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HEAT CAPACITY RATIOS CALCULATED FROM THE BENEDICT-WEBB-RUBIN EQUATION OF STATE

by

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SUMMARY

The ratio of the isobaric heat capacity to the constant volume heat capacity has been calculated over a range of temperatures and pressures for the following hydrocarbons: methane, ethylene, ethane, propane, and n-butane. Graphs and tables of calculated data are presented showing the effect of temperature and pressure on the ratio of the heat capacities for these compounds.

The deviations of the heat capacities from ideal gas behavior were calculated by previous investigators from an equation based on the Benedict-Webb-Rubin equation of state. Experimental data were used to evaluate the heat capacities of the ideal gases, and were used together with the calculated deviations to obtain the heat capacities of the non-ideal gas states.

The results indicate that the ratio of the heat capacities varies significantly with large changes in pressure at a constant temperature. Calculations which do not allow for this effect may be in considerable error.

The calculated ratios of the heat capacities have been compared with the available experimental data, with the generalized correlation of Edmister, and with calculations based on the Beattie-Bridgeman equation of state.

INTRODUCTION

The chemical and petroleum industries are making increased use of processes requiring high temperatures and pressures. Thermodynamic data in this range of operating conditions are necessary for accurate process and equipment design.

Sufficient data are available to accurately calculate the heat capacities of the light hydrocarbon gases at low pressures. This has been done by the American Petroleum Institute Research Project 44 (1), which has reported heat capacities for the ideal gas state.

When higher pressures are considered, it is found that few heat capacity data are available. This is due mainly to the difficulties encountered in developing an adequate experimental technique. A summary of some experimental methods which might be used was published by Masi (2).

Most of the direct experimental data on the light hydrocarbon gases have been obtained through API Research Project 37. Heat capacities were measured by an adiabatic compression method or by calculation from measured values of the Joule-Thomson coefficient. The latter method is not a direct measurement in the strict sense.

Because of the difficulties involved in obtaining accurate experimental data, indirect methods were considered for calculating heat capacities. The generalized correlations of Edmister (3,4,5,6), Hougen and Watson (7), and Watson and Smith (8), made use of reduced properties to correlate P-V-T data. Generalized heat capacity correlations were then derived from the P-V-T correlations. These correlations represent averaged values at reduced conditions for a number of hydrocarbons.

A similar approach based on P-V-T data is the use of these data to develop an equation of state for a particular hydrocarbon. The deviation of the heat capacity from the ideal gas value can then be calculated by differentiation and algebraic manipulation of the equation.

Several equations of state were considered. Two equations which are accurate over a wide range are the Beattie-Bridgeman (9,10), and the Benedict-Webb-Rubin (11,12) equations. The Beattie-Bridgeman equation, which employs five empirical constants, was not developed to reproduce properties of the gas in the critical range or above the critical density. The specific heats for several gases were calculated from this equation by Ellenwood, Kulik, and Gay (13).

A modification of the Beattie-Bridgeman equation is the Benedict-Webb-Rubin equation, which employs eight empirical constants. It was developed to reproduce most

accurately a) P-V-T properties of the gas phase up to about 1.8 times the critical density, b) the critical properties, and c) the vapor pressures above one atmosphere. This equation is extremely flexible and is believed to be the most accurate in this field to date. However, as will be pointed out later, extrapolation beyond the range of the data should be done with caution.

The use of this equation of state to predict the deviation of the heat capacity of a non-ideal gas state from the ideal gas state has been demonstrated by previous investigators. Heat capacities relative to the ideal gas state have been calculated over a wide range of temperatures and pressures for methane by Sledjeski (14,15), for ethylene by Sibilia (16), for ethane by Reiter (17), for propane by Seifarth (18,19), and for n-butane by Glueck (20). Using these calculated deviations and ideal state heat capacity data from API Research Project 44 (1), Sledjeski also calculated the ratio of the heat capacities for methane (21), and Reiter calculated the ratio for ethane (17). In this present work the ratio of the heat capacities has been similarly calculated for ethylene, propane, and n-butane.

There is little basis for comparison of these calculations with other data since there are practically no constant volume heat capacity data at high pressures. In

this present work, the results obtained from applying Edmister's generalized correlation are presented for all five gases. The effect on the ratio of the heat capacities of using the values of the isobaric heat capacity determined by Ellenwood et.al. was calculated for methane and ethylene. Similarly, this effect was calculated for methane in this work from the data of Budenholtzer, Sage, and Lacey (22), who evaluated isobaric heat capacities from experimental Joule-Thomson coefficients and values of the heat capacity at infinite dilution. The heat capacity data for ethane of Sage, Webster, and Lacey (23, 24) were also used for comparison. No suitable experimental data in the range of interest was found for propane or n-butane.

EQUATIONS USED FOR CALCULATIONS

The Benedict-Webb-Rubin Equation of State (1) may be expressed as follows:

$$P = \frac{RT}{V} + \left(B_oRT - A_o - \frac{C_o}{T_2}\right)\frac{1}{V2} + \left(bRT-a\right)\frac{1}{V3} + \frac{a\alpha}{V6} + \frac{c}{V3T2}\left(1+\frac{\gamma}{V2}\right)e^{-\gamma/V2}$$

The derivation of expressions for the deviation from ideality of the heat capacities is based on the following thermodynamic relationships:

(1) $$C_p-C_v = \frac{-T\left(\partial P/\partial T\right)_V^2}{\left(\partial P/\partial V\right)_T}$$

(2) $$\left(\partial C_v/\partial V\right)_T = T\left(\partial^2 P/\partial T^2\right)_V$$

or

$$C_v-C_v^* = \int_\infty^{V_T}\left(\partial^2 P/\partial T^2\right)_V dV$$

(3) $$C_p^*-C_v^* = R$$

By performing the indicated operations and combining the three equations, the desired equations for $C_p-C_p^*$ and $C_v-C_v^*$ may be obtained. The complete derivation may be found elsewhere (14,16,17,18,20). The derived equations are:

(4) $$C_v-C_v^* = \frac{6c}{T3}\left[\frac{e^{-\gamma V-2}}{\gamma} + \frac{e^{-\gamma V-2}}{2V2} + \frac{C_o}{cV}\right] - \frac{6c}{\gamma T3}$$

(5) $C_p - C_p^* =$

$$\frac{-T\left[\frac{R}{V}+\frac{(B_oR+2C_o/T^3)}{V2}+\frac{bR}{V3}-\frac{2c\ (1+\gamma/V^2)e^{-\gamma V^{-2}}}{T3V3}\right]^2}{\left[-\frac{RT}{V2}-\frac{2}{V3}(B_oRT-A_o-C_o/T^2)-\frac{3}{V4}(bRT-a)-\frac{6a\alpha}{V7}\right.}$$

$$\left.+\frac{c}{T2}(-3/V^4-3\gamma/V^6+2\gamma^2/V^8)\ e^{-\gamma V^{-2}}\right]$$

$$+\frac{6c}{T3}\left[\frac{e^{-\gamma V^{-2}}}{\gamma}+\frac{e^{-\gamma V^{-2}}}{2V2}+\frac{C_o}{cV}\right]-\frac{6c}{\gamma T3}-R$$

The values of C_p and C_v may then be obtained by adding the ideal gas values to the deviations as follows:

$$C_p = (C_p - C_p^*) + C_p^*$$

$$C_v = (C_v - C_v^*) + C_v^*$$

The ratio of the heat capacities may then be calculated.

METHOD OF CALCULATION

Previous investigators (14,16,17,18,20) have calculated values of $C_p-C_p^*$, and $C_v-C_v^*$ using equations (4.) and (5.). Values of P at the selected values of V and T were calculated by them from equation (1.). The constants which they used for the Benedict-Webb-Rubin equation are shown in Table I.

In this work, values taken from the tables of data calculated for ethylene by Sibilia (16), for propane by Seifarth (18), and for n-butane by Glueck (20) were used together with the heat capacities of the ideal gas state to calculate the heat capacities of the non-ideal states. The ideal state heat capacity data at constant pressure, which are shown in Table II, were obtained from an API Research Project 44 publication (1). Graphs of these data were made versus temperature on a large enough scale so that the maximum error in interpolating the ideal state heat capacity was 0.05 $\frac{\text{cal}}{\text{deg-mol}}$ or about 0.002 $\frac{\text{liter-atm.}}{\text{gm mol-}^{\circ}\text{K}}$.

The units were converted from gm cal/gm mol-$^{\circ}$K to liter-atm/gm mol-$^{\circ}$K by multiplying the interpolated value of C_p^* by 0.0412917. The result was then added to the value of $C_p-C_p^*$ calculated by previous investigators. From the value of C_p which was obtained, the value of C_p-C_v was subtracted giving a value of C_v. The ratio of

C_p/C_v was then calculated. The value of C_v^* was calculated from the interpolated value of C_p^* by subtracting from it a value of the gas constant R of 0.08207 $\frac{\text{liter-atm.}}{\text{gm mol-}^\circ\text{K}}$ These calculations are shown in Table III for ethylene, in Table IV for propane, and in Table V for n-butane.

The values of C_p/C_v were plotted versus the pressure which previous investigators had calculated from equation (1), at constant values of temperature. These plots are shown as Figure 1 for ethylene, Figure 2 for propane, and Figure 3 for n-butane. Using these plots, values of C_p/C_v were read for various temperatures at constant values of pressure. Table VI shows these values for ethylene, Table VII for propane, and Table VIII for n-butane. These data are plotted against temperature with pressure as a parameter in Figure 5 for ethylene, in Figure 7 for propane, and in Figure 8 for n-butane.

Previously, Sledjeski (21) had similarly calculated C_p/C_v for methane, and Reiter (17) had calculated C_p/C_v for ethane. Their results are reproduced as Figure 4 for methane and Figure 6 for ethane. Reiter's calculations, shown in Table IX, were replotted at different pressure parameters. The values used for Figure 6 are shown in Table X.

For the purpose of comparison with the calculated

values, values of C_p/C_v from Edmister's generalized correlation were calculated for methane, ethylene, ethane, propane, and n-butane. The critical constants used for calculating reduced conditions are shown in Table XI. The calculated values of C_p/C_v from Edmister's correlation are shown in Tables XII to XVI. These values were plotted in Figures 9 to 13, which were then cross-plotted to obtain the comparisons shown in Figures 14 to 18.

For comparison of other experimental or calculated values of C_p with C_p/C_v from the Benedict-Webb-Rubin equation the following was done:

a.) the Benedict-Webb-Rubin value of C_p/C_v was read from Figures 4 to 8 at the experimental pressure and temperature,

b.) this value of C_p/C_v was multiplied by the ratio of the experimental C_p to the C_p calculated from the Benedict-Webb-Rubin equation at the experimental temperature and pressure,

c.) the results of these calculations were plotted on Figures 14 to 18 for comparison.

The data calculated from the Beattie-Bridgeman equation of state by Ellenwood et.al. for methane and ethylene were compared in this manner. They were plotted on Figures 14 and 15, and are shown in Tables XVII and XVIII.

The data of Budenholtzer, Sage, and Lacey (22) on methane was also compared in this manner and are shown in Table XIX and on Figure 14.

A comparison of the data of Sage, Webster, Lacey, and Budenholtzer (23,24) for ethane is shown in Table XX and on Figure 16.

DISCUSSION OF RESULTS

General

Comparison and evaluation of the C_p/C_v calculations is made difficult by the fact that there are few data on C_p and almost no data on C_v at high pressures. However, the available C_p data can be used as a basis for comparison if the values of C_v calculated from the Benedict-Webb-Rubin equation are used. This might not be too inaccurate a comparison since C_v changes much less than C_p with pressure. However, final evaluation of these results must await the determination of additional experimental data.

Methane

As indicated in Figure 14, the agreement is very good between the experimental data of Budenholtzer, Sage, and Lacey (22), and the results obtained from the Benedict-Webb-Rubin equation. However, it appears that below about 200°F, the C_p/C_v calculated would become increasingly high in respect to the experimental data. Since the Budenholtzer data are derived from Joule-Thomson measurements and are believed accurate, the Benedict-Webb-Rubin equation appears to be reliable above 200°F.

The Edmister generalized correlation appears to predict higher than the experimental data. The Ellenwood

calculation based on the Beattie-Bridgeman equation shows the greatest disagreement with the experimental data.

It is recommended, therefore, that the Benedict-Webb-Rubin results be used above 200°F and 1500 psia and up to 1.8 times the critical density. Below this range, the experimental C_p data of Budenholtzer, Sage, and Lacey should be used together with values of C_v calculated from the Benedict-Webb-Rubin equation.

Ethylene

The Edmister and Benedict-Webb-Rubin calculations agree quite well. The Beattie-Bridgeman equation predicts lower values. In view of the lack of experimental data, there is no definite criterion for judging reliability. However, since the generalized correlation agrees quite well with the results from the Benedict-Webb-Rubin equation, it is recommended that the latter equation be used.

