.089	0.9626	4.362	0.9686	4.633	0.9738
40	3.025	0.9494	3.235	0.9578	3.443	0.9649
50	2.3848	0.9357	2.5578	0.9467	2.7287	0.9558
60	1.9568	0.9213	2.1061	0.9354	2.2522	0.9467
80	1.4178	0.8900	1.5399	0.9119	1.6556	0.9279
100	0.02968	0.0233	1.1982	0.8870	1.2966	0.9084
125	0.02966	0.0291	0.9220	0.8532	1.0080	0.8927
150	0.02965	0.0349	0.7344	0.8155	0.8160	0.8575
200	0.02960	0.0465	0.03115	0.0461	0.5657	0.7926
300	0.02952	0.0695	0.03102	0.0689	0.03303	0.0694
400	0.02944	0.0924	0.03090	0.0915	0.03284	0.0921
500	0.02936	0.1152	0.03078	0.1139	0.03265	0.1144
600	0.02928	0.1379	0.03067	0.1362	0.03248	0.1365
800	0.02914	0.1829	0.03046	0.1804	0.03216	0.1802
1000	0.02900	0.2276	0.03026	0.2240	0.03186	0.2232
1250	0.02882	0.2827	0.03001	0.2777	0.03153	0.2761
1500	0.02866	0.3373	0.02980	0.3309	0.03122	0.3281
1750	0.02850	0.3914	0.02961	0.3836	0.03094	0.3793
2000	0.02836	0.4451	0.02943	0.4357	0.03069	0.4300
2250	0.02822	0.4982	0.02927	0.4875	0.03047	0.4803
2500	0.02809	0.5510	0.02912	0.5389	0.03026	0.5300
2750	0.02796	0.6033	0.02897	0.5897	0.03007	0.5793
3000	0.02784	0.6554	0.02883	0.6402	0.02990	0.6284
3500	0.02762	0.7586	0.02856	0.7400	0.02959	0.7256
4000	0.02742	0.8606	0.02832	0.8386	0.02931	0.8214
4500	0.02724	0.9619	0.02810	0.9360	0.02906	0.9161
5000	0.02707	1.0621	0.02790	1.0326	0.02885	1.0106
6000	0.02677	1.2604	0.02755	1.2236	0.02840	1.1938
7000	0.02652	1.4567	0.02725	1.4120	0.02801	1.3736
8000	0.02630	1.6510	0.02696	1.5966	0.02766	1.5502
9000	0.02610	1.8432	0.02670	1.7788	0.02734	1.7238
10000	0.02591	2.0331	0.02645	1.9580	0.02701	1.8923

* Figures in parentheses represent vapor pressures in pounds per square inch absolute.

TABLE I. (Cont'd.)

Pressure lb./sq.in. abs.	130° F. V	(327.1) Z	160° F. V	(456.6) Z	180° F. V	(562.0) Z
Bubble Point	0.03572	0.07769	0.03983	0.11507	0.04501	0.15505
Dew Point	0.3109	0.6762	0.2002	0.5782	0.1404	0.4836
0		1.000		1.000		1.000
14.7	10.125	0.9894	10.657	0.9909	11.010	0.9918
20	7.411	0.9855	7.805	0.9876	8.066	0.9888
30	4.904	0.9782	5.170	0.9813	5.347	0.9831
40	3.650	0.9707	3.853	0.9750	3.987	0.9774
50	2.8971	0.9632	3.062	0.9686	3.171	0.9717
60	2.3952	0.9556	2.5344	0.9621	2.6265	0.9659
80	1.7671	0.9400	1.8748	0.9490	1.9459	0.9542
100	1.3895	0.9239	1.4786	0.9355	1.5373	0.9423
125	1.0865	0.9031	1.1611	0.9183	1.2099	0.9270
150	0.8837	0.8814	0.9489	0.9005	0.9912	0.9113
200	0.6276	0.8346	0.6823	0.8633	0.7166	0.8784
300	0.3598	0.7177	0.4103	0.7789	0.4382	0.8058
400	0.03553	0.0945	0.26393	0.6680	0.29327	0.7190
500	0.03521	0.1171	0.03950	0.1250	0.19750	0.6053
600	0.03491	0.1393	0.03863	0.1467	0.04365	0.1605
800	0.03437	0.1828	0.03740	0.1893	0.04053	0.1987
1000	0.03391	0.2255	0.03650	0.2309	0.03896	0.2388
1250	0.03337	0.2774	0.03562	0.2817	0.03755	0.2877
1500	0.03291	0.3283	0.03492	0.3314	0.03655	0.3360
1750	0.03251	0.3783	0.03435	0.3803	0.03579	0.3839
2000	0.03216	0.4277	0.03384	0.4282	0.03520	0.4315
2250	0.03185	0.4765	0.03347	0.4765	0.03470	0.4786
2500	0.03157	0.5248	0.03310	0.5236	0.03428	0.5253
2750	0.03132	0.5727	0.03276	0.5700	0.03386	0.5707
3000	0.03108	0.6200	0.03245	0.6159	0.03350	0.6160
3500	0.03067	0.7138	0.03190	0.7064	0.03288	0.7054
4000	0.03031	0.8062	0.03143	0.7954	0.03234	0.7929
4500	0.03000	0.8977	0.03102	0.8832	0.03186	0.8788
5000	0.02971	0.9878	0.03066	0.9700	0.03145	0.9638
6000	0.02922	1.1658	0.03006	1.1412	0.03076	1.1312
7000	0.02878	1.3396	0.02954	1.3083	0.03012	1.2923
8000	0.02836	1.5086	0.02909	1.4725	0.02960	1.4514
9000	0.02799	1.6750	0.02869	1.6337	0.02914	1.6075
10000	0.02763	1.8372	0.02830	1.7906	0.02873	1.7610