Ethane

The Edmister and Benedict-Webb-Rubin calculations show very good agreement. However, both deviate significantly from the experimental data of Sage et.al. (23,24). Barkelew, Valentine, and Hurd (25), reported that there might be some doubt of the accuracy of the Sage data since they were based on saturated vapor enthalpies, which are difficult to determine accurately. Until other experimen-

tal data are available, this point is questionable.

It is recommended that the data of Sage, et.al. be used below 250°F, and the results from the Benedict-Webb-Rubin equation be used above 250°F.

Propane

The small amount of experimental data available are those of Sage, Kennedy, and Lacey (26) which cover the range of 60°-200°F and from one atmosphere to 550 psia. In the range of interest in this work, there are no data except the Edmister generalized correlation. As shown in Figure 17, results of both calculations agree very well. In view of the fact that the generalized correlation was developed from averaged values from a number of hydrocarbons, it is believed that the results from the Benedict-Webb-Rubin equation are more accurate.

It is recommended that the data of Sage, Kennedy, and Lacey (26) be used below 200°F and 550 psia. Use of the Benedict-Webb-Rubin equation is recommended above this range.

n-Butane

No satisfactory experimental data are available in the range of interest in this work. As shown in Figure 18, the Edmister generalized correlation agrees quite well with the Benedict-Webb-Rubin results, excepting the region below

550°F and above 1500 psia. Again, no data are available to support either correlation. However, a generalized correlation is developed from an averaging of a number of hydrocarbons, whereas the constants for the Benedict-Webb-Rubin equation were developed to best fit the PVT data on n-butane. Therefore, it is recommended that the data reported in this work be used above 250°F.

Constants for Benedict-Webb-Rubin Equation

Selleck, Opfell, Schlinger, and Sage (27,28) have determined sets of constants for the Benedict-Webb-Rubin equation which better fit a wider range of PVT data than the constants originally proposed by Benedict, et.al. By the use of computing machines and statistical methods, they were able to determine the set of constants which gave the lowest standard error of estimate for methane, ethane, propane, n-butane, and n-pentane. They included PVT data up to 10,000 psia and from 100° to 460°F. This work also illustrated the danger of indiscriminate extrapolation of the Benedict-Webb-Rubin equation, since the best constants fitted by Benedict up to about 3000 psia were not the best set when data up to 10,000 psia were included.

Future work along the lines of this thesis should use the constants developed by Selleck, et.al. As experimental data become available, they should be compared with these calculated data.

NOTATION

The symbols used are:

C_p Heat capacity at constant pressure, molal basis Btu/lb mol-°F

c_p Specific heat at constant pressure in Btu/lb-°F

C_p^* Heat capacity at constant pressure of the gas when exhibiting ideal gas behavior, molal basis Btu/lb mol-°F

C_v Heat capacity at constant volume, molal basis Btu/lb mol-°F

c_v Specific heat at constant volume in Btu/lb-°F

C_v^* Heat capacity at constant volume of the gas when exhibiting ideal gas behavior, molal basis Btu/lb mol-°F

P Absolute pressure lb/sq.in., psia

R Universal Gas Constant

T Absolute Temperature, °R

V Molal Volume, cu.ft/lb-mol.

A_o, B_o, C_o
a, b, c, α, γ Constants for Benedict-Webb-Rubin Equation

REFERENCES

(1) Rossini et.al., "Selected Values of Physical and Thermodynamic Properties of Hydrocarbons and Related Compounds", Carnegie Press (continuation of work of American Petroleum Institute Research Project 44 at National Bureau of Standards, Washington, D.C.) (1953)

(2) Masi, J. F.; A.S.M.E. Trans., 76, 1067-74, (Oct.1954)

(3) Edmister, W. C., Ind.Eng.Chem., 30, 352 (March 1938)

(4) ibid, 32, 373 (March 1940)

(5) Edmister, W. C., "Applications of Thermodynamics to Hydrocarbon Processing: Part XIII- Heat Capacities" published by the Petroleum Refiner (1948)

(6) Edmister, W. C., "Applications of Thermodynamics to Hydrocarbon Processing: Part VII- Hydrocarbon Properties for Derivations" published by the Petroleum Refiner (1948)

(7) Hougen, O. A.; and Watson, K. M., "Chemical Process Principles -Part Two", John Wiley and Sons, Inc., N.Y. (1947)

(8) Watson, K. M.; and Smith, R. L., National Petroleum News (July 1936)

(9) Beattie, J. A.; and Bridgeman, O. C., J.Amer.Chem.Soc., 49, 1665 (1927)

(10) ibid, 50, 3133 (1928)

(11) Benedict, M.; Webb, G. W.; and Rubin, L. C.; J.Chem. Phys., 8, 334-5 (1940)

(12) ibid, Chem.Eng.Prog. 47, 419-22 (1951)

(13) Ellenwood, F. O.; Kulik, N.; Gay, N. R.; "The Specific Heats of Certain Gases Over Wide Ranges of Pressures and Temperature", Cornell University Engineering Experiment Station, Bulletin No.30, (Oct.1942)

(14) Sledjeski, E. W., "Thesis for the Master's Degree in Chemical Engineering", Newark College of Engineering (1950)

(15) Sledjeski, E. W., Ind.Eng.Chem., 43, 2913-15 (1951)

(16) Sibilia, R. J., "Thesis for the Master's Degree in Chemical Engineering", Newark College of Engineering (1953)

(17) Reiter, T. A., "Thesis for the Master's Degree in Chemical Engineering", Newark College of Engineering (1954)

(18) Seifarth, J. H., "Thesis for the Master's Degree in Chemical Engineering", Newark College of Engineering (1952)

(19) Seifarth, J. H.; and Joffe, J., Ind.Eng.Chem., 44, (1952)

(20) Glueck, R. M., "Thesis for the Master's Degree in Chemical Engineering", Newark College of Engineering (1952)

(21) Private communication

(22) Budenholtzer, R. A.; Sage, B. H.; and Lacey, W. N., Ind.Eng.Chem. 31, 369 (1939)

(23) Sage, B. H.; Webster, D. C.; Lacey, W. N., Ind.Eng. Chem. 29, 658 (1937)

(24) Sage, B. H.; Budenholtzer, R. A.; Lacey, W. N., Ind. Eng.Chem. 31, 1288 (1939)

(25) Barkelew, C. H.; Valentine, J. L.; Hurd, C. O.; Trans.Am.Inst.Chem.Engrs. 43, No.1, 25, (1947)

(26) Sage, B. H.; Kennedy, E. R.; and Lacey, W. N., Ind. Eng.Chem. 28, 601 (1936)

(27) Selleck, F. T.; Opfell, J. B.; Sage, B. H.; Ind. Eng. Chem. 45, 1350 (June 1953)

(28) Opfell, J. B.; Schlinger, W. G.; and Sage, B. H., Ind.Eng.Chem. 46, 1286-91 (June 1954)

TABLE I

Benedict-Webb-Rubin Equation of State (11,12)

$$P = \frac{RT}{V} + \left(B_oRT - A_o - \frac{C_o}{T^2}\right)\frac{1}{V^2} + \left(bRT - a\right)\frac{1}{V^3} + \frac{a\alpha}{V^6} + \frac{c}{V^3T^2}\left[\left(1 + \frac{\gamma}{V^2}\right)e^{-\gamma/V^2}\right]$$

where
- P is the absolute pressure
- T is the absolute temperature
- V is the molal volume
- R is the universal gas constant

The constants for some hydrocarbon gases are (12):

	Methane	Ethylene	Ethane	Propane	n-Butane
Metric Units /1/					
$B_o \times 10^2$	4.26000	5.56833	6.27724	9.73130	12.4361
A_o	1.85500	3.33958	4.15556	6.87225	10.0847
C_o x10^{-5}	0.225700	1.31140	1.79592	5.08256	9.92830
$b \times 10^2$	0.338004	0.86000	1.11220	2.25000	3.99983
$a \times 10$	0.494000	2.59000	3.45160	9.47700	18.8231
c x10^{-5}	0.0254500	0.21120	0.327670	1.29000	3.16400
$\gamma \times 10^2$	0.60000	0.923000	1.18000	2.20000	3.40000
α	0.124359	0.178000	0.243389	0.607175	1.10132
English Units /2/					
B_o	0.682401	0.891990	1.00554	1.55884	2.20329
A_o x10^{-4}	0.699525	1.25936	1.56707	2.59154	3.85874
C_o x10^{-9}	0.275763	1.60228	2.19427	6.20993	10.3847
b	0.867325	2.20678	2.85393	5.77355	10.8890
a x10^{-4}	0.298412	1.56455	2.08502	5.72480	11.7047
c x10^{-9}	0.498106	4.13360	6.41314	25.2478	55.9777
γ	1.53961	2.36844	3.02790	5.64524	8.72447
$\alpha \times 10^3$	0.511172	0.731661	1.00044	2.49577	4.41496

/1/ atmospheres, liters, gram mol, ^oK
R = 0.08207 $T^oK = t^oc + 273.13$

/2/ lb/in^2, cubic feet, lb mol, ^oR
R = 10.7335 $^oR = {}^oF + 459.63$

TABLE II

Values of Isobaric Heat Capacities in the Ideal Gas State for Various Temperatures (1)

Temp. °K	Methane	Ethylene	Ethane	Propane	n-Butane
	- - - - - - - -Cal/gm mol-°K- - - - - - - - -				
0	0	0	0	0	0
100	7.949	--	8.59	9.84	--
150	7.953	--	9.32	11.61	--
200	8.002	--	10.17	13.25	--
250	8.185	--	11.28	15.37	20.51
298.16	8.536	10.41	12.58	17.57	23.29
300	8.552	10.45	12.64	17.66	23.40
350	9.082	--	14.13	20.11	26.54
400	9.721	12.90	15.68	22.54	29.60
450	10.42	--	17.19	24.84	32.55
500	11.13	15.16	18.66	27.02	35.34
600	12.55	17.10	21.35	30.88	40.30
700	13.88	18.76	23.72	34.20	44.55
800	15.10	20.20	25.83	37.08	48.23
900	16.21	21.46	27.69	39.61	51.44
1000	17.21	22.57	29.33	41.83	54.22
1100	18.09	23.54	30.77	43.75	56.64
1200	18.88	24.39	32.02	45.42	58.74
1300	19.57	25.14	33.11	46.89	60.58

TABLE III

Calculated Data for Ethylene
Based on Calculations of Reference 16

P psia	$C_p - C_p^*$	C_p	$C_p - C_v$	C_v	C_p/C_v
	liter-atm/gm mol-°K				
T = 32°F					
0	0	0.40342	0.082054	0.32137	1.2553
63.65	0.02106	0.42448	0.09553	0.32895	1.2904
150.97	0.05680	0.46022	0.12034	0.33988	1.3541
276.04	0.13120	0.53462	0.17777	0.35685	1.4982
346.22	0.19541	0.59883	0.23153	0.36731	1.6303
458.09	0.38420	0.78766	0.40151	0.38615	2.0398
553.86	0.70574	1.10916	0.70284	0.40073	2.7678
587.75	1.08374	1.48716	1.07158	0.41558	3.5785
616.71	2.32933	2.73275	2.30651	0.42624	6.4113
624.83	4.09101	4.49443	4.06368	0.43075	10.4340
T= 104°F					
0	0	0.44512	0.082054	0.36307	1.2260
73.65	0.01488	0.46001	0.09191	0.36810	1.2497
117.23	0.03872	0.48384	0.10849	0.37535	1.2890
332.57	0.08319	0.52831	0.14169	0.38662	1.3665
424.93	0.11684	0.56197	0.16841	0.39356	1.4279
585.40	0.19781	0.64293	0.23687	0.40606	1.5833
749.84	0.33173	0.77686	0.35641	0.42045	1.8477
825.75	0.41929	0.86441	0.43883	0.42559	2.0311
915.03	0.56724	1.01236	0.58048	0.43189	2.3441
941.56	0.66841	1.11354	0.67788	0.43565	2.5560
1023.2	0.81950	1.26463	0.82461	0.44001	2.8741

TABLE III (continued)

P psia	$C_p - C_p^*$	C_p	$C_p - C_v$	C_v	C_p/C_v
	liter-atm/gm mol-°K				
T = 212°F					
0	0	0.50624	0.082054	0.42419	1.1934
88.51	0.00980	0.51604	0.08889	0.42715	1.2081
215.84	0.02514	0.53138	0.09994	0.43144	1.2316
414.46	0.05251	0.55874	0.12065	0.43809	1.2754
538.17	0.07207	0.57831	0.13612	0.44219	1.3078
766.85	0.11429	0.62053	0.17094	0.44958	1.3802
1029.9	0.17515	0.68139	0.22389	0.45749	1.4894
1164.9	0.20952	0.71576	0.25463	0.46113	1.5522
1342.5	0.25868	0.76492	0.29962	0.46530	1.6439
1421.6	0.28782	0.79405	0.32698	0.46707	1.7001
1594.5	0.32597	0.83221	0.36256	0.46965	1.7720
T = 302°F					
0	0	0.55413	0.082054	0.47208	1.1738
100.83	0.00546	0.55960	0.08549	0.47411	1.1803
247.60	0.01808	0.57221	0.09517	0.47705	1.1995
481.23	0.03893	0.59307	0.11145	0.48161	1.2314
630.08	0.05294	0.60707	0.12265	0.48443	1.2532
913.54	0.08221	0.63635	0.14686	0.48949	1.3000
1255.4	0.12204	0.67618	0.18126	0.49492	1.3662
1438.4	0.14365	0.69779	0.20038	0.49741	1.4028
1688.5	0.17338	0.72751	0.22724	0.50027	1.4542
1810.1	0.19027	0.74440	0.24292	0.50149	1.4844
2061.2	0.21283	0.76697	0.26371	0.50325	1.5240

TABLE III (continued)

P psia	$C_p - C_p^*$	C_p	$C_p - C_v$	C_v	C_p/C_v
	liter-atm/gm mol-°K				
T = 392°F					
0	0	0.60162	0.082054	0.51957	1.1579
113.11	0.00585	0.60747	0.08646	0.52101	1.1660
279.15	0.01487	0.61649	0.09337	0.52311	1.1785
547.22	0.03040	0.63202	0.10564	0.52638	1.2007
720.69	0.04111	0.64273	0.11434	0.52839	1.2164
1057.6	0.06306	0.66468	0.13267	0.53202	1.2494
1469.2	0.09201	0.69363	0.15773	0.53590	1.2943
1707.0	0.10743	0.70905	0.17137	0.53768	1.3187
2029.1	0.12830	0.72992	0.19019	0.53973	1.3524
2192.6	0.13985	0.74147	0.20089	0.54059	1.3716
2523.0	0.15586	0.75748	0.21562	0.54186	1.3979
2809.0	0.16858	0.77020	0.22762	0.54258	1.4195
3428.8	0.18747	0.78909	0.24599	0.54310	1.4529
4063.0	0.19689	0.79851	0.25586	0.54265	1.4715
5953.3	0.19253	0.79415	0.25467	0.53949	1.4721
T = 482°F					
0	0	0.64580	0.082054	0.56375	1.1456
125.37	0.00478	0.65058	0.08577	0.56481	1.1519
310.57	0.01212	0.65792	0.09155	0.56637	1.1616
612.72	0.02468	0.67048	0.10169	0.56879	1.1788
810.48	0.03323	0.67904	0.10876	0.57027	1.1907
1200.0	0.05057	0.69637	0.12342	0.57296	1.2154

TABLE III (continued)

P psia	$C_p - C_p^*$	C_p	$C_p - C_v$	C_v	C_p/C_v
	liter-atm/gm mol-°K				
T = 482°F (continued)					
1695.6	0.07304	0.71885	0.14302	0.57583	1.2484
1972.7	0.08484	0.73064	0.15350	0.57714	1.2660
2366.3	0.10075	0.74655	0.16790	0.57866	1.2901
2571.2	0.10942	0.75522	0.17592	0.57930	1.3037
2981.7	0.12186	0.76766	0.18742	0.58024	1.3230
3343.1	0.13178	0.77758	0.19681	0.58077	1.3389
4127.4	0.14722	0.79302	0.21186	0.58115	1.3646
4951.5	0.15605	0.80185	0.22103	0.58082	1.3806
7374.7	0.15782	0.80362	0.22514	0.57848	1.3892
T = 572°F					
0	0	0.68586	0.082054	0.60381	1.1359
137.62	0.00462	0.69048	0.08587	0.60461	1.1420
341.90	0.01018	0.69603	0.09024	0.60579	1.1490
677.88	0.02062	0.70648	0.09885	0.60763	1.1627
899.73	0.02769	0.71355	0.10479	0.60876	1.1721
1341.4	0.04189	0.72775	0.11695	0.61080	1.1915
1912.7	0.06003	0.74589	0.13291	0.61298	1.2168
2236.3	0.06958	0.75544	0.14145	0.61398	1.2304
2701.3	0.08237	0.76823	0.15309	0.61514	1.2489
2947.2	0.08925	0.77511	0.15949	0.61562	1.2591
3438.2	0.09946	0.78531	0.16897	0.61634	1.2742
3875.6	0.10764	0.79349	0.17675	0.61674	1.2866

TABLE III (continued)

P psia	$C_p-C_p^*$	C_p	C_p-C_v	C_v	C_p/C_v
	liter-atm/gm mol-°K				
T = 572°F (continued)					
4832.1	0.12086	0.80671	0.18968	0.61703	1.3074
5842.6	0.12918	0.81504	0.19826	0.61678	1.3214
8805.1	0.13437	0.82022	0.20522	0.61500	1.3337
T = 752°F					
0	0	0.75729	0.082054	0.67524	1.1215
162.08	0.00303	0.76032	0.08459	0.67573	1.1252
404.38	0.00762	0.76491	0.08845	0.67646	1.1308
807.60	0.01535	0.77264	0.09505	0.67759	1.1403
1077.2	0.02053	0.77782	0.09953	0.67829	1.1467
1622.2	0.03081	0.78810	0.10855	0.67955	1.1597
2343.5	0.04327	0.80055	0.11966	0.68090	1.1757
2759.7	0.05056	0.80785	0.12633	0.68151	1.1854
3366.9	0.05968	0.81697	0.13474	0.68223	1.1975
3694.3	0.06452	0.82180	0.13928	0.68253	1.2041
4347.4	0.07208	0.82937	0.14641	0.68297	1.2144
4937.6	0.07822	0.83551	0.15230	0.68321	1.2229
6241.7	0.08874	0.84603	0.16263	0.68340	1.2380
7629.4	0.09625	0.85353	0.17030	0.68324	1.2493
T = 932°F					
0	0	0.81840	0.082054	0.73635	1.1114
186.52	0.00235	0.82075	0.08408	0.73667	1.1141
466.73	0.00573	0.82413	0.08698	0.73715	1.1180

TABLE III (continued)

P psia	$C_p-C_p^*$	C_p	C_p-C_v	C_v	C_p/C_v
	liter-atm/gm mol-°K				
T = 932°F (continued)					
936.83	0.01214	0.83054	0.09264	0.73790	1.1256
1253.8	0.01618	0.83458	0.09622	0.73836	1.1303
1901.3	0.02415	0.84256	0.10337	0.73919	1.1398
2771.7	0.03411	0.85251	0.11243	0.74008	1.1519
3280.1	0.04002	0.85842	0.11794	0.74049	1.1593
4029.1	0.04642	0.86482	0.12387	0.74096	1.1672
4437.7	0.05015	0.86855	0.12739	0.74115	1.1719
5253.5	0.05622	0.87462	0.13317	0.74144	1.1796
5997.1	0.06121	0.87961	0.13800	0.74161	1.1861
7507.4	0.07014	0.88854	0.14681	0.74173	1.1979
9420.0	0.07704	0.89544	0.15382	0.74163	1.2074
T = 1112°F					
0	0	0.87249	0.082054	0.79044	1.1038
210.94	0.00200	0.87450	0.08384	0.79066	1.1060
529.01	0.00222	0.87471	0.08372	0.79099	1.1059
1065.8	0.01000	0.88249	0.09098	0.79151	1.1150
1430.0	0.01329	0.88579	0.09396	0.79183	1.1187
2179.6	0.01976	0.89226	0.09985	0.79241	1.1260
3198.4	0.02780	0.90029	0.10727	0.79302	1.1353
3798.8	0.03206	0.90455	0.11125	0.79331	1.1402
4689.5	0.03783	0.91032	0.11669	0.79363	1.1470
5178.9	0.04087	0.91336	0.11959	0.79377	1.1507

TABLE III (continued)

P psia	$C_p - C_p^*$	C_p	$C_p - C_v$	C_v	C_p/C_v
	liter-atm/gm mol-°K				
T = 1112°F (continued)					
6157.8	0.04598	0.91847	0.12450	0.79397	1.1568
7055.2	0.05024	0.92273	0.12864	0.79409	1.1620
9061.1	0.05812	0.93061	0.13644	0.79417	1.1718
T = 1292°F					
0	0	0.91998	0.082054	0.83793	1.0979
235.36	0.00174	0.92171	0.08364	0.83808	1.0998
591.23	0.00132	0.92130	0.08298	0.83832	1.0990
1194.6	0.00849	0.92847	0.08977	0.83869	1.1070
1605.9	0.01126	0.93124	0.09231	0.83893	1.1100
2457.3	0.01667	0.93665	0.09731	0.83934	1.1159
3624.2	0.02342	0.94340	0.10361	0.83979	1.1234
4316.4	0.02697	0.94695	0.10696	0.83999	1.1273
5348.6	0.03185	0.95183	0.11160	0.84023	1.1328
5918.7	0.03443	0.95441	0.11408	0.84033	1.1358
7061.1	0.03888	0.95886	0.11838	0.84047	1.1409
8112.4	0.04263	0.96261	0.12205	0.84056	1.1452
10470.9	0.04977	0.96975	0.12914	0.84062	1.1536
T = 1472°F					
0	0	0.96168	0.082054	0.87963	1.0933
259.77	0.00150	0.96318	0.08344	0.87974	1.0949
653.43	0.00064	0.96232	0.08240	0.87992	1.0936
1323.2	0.00736	0.96905	0.08885	0.88020	1.1009

TABLE III (continued)

P psia	$C_p - C_p^*$	C_p	$C_p - C_v$	C_v	C_p/C_v
		liter-atm/gm mol-°K			
T = 1472°F					
1781.6	0.00975	0.97143	0.09106	0.88037	1.1034
2734.7	0.01439	0.97607	0.09539	0.88068	1.1083
4049.5	0.02014	0.98183	0.10081	0.88101	1.1144
4833.4	0.02323	0.98491	0.10374	0.88117	1.1177
6007.0	0.02747	0.98916	0.10781	0.88134	1.1223
6657.7	0.02972	0.99140	0.10999	0.88142	1.1248
7963.6	0.03368	0.99537	0.11384	0.88153	1.1291
9169.1	0.03706	0.99875	0.11716	0.88159	1.1329
T = 1652°F					
0	0	0.99802	0.082054	0.91597	1.0896
284.18	0.00133	0.99935	0.08330	0.91605	1.0909
715.61	0.00329	1.00131	0.08513	0.91618	1.0929
1451.8	0.00650	1.00452	0.08812	0.91640	1.0962
1957.2	0.00858	1.00660	0.09007	0.91653	1.0983
3011.8	0.01263	1.01065	0.09388	0.91677	1.1024
4474.3	0.01766	1.01568	0.09866	0.91702	1.1076
5349.9	0.02037	1.01839	0.10125	0.91714	1.1104
6664.8	0.02413	1.02215	0.10488	0.91727	1.1143
7396.1	0.02613	1.02415	0.10682	0.91733	1.1165
8865.7	0.02973	1.02775	0.11034	0.91741	1.1203
10225.4	0.03283	1.03085	0.11339	0.91746	1.1236

TABLE III (continued)

P psia	$C_p - C_p^*$	C_p	$C_p - C_v$	C_v	C_p/C_v
		liter-atm/gm mol-°K			
T = 1832°F					
0	0	1.02982	0.082054	0.94777	1.0866
308.59	0.00122	1.03104	0.08322	0.94782	1.0878
777.77	0.00296	1.03277	0.08484	0.94793	1.0895
1580.4	0.00581	1.03563	0.08753	0.94810	1.0923
2132.7	0.00766	1.03747	0.08928	0.94820	1.0942
3288.8	0.01124	1.04106	0.09267	0.94838	1.0977
4898.9	0.01570	1.04551	0.09693	0.94858	1.1022
5866.0	0.01812	1.04794	0.09926	0.94868	1.1046
7322.3	0.02151	1.05132	0.10254	0.94878	1.1081
8134.0	0.02322	1.05303	0.10431	0.94873	1.1099
9767.4	0.02662	1.05644	0.10755	0.94889	1.1133
T = 2012°F					
0	0	1.05789	0.082054	0.97584	1.0841
333.00	0.00109	1.05898	0.08310	0.97589	1.0852
839.92	0.00268	1.06057	0.08460	0.97597	1.0867
1708.9	0.00525	1.06314	0.08704	0.97610	1.0892
2308.2	0.00692	1.06481	0.08863	0.97619	1.0908
3565.6	0.01014	1.06803	0.09170	0.97633	1.0939
5323.2	0.01411	1.07200	0.09551	0.97649	1.0978
6382.0	0.01629	1.07419	0.09762	0.97657	1.0910
7979.6	0.01938	1.07727	0.10062	0.97665	1.1030
8871.8	0.02104	1.07893	0.10225	0.97668	1.1047
10668.9	0.02411	1.08200	0.10527	0.97674	1.1078

TABLE III (continued)