TABLE I. (Cont'd.)

Pressure lb./sq.in. abs.	190° F. V	190° F. Z (622.1)	220° F. V	220° F. Z	280° F. V	280° F. Z
Bubble Point	0.05000	0.18772				
Dew Point	0.1088	0.4083				
0		1.000		1.000		1.000
14.7	11.187	0.9922	11.716	0.9933	12.772	0.9949
20	8.197	0.9894	8.588	0.9908	9.367	0.9931
30	5.435	0.9840	5.698	0.9862	6.223	0.9896
40	4.054	0.9786	4.254	0.9815	4.651	0.9861
50	3.225	0.9731	3.387	0.9768	3.707	0.9826
60	2.6722	0.9676	2.8085	0.9721	3.078	0.9790
80	1.9811	0.9565	2.0857	0.9625	2.2919	0.9719
100	1.5661	0.9451	1.6518	0.9529	1.8201	0.9648
125	1.2336	0.9306	1.3044	0.9406	1.4424	0.9557
150	1.0117	0.9158	1.0726	0.9281	1.1905	0.9466
200	0.7331	0.8849	0.7820	0.9022	0.8753	0.9279
300	0.4512	0.8170	0.4894	0.8470	0.5591	0.8892
400	0.3059	0.7383	0.3406	0.7859	0.4001	0.8484
500	0.21280	0.6421	0.24870	0.7173	0.3040	0.8057
600	0.13376	0.4844	0.18375	0.6360	0.23924	0.7609
800	0.04287	0.2070	0.08018	0.2775	0.15665	0.6643
1000	0.04050	0.2444	0.04876	0.2813	0.10527	0.5580
1250	0.03870	0.2919	0.04356	0.3141	0.06927	0.4590
1500	0.03750	0.3395	0.04127	0.3571	0.05351	0.4255
1750	0.03661	0.3867	0.03973	0.4011	0.04962	0.4603
2000	0.03595	0.4339	0.03856	0.4449	0.04612	0.4890
2250	0.03535	0.4800	0.03765	0.4887	0.04382	0.5226
2500	0.03486	0.5260	0.03691	0.5323	0.04225	0.5599
2750	0.03441	0.5711	0.03628	0.5755	0.04098	0.5974
3000	0.03401	0.6158	0.03573	0.6183	0.03992	0.6348
3500	0.03331	0.7036	0.03480	0.7026	0.03835	0.7115
4000	0.03271	0.7896	0.03407	0.7862	0.03714	0.7875
4500	0.03220	0.8745	0.03342	0.8676	0.03618	0.8630
5000	0.03175	0.9581	0.03288	0.9484	0.03537	0.9375
6000	0.03100	1.1225	0.03196	1.1062	0.03409	1.0842
7000	0.03036	1.2826	0.03125	1.2619	0.03311	1.2286
8000	0.02982	1.4397	0.03166	1.4149	0.03231	1.3702
9000	0.02934	1.5936	0.03014	1.5648	0.03165	1.5099
10000	0.02895	1.7471	0.02963	1.7093	0.03105	1.6459

TABLE I (Cont'd.)