P psia	$C_p - C_p^*$	C_p	$C_p - C_v$	C_v	C_p/C_v
	liter-atm/gm mol-°K				
T = 2192°F					
0	0	1.08226	0.082054	1.00021	1.0820
357.40	0.00100	1.08325	0.08302	1.00023	1.0830
902.07	0.00245	1.08471	0.08440	1.00030	1.0844
1837.3	0.00479	1.08705	0.08664	1.00041	1.0866
2483.6	0.00629	1.08855	0.08807	1.00048	1.0880
3842.3	0.00919	1.09144	0.09084	1.00060	1.0908
5747.4	0.01277	1.09503	0.09434	1.00069	1.0943
6897.7	0.01481	1.09706	0.09627	1.00079	1.0962
8636.6	0.01764	1.10990	0.09905	1.00085	1.1090
9609.2	0.01918	1.10144	0.10055	1.00088	1.1005
11570.2	0.02206	1.10432	0.10340	1.00092	1.1033
T = 2372°F					
0	0	1.10331	0.082054	1.02126	1.0804
381.80	0.00092	1.10423	0.08295	1.02128	1.0812
964.21	0.00226	1.10557	0.08423	1.02134	1.0825
1965.8	0.00440	1.10771	0.08628	1.02143	1.0845
2659.0	0.00577	1.10908	0.08760	1.02148	1.0858
4119.0	0.00841	1.11172	0.09014	1.02158	1.0882
6171.5	0.01171	1.11503	0.09334	1.02169	1.0914
7413.4	0.01355	1.11687	0.09513	1.02174	1.0931
9287.1	0.01619	1.11950	0.09771	1.02179	1.0956
10346.5	0.01762	1.12094	0.09912	1.02182	1.0970
12471.4	0.02034	1.12366	0.10181	1.02185	1.0996

TABLE IV

Calculated Data for Propane
Based On Calculations of Reference 18

P psia	$C_p - C_p^*$	C_p	$C_p - C_v$	C_v	C_p/C_v
	liter-atm/gm mol-°K				
T = 200°F					
0	0	0.86341	0.082054	0.78136	1.1050
43.073	0.016767	0.88018	0.092524	0.78765	1.1175
298.26	0.17846	1.04187	0.21357	0.82830	1.2578
338.53	0.22492	1.08833	0.25294	0.83539	1.3028
441.98	0.52702	1.39043	0.52767	0.86276	1.6116
T = 400°F					
0	0	1.07524	0.082054	0.99319	1.0826
112.15	0.017462	1.09270	0.094023	0.99867	1.0941
505.67	0.097328	1.17256	0.15497	1.01760	1.1523
612.95	0.12588	1.20111	0.17850	1.02261	1.1746
778.14	0.17696	1.25219	0.22222	1.02998	1.2157
900.24	0.22023	1.29547	0.26050	1.03497	1.2517
1070.1	0.28683	1.36207	0.32104	1.04103	1.3084
1539.4	0.44036	1.51559	0.46631	1.04929	1.4444
2700.7	0.45461	1.52984	0.49212	1.03772	1.4742
T = 500°F					
0	0	1.17062	0.082054	1.08856	1.0754
207.41	0.022785	1.19340	0.09842	1.09498	1.0899
585.52	0.072946	1.24357	0.13746	1.10610	1.1243
1085.2	0.15656	1.32718	0.20859	1.11859	1.1865
1696.8	0.28599	1.45661	0.32909	1.12752	1.2919

TABLE IV (continued)

P psia	$C_p - C_p^*$	C_p	$C_p - C_v$	C_v	C_p/C_v
		liter-atm/gm mol-°K			
T = 500°F (continued)					
2542.7	0.31637	1.48699	0.35923	1.12775	1.3185
2999.6	0.31452	1.48514	0.35991	1.12523	1.3198
T = 600°F					
0	0	1.25774	0.082054	1.17569	1.0698
231.01	0.01830	1.27605	0.09559	1.18046	1.0810
664.09	0.05740	1.31515	0.12643	1.18872	1.1064
1266.8	0.11959	1.37733	0.17934	1.19800	1.1497
2057.7	0.19253	1.45027	0.24565	1.20462	1.2039
3213.2	0.23843	1.49618	0.29139	1.20479	1.2419
4938.6	0.23945	1.49720	0.29773	1.19946	1.2482
T = 800°F					
0	0	1.41135	0.082054	1.32930	1.0617
276.41	0.01268	1.42403	0.09194	1.33209	1.0690
550.19	0.02576	1.43711	0.10244	1.33467	1.0768
818.86	0.03916	1.45051	0.11350	1.33702	1.0849
1162.3	0.05649	1.46784	0.12818	1.33966	1.0957
2768.9	0.12516	1.53651	0.19003	1.34648	1.1411
4565.1	0.15940	1.57075	0.22415	1.34660	1.1665
5553.5	0.16515	1.57649	0.23102	1.34547	1.1717
7232.6	0.16794	1.57929	0.23588	1.34341	1.1756
T = 1000°F					
0	0	1.54266	0.082054	1.46060	1.0562
97.644	0.00288	1.54554	0.08436	1.46118	1.0577

TABLE IV (continued)

P psia	$C_p - C_p^*$	C_p	$C_p - C_v$	C_v	C_p/C_v
	liter-atm/gm mol-°K				
T = 1000°F (continued)					
486.10	0.01454	1.55720	0.09391	1.46329	1.0642
973.41	0.02923	1.57188	0.10628	1.46560	1.0725
1394.2	0.04180	1.58446	0.11716	1.46730	1.0798
1975.5	0.05818	1.60083	0.13168	1.46915	1.0896
3484.0	0.09169	1.63435	0.16267	1.47168	1.1105
4364.4	0.10504	1.64770	0.17562	1.47208	1.1193
5924.8	0.12000	1.66266	0.19090	1.47176	1.1297
6958.2	0.12497	1.66763	0.19639	1.47124	1.1335
8465.3	0.12957	1.67223	0.20191	1.47032	1.1373
9554.2	0.12990	1.67256	0.20285	1.46971	1.1380
T = 1340°F					
0	0	1.72682	0.082054	1.64477	1.0499
120.71	0.00200	1.72882	0.08377	1.64505	1.0509
491.5	0.01578	1.74260	0.09670	1.64591	1.0587
1230.1	0.02000	1.74681	0.09940	1.64741	1.0603
1785.3	0.02843	1.75524	0.10693	1.64831	1.0649
2569.2	0.03936	1.76618	0.11688	1.64930	1.0709
4688.6	0.06246	1.78928	0.13863	1.65065	1.0840
8248.3	0.07813	1.80495	0.15427	1.65069	1.0935

TABLE V

Calculated Data for n-Butane
Based on Calculations of Reference 20

P psia	$C_p - C_p^*$	C_p	$C_p - C_v$	C_v	C_p/C_v
	liter-atm/gm mol-°K				
T = 350.37°F					
0	0	1.34405	0.082054	1.26200	1.0650
102.58	0.03799	1.38204	0.10666	1.27538	1.0836
235.98	0.10302	1.44706	0.15499	1.29208	1.1200
407.02	0.25246	1.59651	0.27959	1.31692	1.2123
492.48	0.39505	1.73909	0.40847	1.33063	1.3070
610.91	0.84774	2.19178	0.84062	1.35116	1.6222
896.14	1.57516	2.91921	1.56990	1.34931	2.1635
T = 440.37°F					
0	0	1.45925	0.082054	1.37720	1.0596
115.47	0.02892	1.48817	0.10122	1.38695	1.0730
270.52	0.07629	1.53554	0.13641	1.39912	1.0975
486.56	0.17389	1.63314	0.21590	1.41724	1.1523
605.95	0.25341	1.71265	0.28543	1.42723	1.2000
637.02	0.27829	1.73753	0.30776	1.42977	1.2153
800.97	0.44272	1.90196	0.45977	1.44220	1.3188
T = 485.37°F					
0	0	1.51210	0.082054	1.43004	1.0574
121.86	0.02560	1.53770	0.09923	1.43848	1.0690
287.82	0.06690	1.57900	0.13001	1.44899	1.0897
525.36	0.14904	1.66114	0.19651	1.46464	1.1342
661.42	0.19886	1.71097	0.23770	1.47327	1.1613

TABLE V (continued)

P psia	$C_p - C_p^*$	C_p	$C_p - C_v$	C_v	C_p/C_v
	liter-atm/gm mol-°K				
T = 485.37°F (continued)					
813.07	0.30175	1.81386	0.33175	1.48211	1.2238
893.91	0.34660	1.85869	0.37250	1.48620	1.2506
1153.0	0.51464	2.02674	0.53204	1.49470	1.3560
1296.1	0.56387	2.07597	0.58015	1.49582	1.3879
T = 530.37°F					
0	0	1.56454	0.082054	1.48249	1.0554
304.97	0.05926	1.62380	0.12484	1.49896	1.0833
563.68	0.12972	1.69426	0.18169	1.51257	1.1201
715.78	0.18267	1.74721	0.22714	1.52008	1.1494
985.78	0.29526	1.85980	0.32848	1.53132	1.2145
1304.6	0.41613	1.98067	0.44195	1.53872	1.2872
1482.1	0.45460	2.01914	0.47945	1.53969	1.3114
1764.5	0.47126	2.03580	0.49792	1.53788	1.3238
T = 575.37°F					
0	0	1.61492	0.082054	1.53287	1.0535
322.00	0.05296	1.66788	0.12060	1.54728	1.0780
601.62	0.11478	1.72969	0.17005	1.55964	1.1090
769.70	0.15924	1.77415	0.20840	1.56576	1.1331
1076.8	0.25171	1.86663	0.29103	1.57560	1.1847
1469.6	0.34866	1.96357	0.38150	1.58207	1.2411
1669.4	0.38047	1.99539	0.41247	1.58292	1.2606
2013.0	0.39721	2.01212	0.43079	1.58133	1.2724

TABLE V (continued)

P psia	$C_p - C_p^*$	C_p	$C_p - C_v$	C_v	C_p/C_v
	liter-atm/gm mol-°K				
T = 620.37°F					
0	0	1.66406	0.082054	1.58201	1.0519
338.92	0.04769	1.71175	0.11706	1.59469	1.0734
442.77	0.06505	1.72911	0.13069	1.59842	1.0818
639.14	0.10181	1.76586	0.16070	1.60517	1.1001
1167.0	0.21865	1.88270	0.26309	1.61961	1.1624
1599.6	0.29939	1.96344	0.33813	1.62531	1.2080
1856.1	0.32682	1.99087	0.36481	1.62606	1.2244
2262.5	0.34361	2.00766	0.38300	1.62466	1.2357
2513.7	0.34323	2.00728	0.38427	1.62302	1.2368
3062.8	0.33008	1.99414	0.37531	1.61883	1.2318
T = 647.37°F					
0	0	1.69172	0.082054	1.60967	1.0510
661.54	0.09538	1.78710	0.15593	1.63118	1.0956
855.21	0.13167	1.82339	0.18685	1.63655	1.1142
1220.9	0.20239	1.89411	0.24952	1.64459	1.1517
1688.5	0.27574	1.96746	0.31758	1.64988	1.1925
1968.2	0.30115	1.99287	0.34229	1.65058	1.2074
2412.8	0.31759	2.00931	0.36003	1.64928	1.2183
2681.5	0.31834	2.01006	0.36231	1.64775	1.2199
T = 668.37°F					
0	0	1.70989	0.082054	1.62784	1.0504
148.06	0.01693	1.72681	0.09399	1.63282	1.0576

TABLE V (continued)

P psia	$C_p-C_p^*$	C_p	C_p-C_v	C_v	C_p/C_v
	liter-atm/gm mol-°K				
T = 665.37°F (continued)					
355.75	0.04324	1.75313	0.11408	1.63906	1.0696
676.42	0.09147	1.80136	0.15303	1.64833	1.0928
876.10	0.12548	1.83537	0.18193	1.65344	1.1100
1256.7	0.19272	1.90261	0.24150	1.66111	1.1454
1747.6	0.26185	1.97174	0.30559	1.66615	1.1834
2042.9	0.28610	1.99599	0.32918	1.66681	1.1975
2513.1	0.30244	2.01233	0.34675	1.66557	1.2082
2797.4	0.30370	2.01358	0.34946	1.66412	1.2100
T = 710.37°F					
0	0	1.75490	0.082054	1.67285	1.0491
372.51	0.03945	1.79435	0.11153	1.68282	1.0663
713.45	0.08281	1.83771	0.14665	1.69106	1.0867
928.71	0.11299	1.86789	0.17228	1.69561	1.1016
1345.8	0.17188	1.92678	0.22436	1.70242	1.1318
1895.2	0.23231	1.98721	0.28030	1.70690	1.1642
2229.6	0.25416	2.00906	0.30157	1.70749	1.1766
2764.5	0.27020	2.02510	0.31871	1.70639	1.1868
3088.0	0.27246	2.02735	0.32226	1.70510	1.1890
3814.4	0.26724	2.02214	0.32034	1.70180	1.1882
T = 800.37°F					
0	0	1.83955	0.082054	1.75750	1.0467
166.06	0.01317	1.85272	0.09168	1.76104	1.0521

TABLE V (continued)

P psia	$C_p - C_p^*$	C_p	$C_p - C_v$	C_v	C_p/C_v
		liter-atm/gm mol-°K			
T = 800.37°F (continued)					
405.84	0.03336	1.87291	0.10743	1.76547	1.0609
786.91	0.06920	1.90875	0.13668	1.77207	1.0771
1522.7	0.13603	1.97557	0.19440	1.78117	1.1091
2189.6	0.18886	2.02840	0.24364	1.78476	1.1365
2603.1	0.20729	2.04684	0.26161	1.78523	1.1465
3269.1	0.22268	2.06223	0.27788	1.78435	1.1557
4573.9	0.23545	2.07500	0.29432	1.78068	1.1653
T = 890.37°F					
0	0	1.91924	0.082054	1.83719	1.0447
178.58	0.01138	1.93062	0.09056	1.84006	1.0492
438.97	0.02870	1.94794	0.10429	1.84365	1.0566
859.74	0.05904	1.97827	0.12926	1.84901	1.0699
1698.2	0.11405	2.03329	0.17688	1.85641	1.0953
2976.7	0.17181	2.09105	0.23134	1.85971	1.1244
3776.1	0.18934	2.10852	0.24959	1.85899	1.1343
5339.6	0.19542	2.11466	0.25885	1.85580	1.1395
T = 1160.37°F					
0	0	2.12405	0.082054	2.04200	1.0402
216.02	0.00692	2.13096	0.08731	2.04365	1.0427
537.63	0.01988	2.14392	0.09818	2.04574	1.0480
1075.8	0.04020	2.16424	0.11540	2.04885	1.0563
2219.6	0.07868	2.20273	0.14960	2.05313	1.0729

TABLE V (continued)

P psia	$C_p - C_p^*$	C_p	$C_p - C_v$	C_v	C_p/C_v
	liter-atm/gm mol-°K				
T = 1160.37°F (continued)					
4097.5	0.11796	2.24201	0.18697	2.05504	1.0910
5304.8	0.13104	2.25508	0.20046	2.05462	1.0976
7659.7	0.14209	2.26613	0.21324	2.05289	1.1039
T = 1520.37°F					
0	0	2.33876	0.082054	2.25671	1.0364
672.60	0.01380	2.35256	0.09381	2.25875	1.0415
1360.7	0.02757	2.36633	0.10588	2.26045	1.0468
2908.0	0.05345	2.39221	0.12941	2.26280	1.0572
5592.0	0.08230	2.42106	0.15722	2.26384	1.0695
7573.7	0.09384	2.43260	0.16898	2.26362	1.0747
T = 1880.37°F					
0	0	2.50145	0.082054	2.41940	1.0339
798.23	0.01047	2.51192	0.09129	2.42063	1.0377
1643.9	0.02074	2.52219	0.10053	2.42166	1.0415
3592.7	0.04015	2.54160	0.11852	2.42308	1.0489
7086.6	0.05357	2.56502	0.14131	2.42371	1.0583
9408.1	0.07408	2.57553	0.15196	2.42358	1.0627

TABLE VI

Data Read from Graph of C_p/C_v for Ethylene versus Pressure with Temperature Parameters

Pressure psia	Temperature, °F 32	104	212	302	392
0	1.255	1.226	1.193	1.174	1.158
250	1.460	1.325	1.240	1.201	1.176
500	--	1.492	1.297	1.233	1.196
750	--	1.840	1.373	1.271	1.219
1000	--	--	1.473	1.315	1.243
1250	--	--	1.594	1.364	1.267
1500	--	--	1.739	1.416	1.297
1750	--	--	--	1.470	1.324
2000	--	--	--	1.521	1.352
2500	--	--	--	--	1.397
3000	--	--	--	--	1.431
4000	--	--	--	--	1.471
5000	--	--	--	--	1.472
6000	--	--	--	--	1.472
7000	--	--	--	--	--
8000	--	--	--	--	--
9000	--	--	--	--	--
10,000	--	--	--	--	--

TABLE VI (continued)

Pressure psia	Temperature, °F 482	572	752	932	1112
0	1.146	1.136	1.122	1.111	1.104
250	1.159	1.146	1.127	1.115	1.107
500	1.172	1.156	1.132	1.119	1.110
750	1.188	1.166	1.138	1.123	1.113
1000	1.203	1.177	1.144	1.127	1.116
1250	1.219	1.188	1.151	1.131	1.118
1500	1.236	1.199	1.157	1.135	1.120
1750	1.252	1.210	1.163	1.138	1.122
2000	1.268	1.221	1.169	1.141	1.124
2500	1.298	1.242	1.180	1.148	1.128
3000	1.324	1.261	1.191	1.155	1.132
4000	1.361	1.289	1.208	1.167	1.140
5000	1.382	1.310	1.224	1.177	1.148
6000	1.387	1.323	1.235	1.187	1.156
7000	1.389	1.330	1.244	1.195	1.163
8000	--	1.333	1.251	1.201	1.168
9000	--	1.334	--	1.206	1.172
10,000	--	1.335	--	1.210	1.176

TABLE VI (continued)

Pressure psia	Temperature, °F				
	1292	1472	1652	1832	2012
0	1.098	1.093	1.090	1.087	1.084
250	1.100	1.095	1.091	1.088	1.084
500	1.102	1.096	1.092	1.088	1.085
750	1.104	1.098	1.093	1.089	1.086
1000	1.106	1.099	1.094	1.091	1.088
1250	1.108	1.101	1.095	1.091	1.088
1500	1.110	1.102	1.096	1.092	1.089
1750	1.112	1.103	1.097	1.092	1.090
2000	1.114	1.105	1.098	1.094	1.091
2500	1.117	1.108	1.101	1.095	1.092
3000	1.120	1.110	1.102	1.097	1.093
4000	1.126	1.114	1.106	1.100	1.095
5000	1.132	1.118	1.109	1.103	1.097
6000	1.137	1.122	1.112	1.106	1.099
7000	1.141	1.126	1.115	1.108	1.101
8000	1.145	1.129	1.118	1.110	1.103
9000	1.149	1.132	1.121	1.112	1.105
10,000	1.152	1.135	1.123	1.114	1.107

TABLE VII

Data Read from Graph of
C_p/C_v for n-Propane versus Pressure
with Temperature Parameters

Pressure psia	Temperature, °F 200	400	500	600	800	1000	1340
0	1.105	1.083	1.075	1.070	1.062	1.056	1.050
250	1.215	1.110	1.092	1.081	1.069	1.060	1.052
500	--	1.150	1.115	1.096	1.075	1.064	1.054
750	--	1.207	1.142	1.112	1.082	1.069	1.056
1000	--	1.284	1.174	1.129	1.090	1.073	1.058
1250	--	1.368	1.212	1.149	1.099	1.078	1.060
1500	--	1.440	1.256	1.168	1.108	1.082	1.062
1750	--	1.456	1.297	1.185	1.116	1.086	1.064
2000	--	1.463	1.309	1.200	1.123	1.090	1.066
2500	--	1.472	1.318	1.225	1.136	1.098	1.071
3000	--	1.475	1.320	1.239	1.145	1.105	1.074
4000	--	--	--	1.245	1.160	1.116	1.080
5000	--	--	--	1.248	1.169	1.124	1.085
6000	--	--	--	--	1.173	1.130	1.089
7000	--	--	--	--	1.176	1.133	1.092
8000	--	--	--	--	1.179	1.136	1.094
9000	--	--	--	--	1.182	1.138	1.095
10,000	--	--	--	--	1.184	1.139	1.095

TABLE VIII

Data Read from Graph of C_p/C_v for n-Butane versus Pressure with Temperature Parameters

Pressure psia	Temperature, °F 350.4	440.4	485.4	530.4	575.4	620.4	647.4
0	1.065	1.060	1.057	1.055	1.054	1.052	1.051
250	1.124	1.095	1.085	1.078	1.072	1.068	1.066
500	1.316	1.156	1.129	1.109	1.097	1.087	1.084
750	--	1.281	1.200	1.157	1.130	1.111	1.104
1000	--	--	1.303	1.220	1.171	1.140	1.129
1250	--	--	1.378	1.277	1.212	1.172	1.155
1500	--	--	--	1.312	1.245	1.199	1.177
1750	--	--	--	1.323	1.266	1.218	1.196
2000	--	--	--	--	1.272	1.230	1.208
2500	--	--	--	--	--	1.237	1.219
3000	--	--	--	--	--	1.233	--
4000	--	--	--	--	--	--	--
5000	--	--	--	--	--	--	--
6000	--	--	--	--	--	--	--
7000	--	--	--	--	--	--	--
8000	--	--	--	--	--	--	--
9000	--	--	--	--	--	--	--

TABLE VIII (continued)

Pressure psia	Temperature, °F						
	665.4	710.4	800.4	890.4	1160.4	1520.4	1680.4
0	1.050	1.049	1.047	1.045	1.040	1.036	1.034
250	1.064	1.060	1.055	1.051	1.044	1.039	1.036
500	1.081	1.073	1.066	1.058	1.047	1.041	1.037
750	1.100	1.089	1.076	1.066	1.051	1.043	1.038
1000	1.120	1.108	1.087	1.073	1.055	1.045	1.039
1250	1.144	1.125	1.098	1.081	1.059	1.046	1.040
1500	1.165	1.142	1.109	1.089	1.062	1.048	1.041
1750	1.183	1.156	1.120	1.096	1.066	1.050	1.042
2000	1.196	1.168	1.130	1.104	1.069	1.052	1.043
2500	1.208	1.183	1.145	1.116	1.076	1.055	1.045
3000	--	1.188	1.153	1.124	1.081	1.058	1.047
4000	--	--	1.163	1.136	1.090	1.064	1.050
5000	--	--	--	1.139	1.096	1.068	1.053
6000	--	--	--	--	1.099	1.071	1.055
7000	--	--	--	--	1.102	1.073	1.057
8000	--	--	--	--	--	--	1.059
9000	--	--	--	--	--	--	1.061

TABLE IX

From Data for Ethane
Reference 17

Temperature °F	Pressure psia	C_p/C_v
150	0	1.1686
	124.99	1.2026
	238.71	1.2419
	373.95	1.3052
	556.52	1.4439
	744.04	1.6927
250	0	1.1469
	147.50	1.1689
	285.75	1.1934
	456.76	1.2301
	712.32	1.3021
	989.20	1.4108
	1232.4	1.5299
	1676.3	1.7251
400	0	1.1241
	180.91	1.1372
	355.00	1.1513
	577.62	1.1716
	929.08	1.2087
	1343.6	1.2583
	1745.0	1.3083

TABLE IX (continued

Temperature °F	Pressure psia	C_p/C_v
400 (cont.)	2573.9	1.3853
	3137.0	1.4116
	4178.2	1.4220
	5436.9	1.4073
	7016.4	1.3792
	9154.4	1.3446
500	0	1.1130
	203.05	1.1229
	400.69	1.1334
	656.97	1.1484
	1070.8	1.1749
	1575.1	1.2089
	2080.8	1.2420
	3169.6	1.2951
	3928.6	1.3166
	5337.3	1.3286
	7017.6	1.3238
	9069.8	1.3090
	11757.	1.2882
600	0	1.1043
	225.13	1.1122
	446.15	1.1203
	735.75	1.1318
	1211.1	1.1518

TABLE IX (continued)

Temperature °F	Pressure psia	C_p/C_v
600 (cont.)	2413.8	1.2012
	3764.1	1.2405
	4722.0	1.2566
	6505.1	1.2702
	7395.4	1.2714
	8611.1	1.2703
	10447.	1.2627
800	0	1.0915
	269.20	1.0970
	536.67	1.1024
	892.29	1.1100
	1489.5	1.1226
	2258.5	1.1390
	3074.8	1.1533
	4950.9	1.1786
	8854.8	1.2023
	11821.	1.2069
1000	0	1.0827
	626.88	1.0897
	1048.3	1.0960
	1319.4	1.0995
	1766.0	1.1049
	2709.7	1.1160

TABLE IX (continued)

Temperature °F	Pressure psia	C_p/C_v
1000 (cont.)	3731.9	1.1264
	6135.9	1.1447
	11211.	1.1646
1400	0	1.0714
	806.90	1.0764
	1358.7	1.0793
	2322.8	1.0851
	3608.0	1.0915
	5040.8	1.0977
	8504.0	1.1093
	14262.	1.1445

TABLE X

Data Read from Graph of C_p/C_v for Ethane versus Pressure with Temperature Parameters