Pressure lb./sq.in. abs.	340° F.		400° F.		460° F.	
	V	Z	V	Z	V	Z
0		1.000		1.000		1.000
14.7	13.825	0.9961	14.875	0.9970	15.923	0.9976
20	10.144	0.9947	10.918	0.9959	11.690	0.9968
30	6.745	0.9921	7.264	0.9939	7.781	0.9952
40	5.045	0.9895	5.437	0.9918	5.826	0.9936
50	4.025	0.9868	4.340	0.9898	4.654	0.9920
60	3.345	0.9841	3.609	0.9877	3.872	0.9904
80	2.4955	0.9788	2.6959	0.9836	2.8944	0.9872
100	1.9854	0.9734	2.1476	0.9795	2.3080	0.9840
125	1.5774	0.9667	1.7090	0.9743	1.8389	0.9800
150	1.3052	0.9599	1.4166	0.9691	1.5261	0.9760
200	0.9649	0.9462	1.0511	0.9588	1.1351	0.9679
300	0.6240	0.9178	0.6851	0.9373	0.7440	0.9515
400	0.4528	0.8880	0.5019	0.9155	0.5480	0.9345
500	0.3495	0.8568	0.3917	0.8933	0.4304	0.9175
600	0.28048	0.8251	0.3183	0.8710	0.3523	0.9012
800	0.19504	0.7650	0.22702	0.8283	0.25529	0.8707
1000	0.14387	0.7054	0.17278	0.7330	0.19734	0.8413
1250	0.10365	0.6352	0.13021	0.7423	0.15162	0.8080
1500	0.08009	0.5890	0.10276	0.7030	0.12189	0.7795
1750	0.06631	0.5690	0.08497	0.6782	0.10163	0.7582
2000	0.05828	0.5715	0.07319	0.6676	0.08758	0.7468
2250	0.05333	0.5883	0.06519	0.6690	0.07753	0.7437
2500	0.04993	0.6120	0.05957	0.6792	0.07012	0.7474
2750	0.04743	0.6395	0.05556	0.6968	0.06454	0.7567
3000	0.04551	0.6694	0.05248	0.7181	0.06028	0.7710
3500	0.04275	0.7336	0.04816	0.7688	0.05430	0.8102
4000	0.04090	0.8021	0.04532	0.8268	0.05023	0.8566
4500	0.03947	0.8708	0.04317	0.8860	0.04732	0.9078
5000	0.03827	0.9382	0.04153	0.94153	0.04511	0.9616
6000	0.03648	1.0732	0.03908	1.0694	0.04206	1.0759
7000	0.03514	1.2060	0.03734	1.1921	0.03980	1.1878
8000	0.03410	1.3375	0.03603	1.3146	0.03809	1.2911
9000	0.03327	1.4681	0.03497	1.4354	0.03680	1.4120
10000	0.03257	1.5969	0.03412	1.5561	0.03577	1.5250

TABLE II

PROPERTIES OF COEXISTING LIQUID

AND GAS PHASES OF PROPENE

Pressure Lb./Sq. In. Abs.	Temperature °F.	Dew Point V	Dew Point Z	Bubble Point V	Bubble Point Z
100	42.2	1.0970	0.8570	0.02982	0.0233
125	56.3	0.8787	0.8346	0.03050	0.0290
150	69.0	0.7310	0.8132	0.03117	0.0347
200	90.1	0.5417	0.7727	0.03251	0.0464
250	107.6	0.4247	0.7339	0.03376	0.0583
300	122.6	0.3446	0.6962	0.03499	0.0707
350	135.9	0.28608	0.6592	0.03636	0.0838
400	147.8	0.24092	0.6220	0.03786	0.0978
450	158.6	0.20444	0.5834	0.03956	0.1129
500	168.6	0.17380	0.5423	0.04163	0.1299
550	177.9	0.14666	0.4960	0.04417	0.1494
600	186.5	0.12066	0.4393	0.04782	0.1741
650	194.3	0.09020	0.3515	0.05562	0.2168
668[a]	197.0[a]	0.06944	0.2770	0.06944	0.2770

a Critical state.

TABLE III

LATENT HEAT OF VAPORIZATION OF PROPENE

Temperature °F.	Authors B.t.u./lb.	Vaughan and Graves B.t.u./lb.
40	155.6	158.4
70	144.6	146.1
100	130.6	132.5
130	113.1	115.6
160	89.1	90.8
180	64.5	65.3
190	44.8	45.6

TABLE IV

SINGLE-PHASE VOLUMETRIC BEHAVIOR OF A MIXTURE OF PROPENE AND 1-BUTENE WITH 17.050 MOLE PER CENT 1-BUTENE

Pressure lb./sq.in. abs.	40° F.		70° F.		100° F.	
	V	Z	V	Z	V	Z
0	-	-	-	1.000	-	1.000
14.7	-	-	8.543	.9822	9.057	.9854
20	-	-	6.236	.9757	6.619	.9801
30	-	-	4.104	.9632	4.367	.9699
40	-	-	3.037	.9503	3.240	.9596
50	-	-	2.3957	.9371	2.5638	.9491
60	-	-	1.9671	.9233	2.1124	.9383
80	-	-	1.4277	.8935	1.5470	.9163
100	.02873	.0238	1.0978	.8588	1.2062	.8930
125	.02871	.0298	-	-	.9311	.8616
150	.02869	.0357	.03010	.0353	.7442	.8264
200	.02865	.0475	.03006	.0470	.03184	.0471
300	.02857	.0711	.02997	.0703	.03170	.0704
400	.02850	.0945	.02988	.0935	.03156	.0935
500	.02842	.1178	.02980	.1166	.03142	.1163
600	.02835	.1411	.02970	.1394	.03129	.1390
800	.02821	.1871	.02954	.1849	.03104	.1838
1000	.02808	.2329	.02938	.2298	.03081	.2281
1250	.02793	.2895	.02919	.2854	.03055	.2827
1500	.02779	.3457	.02900	.3403	.03030	.3365
1750	.02765	.4013	.02883	.3947	.03007	.3896
2000	.02752	.4564	.02866	.4484	.02985	.4420
2250	.02740	.5112	.02850	.5016	.02965	.4939
2500	.02729	.5658	.02835	.5544	.02945	.5451
2750	.02718	.6198	.02821	.6069	.02928	.5961
3000	.02708	.6734	.02807	.6588	.02911	.6466
3500	.02688	.7802	.02783	.7620	.02880	.7463
4000	.02645	.8774	.02761	.8640	.02853	.8449
4500	.02651	.9893	.02740	.9646	.02827	.9418
5000	.02635	1.0925	.02720	1.0639	.02803	1.0376
6000	.02605	1.2961	.02685	1.2603	.02763	1.2274
7000	.02579	1.4971	.02655	1.4539	.02730	1.4148
8000	.02554	1.6943	.02627	1.6441	.02698	1.5980
9000	.02530	1.8882	.02600	1.8306	.02666	1.7764
10000	.02507	2.0789	.02575	2.0144	.02636	1.9516

TABLE IV (Cont'd.)

Pressure lb./sq.in. abs.	160° F.		220° F.	
	V	Z	V	Z
0	-	1.000	-	1.000
14.7	10.067	.9893	11.071	.9919
20	7.368	.9854	8.111	.9889
30	4.875	.9780	5.377	.9834
40	3.629	.9705	4.010	.9778
50	2.8802	.9630	3.189	.9722
60	2.3812	.9553	2.6424	.9666
80	1.7569	.9398	1.9586	.9552
100	1.3818	.9240	1.5481	.9438
125	1.0810	.9035	1.2194	.9293
150	.8798	.8824	1.0001	.9146
200	.6262	.8374	.7252	.8842
300	.3640	.7302	.4478	.8189
400	.03698	.0989	.3054	.7447
500	.03646	.1219	.21576	.6577
600	.03601	.1448	.14778	.5406
800	.03527	.1887	.04681	.2283
1000	.03466	.2318	.04242	.2586
1250	.03404	.2845	.03992	.3042
1500	.03351	.3361	.03844	.3515
1750	.03306	.3869	.03743	.3993
2000	.03267	.4369	.03658	.4460
2250	.03232	.4863	.03588	.4922
2500	.03201	.5351	.03530	.5380
2750	.03172	.5833	.03480	.5834
3000	.03146	.6311	.03435	.6282
3500	.03099	.7253	.03357	.7163
4000	.03059	.8182	.03293	.8030
4500	.03023	.9096	.03236	.8878
5000	.02991	1.0000	.03187	.9715
6000	.02935	1.1775	.03106	1.1361
7000	.02860	1.3387	.03042	1.2982
8000	.02842	1.5203	.02986	1.4563
9000	.02802	1.6863	.02936	1.6109
10000	.02765	1.8489	.02893	1.7637

TABLE IV (Cont'd.)

Pressure lb./sq.in. abs.	250° F. V	Z	280° F. V	Z
0	-	1.000	-	1.000
14.7	11.571	.9929	12.071	.9938
20	8.481	.9903	8.850	.9915
30	5.626	.9855	5.875	.9873
40	4.199	.9806	4.387	.9831
50	3.342	.9757	3.495	.9788
60	2.7713	.9709	2.8994	.9745
80	2.0574	.9610	2.1554	.9659
100	1.6290	.9511	1.7091	.9574
125	1.2862	.9387	1.3518	.9466
150	1.0574	.9261	1.1136	.9357
200	.7713	.9006	.8155	.9136
300	.4839	.8476	.5177	.9701
400	.3386	.7908	.3658	.8196
500	.24944	.7282	.27392	.7672
600	.18725	.6560	.21182	.7120
800	.09743	.4551	.13174	.5906
1000	.05405	.3156	.08233	.4612
1250	.04579	.3342	.05595	.3918
1500	.04267	.3737	.04839	.4066
1750	.04108	.4163	.04473	.4385
2000	.03935	.4595	.04261	.4774
2250	.03823	.5022	.04099	.5166
2500	.03740	.5459	.03973	.5565
2750	.03670	.5893	.03882	.5980
3000	.03609	.6322	.03810	.6403
3500	.03509	.7171	.03677	.7209
4000	.03426	.8001	.03570	.8000
4500	.03358	.8823	.03483	.8780
5000	.03300	.9634	.03411	.9554
6000	.03200	1.1210	.03298	1.1085
7000	.03123	1.2764	.03209	1.2584
8000	.03061	1.4298	.03138	1.4063
9000	.03009	1.5812	.03077	1.5513
10000	.02960	1.7283	.03025	1.6946