Pressure psia	Temperature, °F 150	250	400	500
0	1.169	1.147	1.124	1.113
250	1.243	1.187	1.142	1.126
500	1.395	1.239	1.164	1.140
750	1.683	1.310	1.189	1.155
1000	--	1.412	1.216	1.170
1250	--	1.532	1.246	1.186
1500	--	--	1.277	1.203
1750	--	--	1.311	1.220
2000	--	--	1.338	1.235
2500	--	--	1.380	1.265
3000	--	--	1.406	1.288
4000	--	--	1.421	1.316
5000	--	--	1.415	1.328
6000	--	--	1.398	1.330
7000	--	--	1.380	1.324
8000	--	--	1.363	1.317
9000	--	--	1.346	1.310
10000	--	--	1.336	1.302

TABLE X (continued)

Pressure psia	Temperature, °F 600	800	1000	1400
0	1.104	1.092	1.083	1.071
250	1.111	1.098	1.086	1.073
500	1.122	1.103	1.089	1.075
750	1.133	1.108	1.092	1.077
1000	1.144	1.113	1.095	1.079
1250	1.155	1.118	1.098	1.081
1500	1.166	1.123	1.101	1.082
1750	1.177	1.128	1.104	1.083
2000	1.187	1.133	1.107	1.084
2500	1.206	1.143	1.113	1.086
3000	1.222	1.152	1.119	1.088
4000	1.245	1.167	1.130	1.092
5000	1.260	1.179	1.139	1.096
6000	1.268	1.188	1.145	1.100
7000	1.271	1.195	1.150	1.103
8000	1.272	1.200	1.154	1.106
9000	1.272	1.203	1.157	1.109
10000	1.273	1.205	1.159	1.111

TABLE XI

Critical Constants (1)

Compound	Critical Temperature °K	°C	°R	°F
Methane	190.7	-82.5	343.3	-116.5
Ethane	305.43	32.27	549.77	90.09
Ethylene	283.06	9.90	509.51	49.82
n-Propane	369.97	96.81	665.95	206.26
n-Butane	425.17	152.01	765.31	305.62

Compound	Critical Pressure atm	lb/in^2	Critical Density gm/ml	lb/ft^3
Methane	45.80	673.1	0.162	10.1
Ethane	48.20	708.3	0.203	12.7
Ethylene	50.50	742.1	0.227	14.2
n-Propane	42.01	617.4	0.220	13.7
n-Butane	37.47	550.7	0.228	14.2

TABLE XII

Calculated Values of C_p/C_v for Methane
from Edmister Generalized Correlations (3,4,5,6)

Pressure psia	Temperature, °F 20.5	89	158	226	398
269	1.384	1.350	1.316	1.294	1.243
538	1.472	1.403	1.359	1.321	1.256
808	1.588	1.463	1.396	1.343	1.271
1077	1.742	1.533	1.429	1.372	1.283
1346	1.912	1.599	1.468	1.398	1.296
1682	2.139	1.672	1.507	1.427	1.312
2020	2.282	1.731	1.549	1.452	1.327
2690	2.088	1.828	1.614	1.499	1.360

TABLE XIII

Calculated Values of C_p/C_v for Ethylene
from Edmister Generalized Correlations (3,4,5,6)

Pressure psia	Temperature, °F						
	100	151	251	355	457	559	814
297	1.354	1.299	1.227	1.192	1.166	1.152	1.127
594	1.599	1.425	1.281	1.221	1.189	1.166	1.133
891	2.347	1.625	1.351	1.255	1.209	1.178	1.141
1188	--	1.847	1.443	1.293	1.227	1.193	1.147
1485	4.146	2.047	1.544	1.331	1.248	1.206	1.154
1855	2.329	2.356	1.678	1.374	1.269	1.222	1.161
2227	--	2.293	1.765	1.411	1.292	1.235	1.169
2970	--	1.826	1.676	1.470	1.329	1.260	1.185

TABLE XIV

Calculated Values of C_p/C_v for Ethane
from Edmister Generalized Correlations (3,4,5,6)

Pressure psia	Temperature, °F 145	200	255	310
100	1.197	1.179	1.161	1.147
200	1.233	1.203	1.176	1.159
300	1.273	1.228	1.192	1.171
400	1.327	1.259	1.209	1.185
500	1.395	1.291	1.231	1.200
750	1.759	1.411	1.293	1.241
1000	--	1.571	1.381	1.297
1500	--	1.882	1.627	1.427
2000	--	--	1.824	1.547
2500	--	--	--	1.579

TABLE XIV (continued)

Pressure psia	Temperature, °F			
	420	530	750	915
100	1.130	1.115	1.098	1.089
200	1.136	1.120	1.101	1.091
300	1.143	1.125	1.104	1.092
400	1.150	1.131	1.107	1.095
500	1.158	1.137	1.109	1.096
750	1.180	1.149	1.115	1.100
1000	1.205	1.161	1.124	1.104
1500	1.253	1.187	1.134	1.113
2000	1.298	1.211	1.150	1.121
2500	1.333	1.231	1.158	1.129

TABLE XV

Calculated Values of C_p/C_v for Propane
from Edmister Generalized Correlations (3,4,5,6)

Pressure psia	Temperature, °F 273	339	472	606	738	872	1205
247	1.152	1.127	1.096	1.081	1.072	1.066	1.056
494	1.263	1.183	1.119	1.094	1.081	1.072	1.059
740	1.605	1.273	1.150	1.109	1.090	1.077	1.062
987	3.884	1.385	1.188	1.125	1.098	1.084	1.065
1234	2.268	1.496	1.231	1.141	1.107	1.090	1.068
1542	1.678	1.590	1.286	1.160	1.116	1.096	1.071
1851	--	1.551	1.323	1.177	1.126	1.102	1.074
2468	--	1.383	1.296	1.204	1.143	1.113	1.081

TABLE XVI

Calculated Values of C_p/C_v for n-Butane
from Edmister Generalized Correlations (3,4,5,6)

Pressure psia	Temperature, °F 343.9	382.2	420.4	458.7	535.3	611.8
110.2	1.086	1.079	1.075	1.071	1.064	1.058
220.4	1.114	1.101	1.092	1.085	1.072	1.065
330.6	1.156	1.132	1.115	1.102	1.082	1.073
440.8	1.232	1.179	1.143	1.123	1.095	1.081
551.0	1.425	1.268	1.180	1.150	1.110	1.091
661.2	2.211	1.414	1.235	1.184	1.127	1.102
771.4	--	1.676	1.310	1.225	1.148	1.115
881.6	2.232	2.587	1.443	1.265	1.170	1.129
1102.0	1.578	1.859	1.580	1.347	1.224	1.157
1377.5	1.369	1.484	1.510	1.404	1.288	1.195
1653.0	--	--	1.386	1.375	1.307	1.222
2204.0	--	--	1.274	1.265	1.245	1.204

TABLE XVI (continued)

Pressure psia	Temperature, °F					
	688.4	765.0	918.1	1071.2	1224.3	1454.0
110.2	1.055	1.052	1.047	1.044	1.041	1.038
220.4	1.060	1.056	1.050	1.046	1.043	1.040
330.6	1.066	1.060	1.053	1.048	1.045	1.041
440.8	1.072	1.065	1.056	1.050	1.047	1.042
551.0	1.079	1.069	1.059	1.052	1.048	1.043
661.2	1.087	1.074	1.062	1.054	1.050	1.044
771.4	1.095	1.080	1.065	1.056	1.051	1.045
881.6	1.103	1.086	1.068	1.058	1.052	1.046
1102.0	1.120	1.097	1.074	1.063	1.055	1.048
1377.5	1.141	1.110	1.081	1.067	1.059	1.050
1653.0	1.159	1.122	1.088	1.071	1.063	1.053
2204.0	1.173	1.141	1.099	1.079	1.069	1.058

TABLE XVII

Values of C_p/C_v for Methane Based on Values of C_p Calculated from Beattie-Bridgeman Equation by Ellenwood, et.al. (13)

Pressure psia	Temp. °F	$(C_p/C_v)_{B-W-R}$	$(C_p)_{B-B}$ Btu/lb-°F	$(C_p)_{B-W-R}$ Btu/lb-°F	$(C_p/C_v)_{B-B}$
500	200	1.318	0.605	.6057	1.316
	400	1.246	0.680	.6872	1.233
	600	1.202	0.770	.7796	1.187
	800	1.175	0.865	.8693	1.169
	1000	1.156	--	--	--
1000	200	1.377	0.640	.6394	1.378
	400	1.268	0.690	.7017	1.247
	600	1.214	0.778	.7876	1.199
	800	1.182	--	--	--
	1000	1.161	--	--	--
2000	200	1.487	0.700	.6979	1.491
	400	1.308	0.715	.7260	1.288
	600	1.234	0.795	.8016	1.224
	800	1.193	0.880	.8845	1.187
	1000	1.168	0.965	.9638	1.169

TABLE XVIII

Values of C_p/C_v for Ethylene Based on Values of C_p Calculated from Beattie-Bridgeman Equation by Ellenwood, et.al. (13)

Pressure psia	Temp. °F	(C_p/C_v)B-W-R	(C_p)B-B Btu/lb-°F	(Cp)B-W-R Btu/lb-°F	(C_p/C_v)B-B
500	200	1.309	0.476	.4920	1.266
	400	1.193	0.538	.5456	1.176
	600	1.151	0.607	.6136	1.139
	800	1.129	0.670	.6758	1.120
	1000	1.115	0.727	.7301	1.110
1000	400	1.239	0.560	.5731	1.211
	600	1.170	0.620	.6261	1.159
	800	1.138	0.680	.6830	1.133
	1000	1.122	0.734	.7351	1.120
3000	400	1.419	0.655	.6696	1.388
	600	1.247	0.660	.6736	1.222
	800	1.180	0.708	.7095	1.177
	1000	1.145	0.753	.7531	1.145

TABLE XIX

Values of C_p/C_v for Methane
Based on Experimental Values
of C_p from Reference 22

Pressure psia	Temp. °F	(C_p/C_v)B-W-R	(C_p)B-S-L Btu/lb-°F	(C_p)B-W-R Btu/lb-°F	(C_p/C_v)B-S-L
500	100	1.381	0.5845	.5853	1.379
	130	1.359	0.5893	.5896	1.358
	160	1.340	0.5958	.5946	1.343
	190	1.323	0.6040	.6031	1.325
	220	1.309	0.6137	.6133	1.310
1000	100	1.491	0.6359	.6468	1.466
	130	1.451	0.6332	.6411	1.433
	160	1.416	0.6333	.6376	1.406
	190	1.386	0.6364	.6391	1.380
	220	1.360	0.6423	.6428	1.359
1500	100	--	0.6917	.7058	--
	130	--	0.6800	.6851	--
	160	1.490	0.6723	.6731	1.488
	190	1.448	0.6703	.6681	1.453
	220	1.412	0.6720	.6688	1.419

TABLE XX

Values of C_p/C_v for Ethane
Based on Experimental Values
of C_p from References 23 and 24

Pressure psia	Temp. °F	$(C_p/C_v)_{B-W-R}$	$(C_p)_{S-W-L}$ Btu/lb-°F	$(C_p)_{B-W-R}$ Btu/lb-°F	$(C_p/C_v)_{S-W-L}$
500	150	1.392	0.575	.5935	1.349
	175	1.328	0.575	.5826	1.311
	200	1.289	0.579	.5776	1.293
	225	1.260	0.588	.5772	1.282
	250	1.239	0.592	.5785	1.268

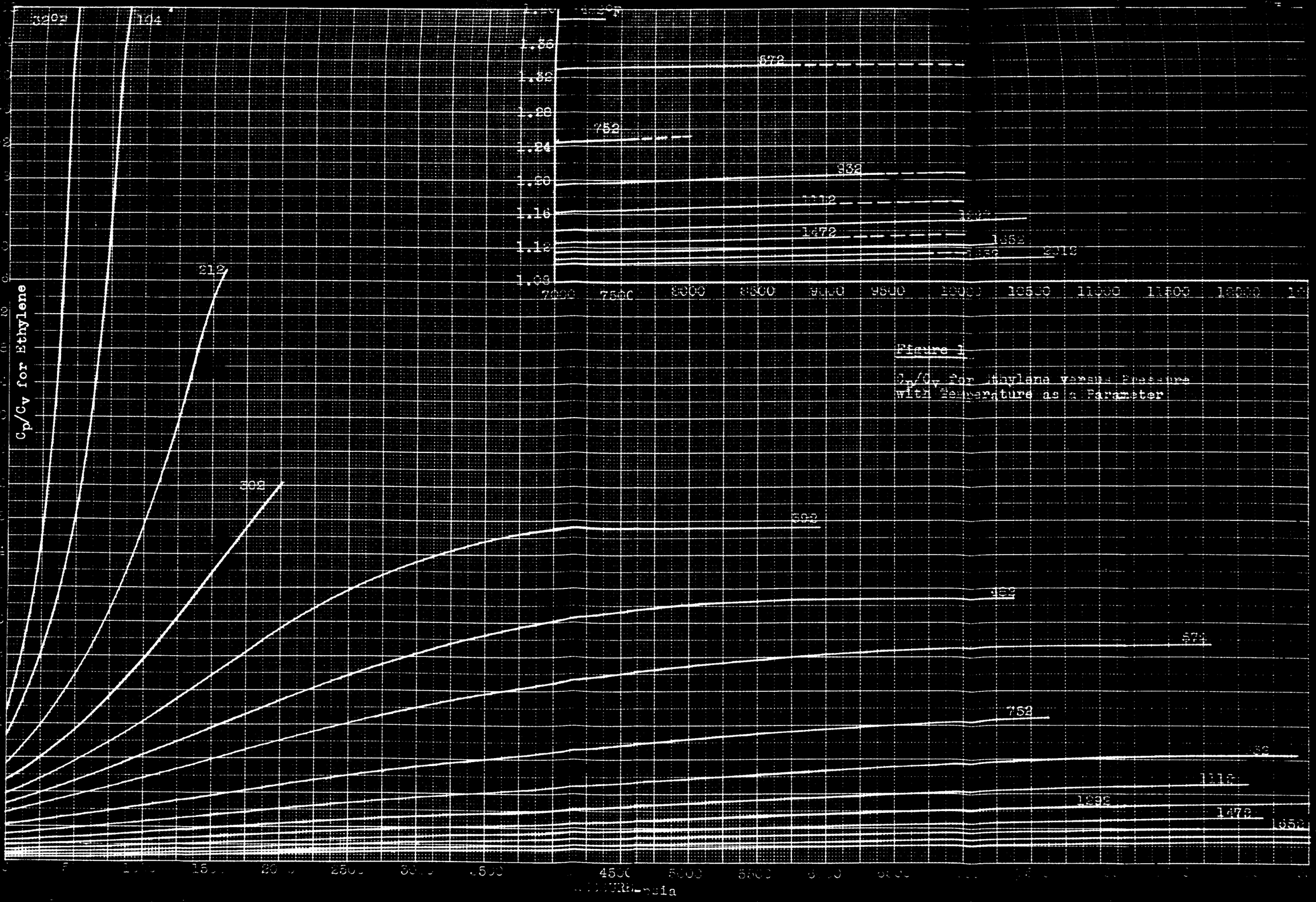


Figure 1

C_p/C_v for Ethylene versus Pressure with Temperature as a Parameter

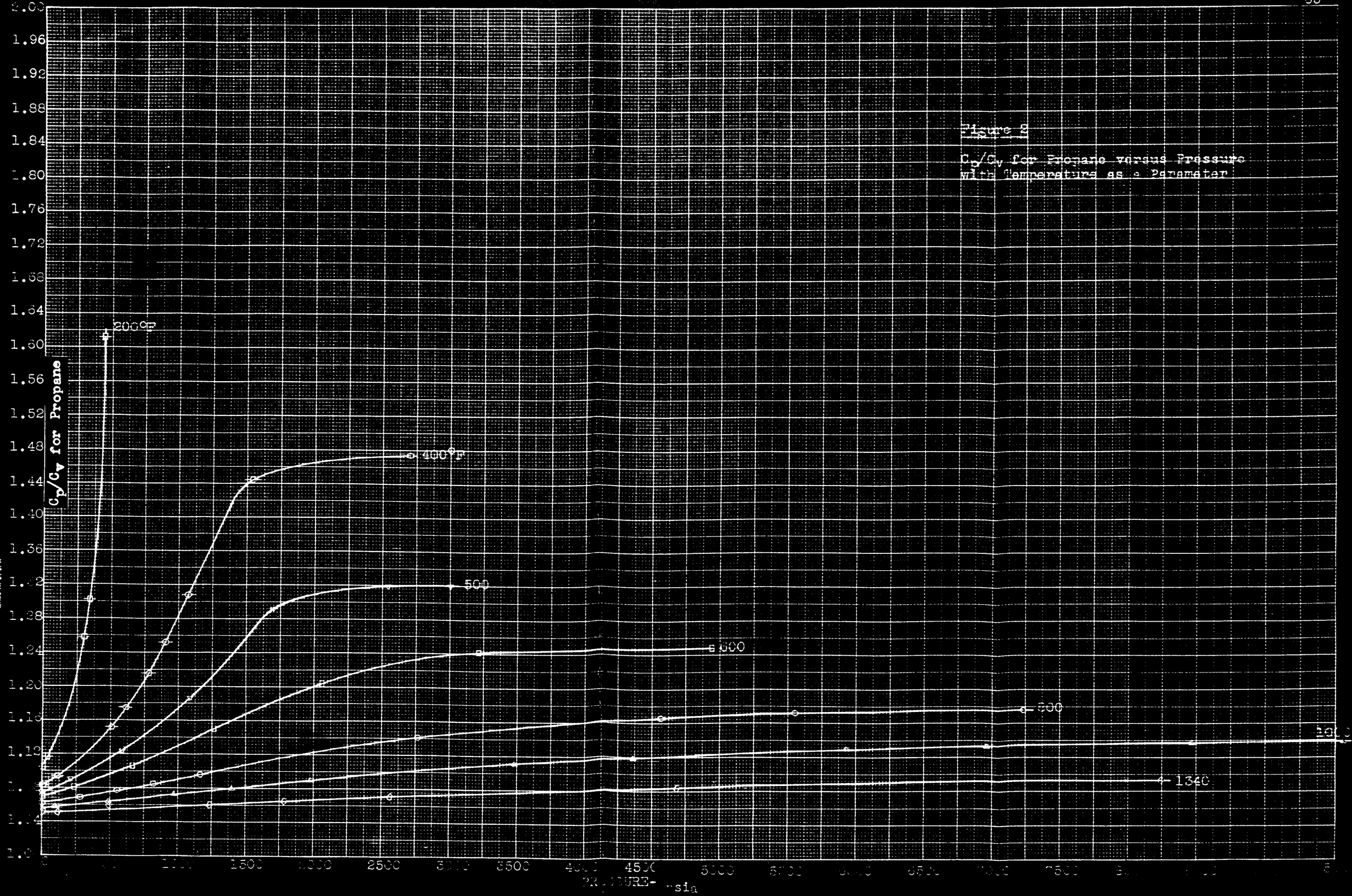


Figure 2

C_p/C_v for Propane versus Pressure with Temperature as a Parameter

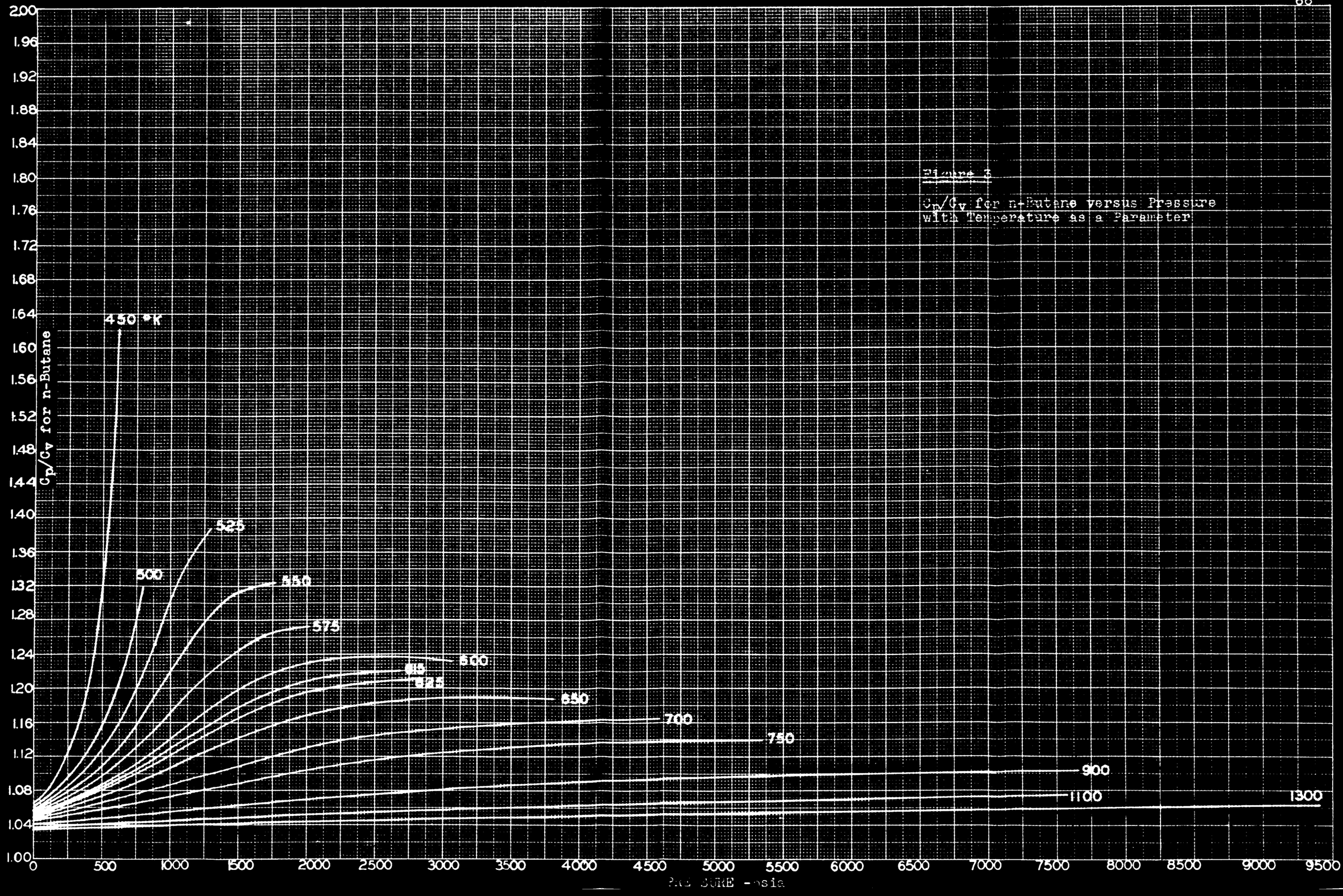


Figure 3

C_p/C_v for n-Butane versus Pressure with Temperature as a Parameter

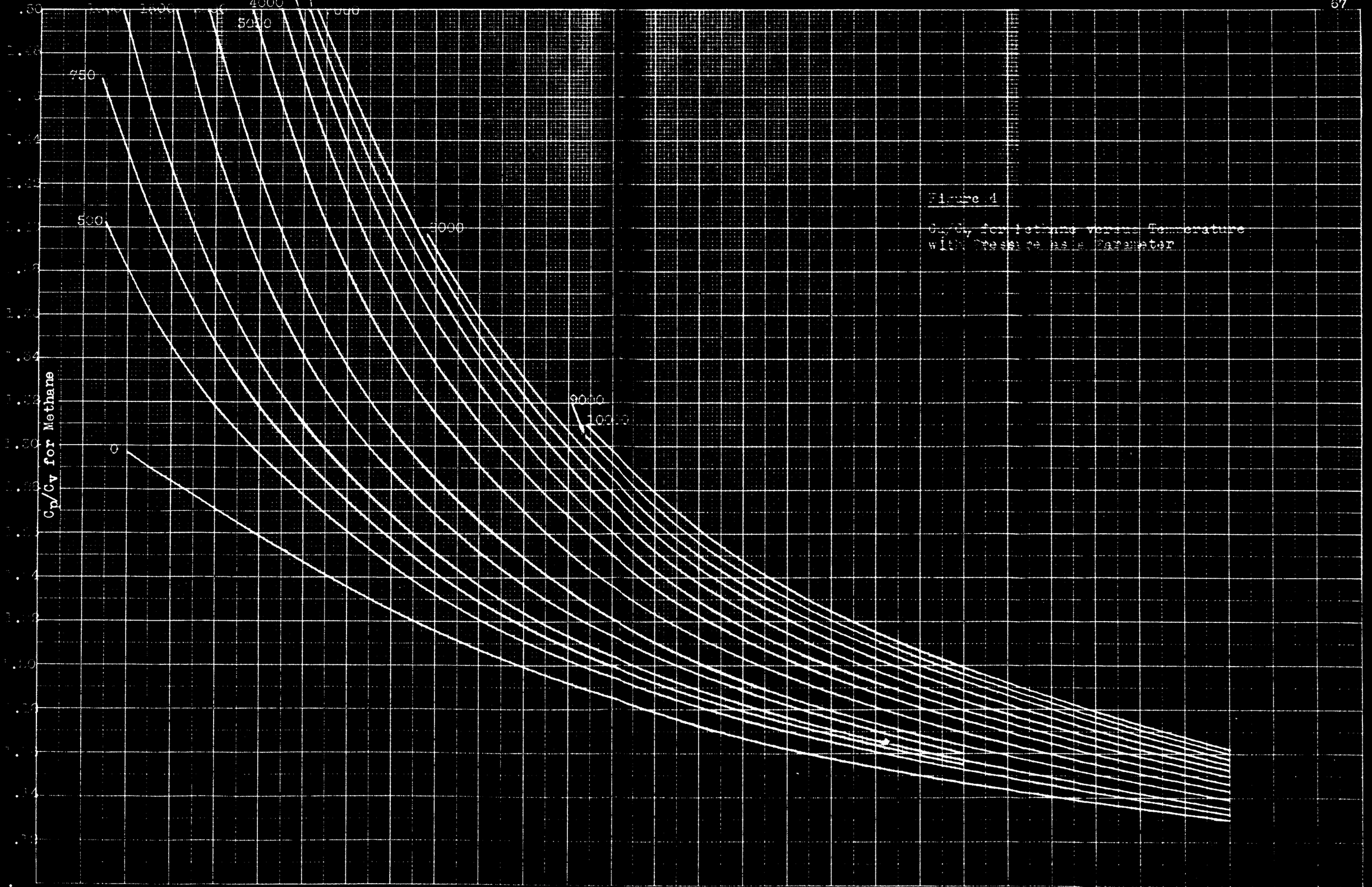


Figure 4

C_p/C_v for Methane versus Temperature
with Pressure as a Parameter