TABLE V

SINGLE-PHASE VOLUMETRIC BEHAVIOR OF A MIXTURE OF PROPENE AND 1-BUTENE WITH 33.153 MOLE PER CENT 1-BUTENE

Pressure lb./sq.in. abs.	40° F.		70° F.		100° F.	
	V	Z	V	Z	V	Z
0	-	-	-	-	-	1.000
14.7	-	-	-	-	8.619	.9854
20	-	-	-	-	6.299	.9800
30	-	-	-	-	4.155	.9697
40	-	-	-	-	3.082	.9590
50	-	-	-	-	2.4371	.9480
60	-	-	-	-	2.0064	.9366
80	.02813	.0196	-	-	1.4654	.9120
100	.02812	.0245	-	-	1.1366	.8842
125	.02810	.0306	.02941	.0302	-	-
150	.02809	.0367	.02939	.0362	-	-
200	.02806	.0489	.02935	.0483	.03085	.0480
300	.02800	.0732	.02926	.0722	.03073	.0717
400	.02794	.0974	.02918	.0959	.03061	.0953
500	.02788	.1215	.02910	.1196	.03050	.1186
600	.02778	.1452	.02902	.1431	.03039	.1419
800	.02772	.1932	.02887	.1899	.03017	.1878
1000	.02762	.2407	.02873	.2362	.02997	.2332
1250	.02750	.1995	.02855	.2934	.02974	.2892
1500	.02739	.3580	.02839	.3501	.02952	.3445
1750	.02727	.4158	.02824	.4062	.02931	.3990
2000	.02717	.4735	.02810	.4620	.02913	.4532
2250	.02706	.5305	.02795	.5170	.02895	.5067
2500	.02696	.5873	.02782	.5717	.02878	.5597
2750	.02681	.6424	.02769	.6260	.02863	.6125
3000	.02676	.6995	.02756	.6797	.02847	.6645
3500	.02658	.8106	.02734	.7866	.02820	.7679
4000	.02640	.9202	.02712	.8917	.02795	.8698
4500	.02623	1.0285	.02693	.9962	.02774	.9711
5000	.02606	1.1354	.02676	1.0999	.02753	1.0709
6000	.02580	1.3489	.02644	1.3041	.02715	1.2673
7000	.02555	1.5585	.02614	1.5042	.02685	1.4622
8000	.02530	1.7637	.02581	1.6973	.02655	1.6524
9000	.02505	1.9998	.02561	1.8947	.02625	1.8379
10000	.02481	2.1619	.02537	2.0855	.02595	2.0188

TABLE V (Cont'd.)

Pressure lb./sq.in. abs.	160° F.		220° F.	
	V	Z	V	Z
0	-	1.000	-	1.000
14.7	9.578	.9891	10.536	.9919
20	7.010	.9851	7.718	.9889
30	4.637	.9775	5.116	.9833
40	3.451	.9698	3.815	.9776
50	2.7385	.9621	3.034	.9719
60	2.2634	.9542	2.5135	.9661
80	1.6688	.9381	1.8623	.9544
100	1.3112	.9213	1.4711	.9424
125	1.0239	.8993	1.1578	.9271
150	.8330	.8780	.9484	.9113
200	.5857	.8231	.6855	.8783
300	-	-	.4186	.8045
400	.03483	.0979	.27925	.7156
500	.03448	.1211	.18620	.5964
600	.03417	.1441	.04172	.1759
800	.03363	.1890	.04090	.2096
1000	.03312	.2327	.03903	.2500
1250	.03268	.2870	.03745	.2999
1500	.03227	.3401	.03650	.3507
1750	.03190	.3922	.03569	.4001
2000	.03158	.4438	.03502	.4487
2250	.03130	.4948	.03441	.4960
2500	.03104	.5453	.03396	.5439
2750	.03080	.5951	.03352	.5905
3000	.03059	.6448	.03313	.6367
3500	.03019	.7424	.03222	.7224
4000	.02984	.8387	.03191	.8177
4500	.02950	.9328	.03143	.9061
5000	.02920	1.0259	.03100	.9930
6000	.02866	1.2083	.03028	1.1639
7000	.02824	1.3890	.02971	1.3323
8000	.02785	1.5655	.02921	1.4970
9000	.02747	1.7371	.02876	1.6582
10000	.02711	1.9049	.02835	1.8161

TABLE V (Cont'd.)

Pressure lb./sq.in. abs.	250° F.		280° F.	
	V	Z	V	Z
0	-	1.000	-	1.000
14.7	11.014	.9931	11.492	.9942
20	8.073	.9906	8.426	.9920
30	5.356	.9858	5.595	.9880
40	3.997	.9809	4.179	.9839
50	3.182	.9761	3.329	.9798
60	2.6381	.9711	2.7622	.9756
80	1.9583	.9612	2.0537	.9671
100	1.5501	.9510	1.6283	.9585
125	1.2231	.9380	1.2876	.9475
150	1.0048	.9247	1.0602	.9362
200	.7311	.8970	.7753	.9128
300	.4547	.8369	.4885	.8626
400	.3134	.7691	.3427	.8069
500	.22518	.6908	.25356	.7463
600	.16105	.5929	.19233	.6793
800	.05629	.2763	.10896	.5131
1000	.04529	.2779	.06172	.3633
1250	.04157	.3188	.04835	.3558
1500	.03957	.3642	.04403	.3888
1750	.03818	.4099	.04164	.4290
2000	.03719	.4563	.04001	.4710
2250	.03644	.5030	.03891	.5153
2500	.03578	.5488	.03792	.5580
2750	.03522	.5942	.03713	.6011
3000	.03471	.6389	.03645	.6437
3500	.03386	.7271	.03533	.7279
4000	.03315	.8135	.03444	.8109
4500	.03255	.8987	.03370	.8927
5000	.03202	.9823	.03308	.9736
6000	.03116	1.1471	.03206	1.1323
7000	.03050	1.3099	.03128	1.2889
8000	.02993	1.4690	.03064	1.4429
9000	.02941	1.6240	.03006	1.5925
10000	.02892	1.7743	.02953	1.7383

TABLE VI

SINGLE-PHASE VOLUMETRIC BEHAVIOR OF A MIXTURE OF PROPENE AND 1-BUTENE WITH 69.050 MOLE PER CENT 1-BUTENE

Pressure lb./sq.in. abs.	40° F.		70° F.		100° F.	
	V	Z	V	Z	V	Z
0	-	-	-	-	-	-
14.7	-	-	-	-	-	-
20	-	-	-	-	-	-
30	-	-	-	-	-	-
40	-	-	-	-	-	-
50	.02695	.0130	-	-	-	-
60	.02694	.0156	-	-	-	-
80	.02692	.0208	.02795	.0204	-	-
100	.02691	.0260	.02793	.0254	-	-
125	.02690	.0325	.02791	.0318	.02918	.0314
150	.02688	.0389	.02790	.0381	.02915	.0377
200	.02685	.0518	.02786	.0507	.02910	.0502
300	.02678	.0775	.02780	.0780	.02900	.0750
400	.02672	.1032	.02774	.1010	.02891	.0997
500	.02666	.1287	.02767	.1260	.02882	.1242
600	.02660	.1541	.02760	.1508	.02874	.1486
800	.02650	.2046	.02749	.2003	.02857	.1970
1000	.02640	.2548	.02737	.2492	.02841	.2449
1250	.02630	.3173	.02723	.3099	.02824	.3042
1500	.02619	.3792	.02710	.3702	.02806	.3628
1750	.02610	.4409	.02697	.4298	.02790	.4208
2000	.02601	.5021	.02685	.4890	.02775	.4783
2250	.02594	.5634	.02674	.5479	.02761	.5354
2500	.02586	.6240	.02664	.6064	.02749	.5923
2750	.02579	.6846	.02653	.6643	.02737	.6487
3000	.02571	.7445	.02644	.7223	.02726	.7048
3500	.02557	.8639	.02610	.8369	.02705	.8160
4000	.02542	.9815	.02610	.9506	.02685	.9256
4500	.02528	1.0981	.02595	1.0633	.02667	1.0343
5000	.02514	1.2133	.02580	1.1746	.02650	1.1419
6000	.02488	1.4409	.02550	1.3932	.02616	1.3528
7000	.02465	1.6655	.02523	1.6082	.02585	1.5595
8000	.02445	1.8880	.02499	1.8204	.02558	1.7637
9000	.02426	2.1075	.02476	2.0291	.02532	1.9640
10000	.02410	2.3263	.02456	2.2364	.02508	2.1615

TABLE VI (Cont'd.)

Pressure lb./sq.in. abs.	160° F. V	160° F. Z	220° F. V	220° F. Z
0	-	1.000	-	1.000
14.7	8.611	.9850	9.484	.9891
20	6.292	.9796	6.941	.9852
30	4.151	.9692	4.592	.9777
40	3.079	.9588	3.417	.9701
50	2.4365	.9483	2.7125	.9625
60	2.0076	.9376	2.2424	.9548
80	1.4707	.9158	1.6544	.9393
100	1.1474	.8931	1.3011	.9234
125	.8870	.8630	1.0181	.9031
150	.7103	.8293	.8287	.8822
200	-	-	.5902	.8376
300	.03215	.0751	.3441	.7326
400	.03194	.0994	-	-
500	.03173	.1235	.03699	.1313
600	.03154	.1473	.03640	.1550
800	.03120	.1943	.03544	.2012
1000	.03092	.2407	.03421	.2428
1250	.03065	.2982	.03400	.3016
1500	.03033	.3541	.03340	.3555
1750	.03009	.4099	.03290	.4086
2000	.02986	.4649	.03246	.4607
2250	.02965	.5193	.03208	.5122
2500	.02945	.5731	.03173	.5629
2750	.02925	.6261	.03141	.6130
3000	.02907	.6788	.03113	.6628
3500	.02874	.7830	.03062	.7606
4000	.02843	.8852	.03018	.8567
4500	.02815	.9860	.02979	.9514
5000	.02790	1.0859	.02945	1.0450
6000	.02743	1.2811	.02886	1.2289
7000	.02703	1.4728	.02835	1.4083
8000	.02670	1.6626	.02793	1.5857
9000	.02638	1.8481	.02753	1.7584
10000	.02608	2.0300	.02715	1.9268

TABLE VI (Cont'd.)

Pressure lb./sq.in. abs.	250° F. V	Z	280° F. V	Z
0	-	1.000	-	1.000
14.7	9.917	.9906	10.349	.9918
20	7.262	.9872	7.582	.9888
30	4.810	.9807	5.025	.9831
40	3.583	.9742	3.747	.9775
50	2.8475	.9677	2.9804	.9718
60	2.3568	.9611	2.4690	.9660
80	1.7431	.9478	1.8297	.9545
100	1.3746	.9343	1.4459	.9429
125	1.0793	.9170	1.1385	.9280
150	.8822	.8994	.9334	.9130
200	.6345	.8624	.6764	.8821
300	.3827	.7804	.4170	.8157
400	.24953	.6784	.28368	.7400
500	-	-	.19870	.6479
600	.04193	.1710	.13258	.5187
800	.03906	.2124	.04739	.2472
1000	.03764	.2558	.04234	.2761
1250	.03641	.3093	.03942	.3213
1500	.03550	.3619	.03783	.3700
1750	.03476	.4134	.03687	.4208
2000	.03414	.4641	.03606	.4703
2250	.03361	.5140	.03533	.5183
2500	.03315	.5633	.03470	.5657
2750	.03273	.6118	.03417	.6128
3000	.03236	.6598	.03371	.6595
3500	.03173	.7548	.03293	.7516
4000	.03119	.8480	.03229	.8423
4500	.03072	.9396	.03174	.9314
5000	.03031	1.0300	.03126	1.0192
6000	.02963	1.2083	.03045	1.1914
7000	.02905	1.3821	.02980	1.3603
8000	.02856	1.5529	.02924	1.5254
9000	.02813	1.7207	.02873	1.6861
10000	.02775	1.8861	.02828	1.8441

TABLE VII

TWO-PHASE VOLUMETRIC DATA FOR A

MIXTURE OF PROPENE AND 1-BUTENE WITH

17.050 MOLE PER CENT 1-BUTENE

40° F.

Pressure lb./sq.in. abs.	V	Z
82.8[a]	.02874	.0197

70° F.

Pressure lb./sq.in. abs.	V	Z
130.6[a]	.03013	.0308
103.6[b]	1.0511	.8518
105	1.0057	.8261
108	.9089	.7679
111	.8106	.7039
114	.7109	.6340
117	.6092	.5576
120	.5031	.4723
122	.4258	.4064
124	.3429	.3326
126	.25383	.2502
128	.15539	.1556
129	.10207	.1030

100° F.

Pressure lb./sq.in. abs.	V	Z
195.3[a]	.03185	.0461
161.4[b]	.6767	.8086
165	.6164	.7530
168	.5671	.7053
171	.5177	.6554
174	.4673	.6020
177	.4161	.5452
180	.3629	.4836
183	.3058	.4143
186	.24501	.3374
188	.20189	.2810
190	.15768	.2218
192	.10974	.1560
194	.05953	.0855

160° F.

Pressure lb./sq.in. abs.	V	Z
389.7[a]	.03705	.0965
346.9[b]	.2864	.6643
350	.27398	.6412
355	.25183	.5978
360	.22653	.5453
365	.19773	.4826
370	.16693	.4130
375	.13460	.3375
380	.10106	.2568
385	.06736	.1734

a - Bubble point b- Dew point

TABLE VIII

TWO-PHASE VOLUMETRIC DATA FOR A

MIXTURE OF PROPENE AND 1-BUTENE WITH

33.153 MOLE PER CENT 1-BUTENE

40° F.

Pressure lb./sq.in. abs.	V	Z
70.5[a]	.02814	.0173

70° F.

Pressure lb./sq.in. abs.	V	Z
111.3[a]	.02942	.0269
82	1.1711	.7894
85	.9313	.7206
88	.9010	.6518
91	.7780	.5820
94	.6624	.5118
97	.5509	.4393
100	.4416	.3630
103	.3334	.2823
105	.26137	.2256
107	.18839	.1657
109	.11406	.1022

100° F.

Pressure lb./sq.in. abs.	V	Z
166.9[a]	.03090	.0401
124.7[b]	.8694	.8434
128	.7875	.7842
131	.7183	.7320
134	.6521	.6798
137	.5892	.6280
140	.5289	.5761
143	.4707	.5237
146	.4132	.4693
149	.3572	.4140
152	.3021	.3572
155	.24630	.2970
158	.19183	.2358
161	.13748	.1722
164	.08386	.1070

160° F.

Pressure lb./sq.in. abs.	V	Z
334.3[a]	.03509	.0824
277.6[b]	.14881	.5183
280	.3517	.6920
285	.3206	.6420
290	.29043	.5918
295	.26052	.5400
300	.23080	.4865
305	.20153	.4319
310	.17253	.3758
315	.14359	.3178
320	.11448	.2574
325	.08122	.1946
330	.05714	.1325

a - Bubble point b - Dew point

TABLE VIII (Cont'd.)

Pressure lb./sq.in. abs.	V	Z
	220° F.	
594.5[a]	.04192	.1751
543.7[b]	.14881	.5183
550	.13544	.4772
555	.12488	.4440
560	.11443	.4105
565	.10432	.3776
570	.09434	.3445
575	.08465	.3118
580	.07495	.2785
585	.06532	.2448
590	.05548	.2097

a - Bubble point

b - Dew point

TABLE IX

TWO-PHASE VOLUMETRIC DATA FOR A

MIXTURE OF PROPENE AND 1-BUTENE WITH

69.050 MOLE PER CENT 1-BUTENE

40° F.		
Pressure lb./sq.in. abs.	V	Z
43.6[a]	.02695	.0113

70° F.		
Pressure lb./sq.in. abs.	V	Z
70.9[a]	.02795	.0180
53	1.4034	.6773
55	1.1337	.5678
57	.9131	.4739
59	.7250	.3895
61	.5676	.3153
63	.4318	.2477
65	.3114	.1843
67	.20456	.1248
69	.10823	.0680

100° F.		
Pressure lb./sq.in. abs.	V	Z
108.4[a]	.02920	.0273
80.8[b]	1.2501	.8705
83	1.0657	.7623
85	.9179	.6724
87	.7893	.5918
89	.6756	.5182
91	.5759	.4517
93	.4873	.3906
95	.4098	.3355
97	.3398	.2841
99	.27636	.2358
101	.21644	.1884
103	.16019	.1422
105	.10807	.0978
107	.06073	.0560

160° F.		
Pressure lb./sq.in. abs.	V	Z
224.9[a]	.03233	.0566
184.1[b]	.5369	.7694
186	.5055	.7318
188	.4702	.6880
190	.4321	.6390
193	.3786	.5687
196	.3315	.5057
200	.27576	.4293
204	.22621	.3592
208	.18202	.2947
212	.14204	.2344
216	.10516	.1768
220	.07107	.1217

a - Bubble point   b - Dew point

TABLE IX (Cont'd.)

220° F. Pressure lb./sq.in. abs.	V	Z
413.1[a]	.03777	.1107
365.4[b]	.24583	.6375
370	.21852	.5738
375	.19081	.5078
380	.16527	.4457
385	.14131	.3861
390	.11959	.3310
395	.09924	.2782
400	.08067	.2290
405	.06322	.1817
410	.04726	.1375

250° F. Pressure lb./sq.in. abs.	V	Z
540.8[a]	.04356	.1601
497.7[b]	.15602	.5278
500	.14884	.5058
505	.13387	.4595
510	.11889	.4121
515	.10436	.3653
520	.09099	.3216
525	.07839	.2797
530	.06674	.2404
535	.05569	.2025
540	.04496	.1650

a - Bubble point

b - Dew point