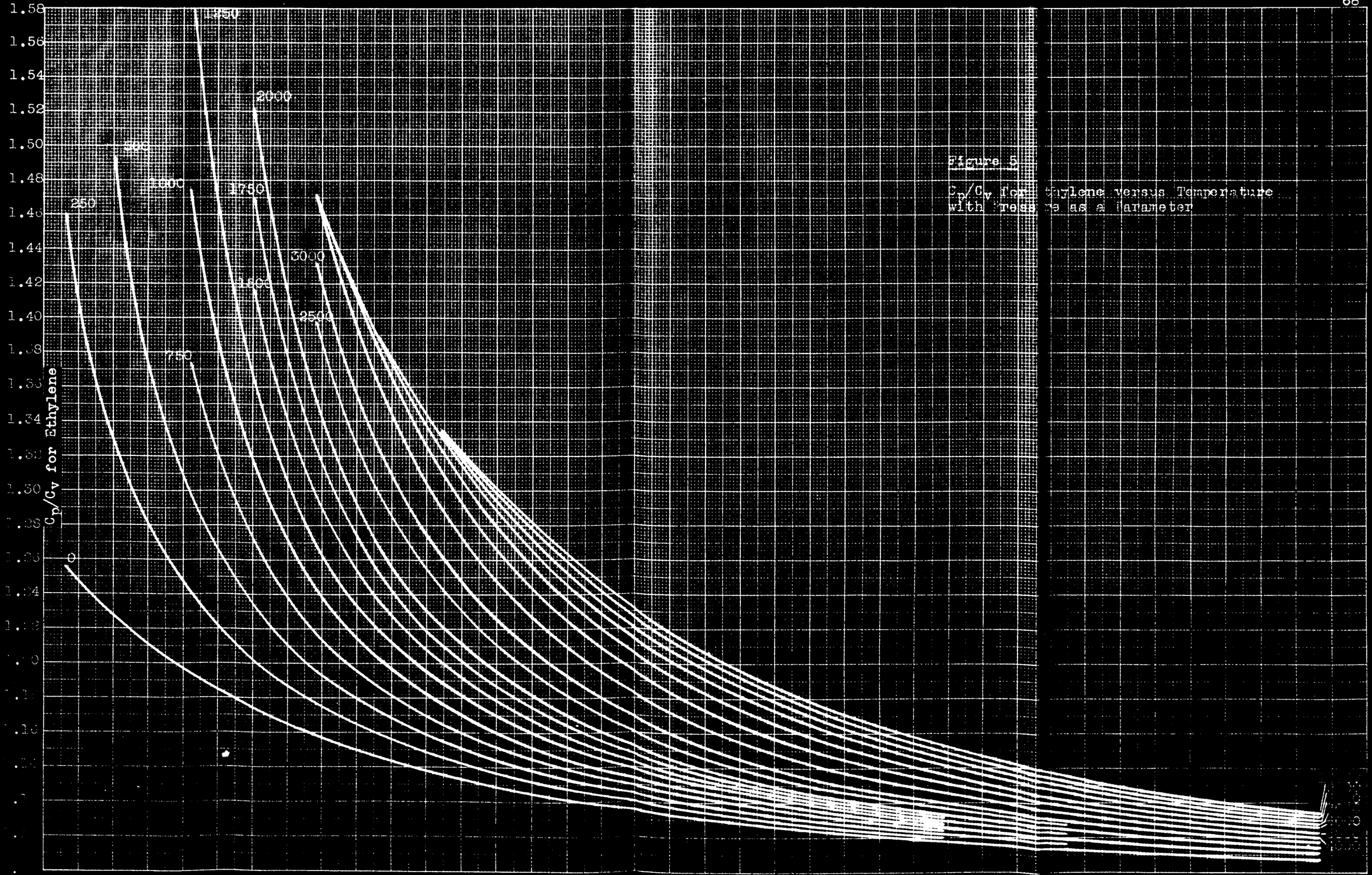
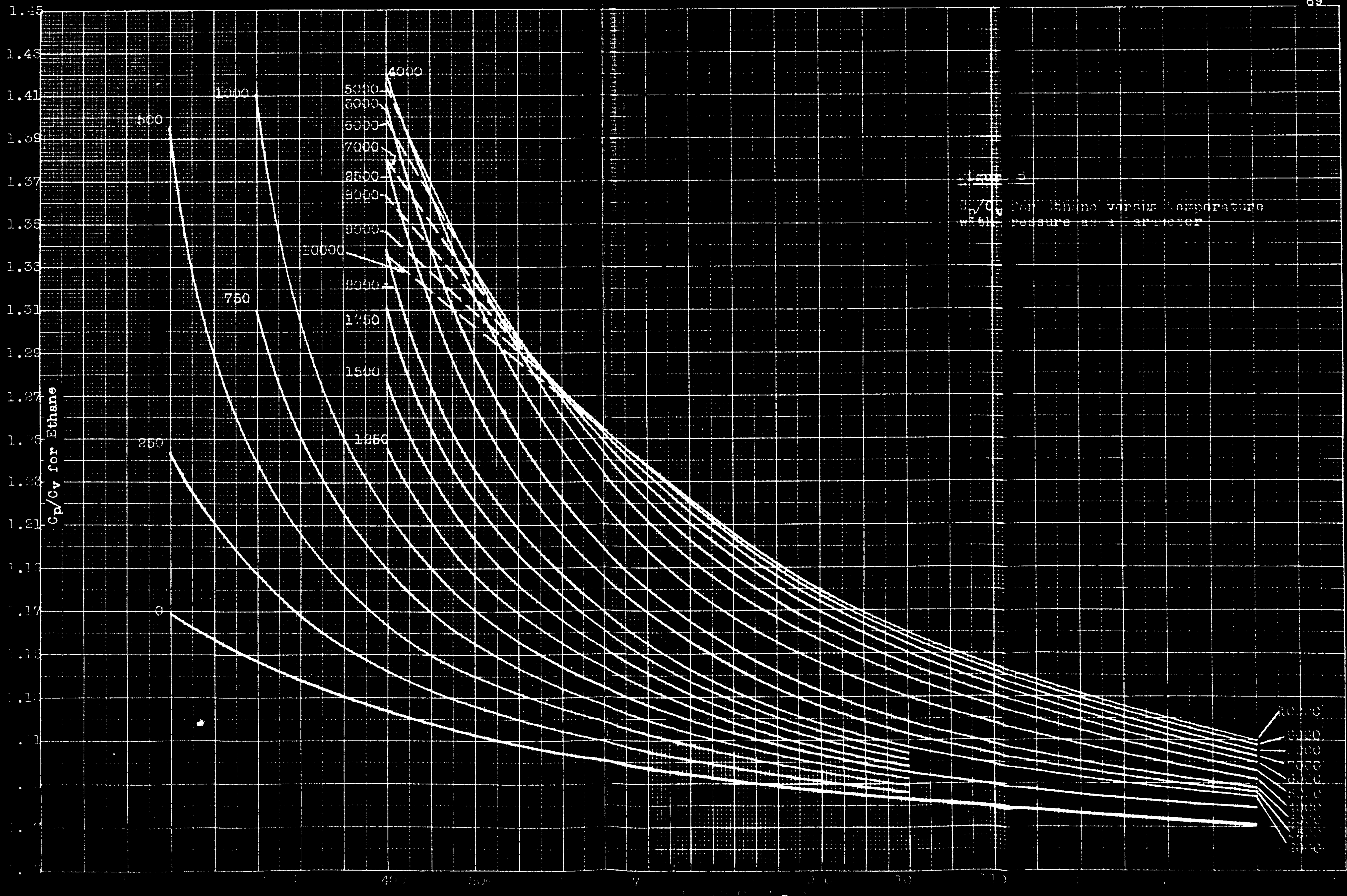


Figure 5

C_p/C_v for Ethylene versus Temperature with Pressure as a Parameter



C_p/C_v for Ethane
1.43
1.41
1.39
1.37
1.35
1.33
1.31
1.29
1.27
1.21
4000
1000
500
750
250
0
10000
1750
1500
1250

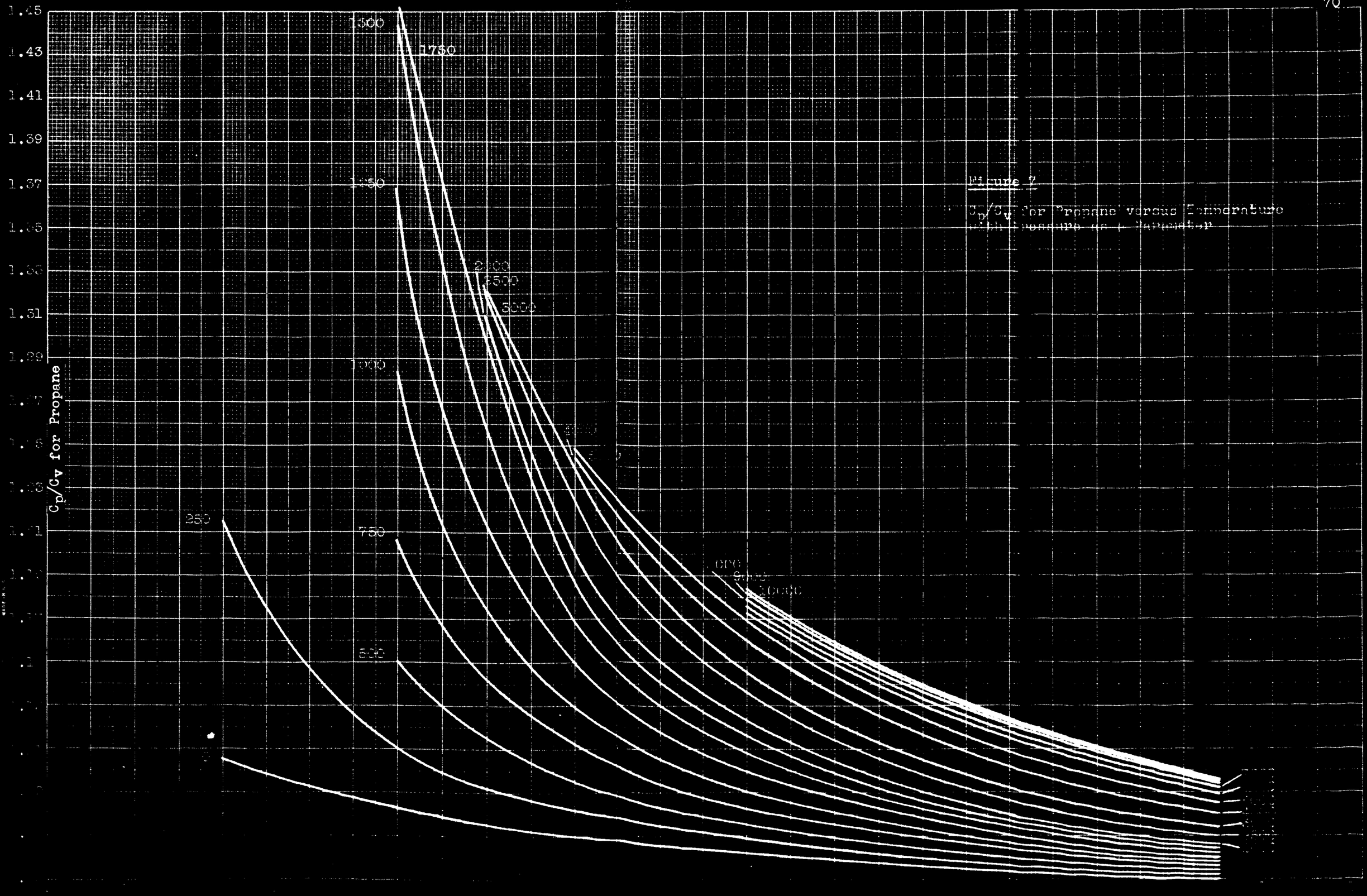


Figure 7

C_p/C_v for Propane versus Temperature
with Pressure as a Parameter

Figure 6

C_p/C_v for n-Butane versus Temperature with Pressure as a Parameter

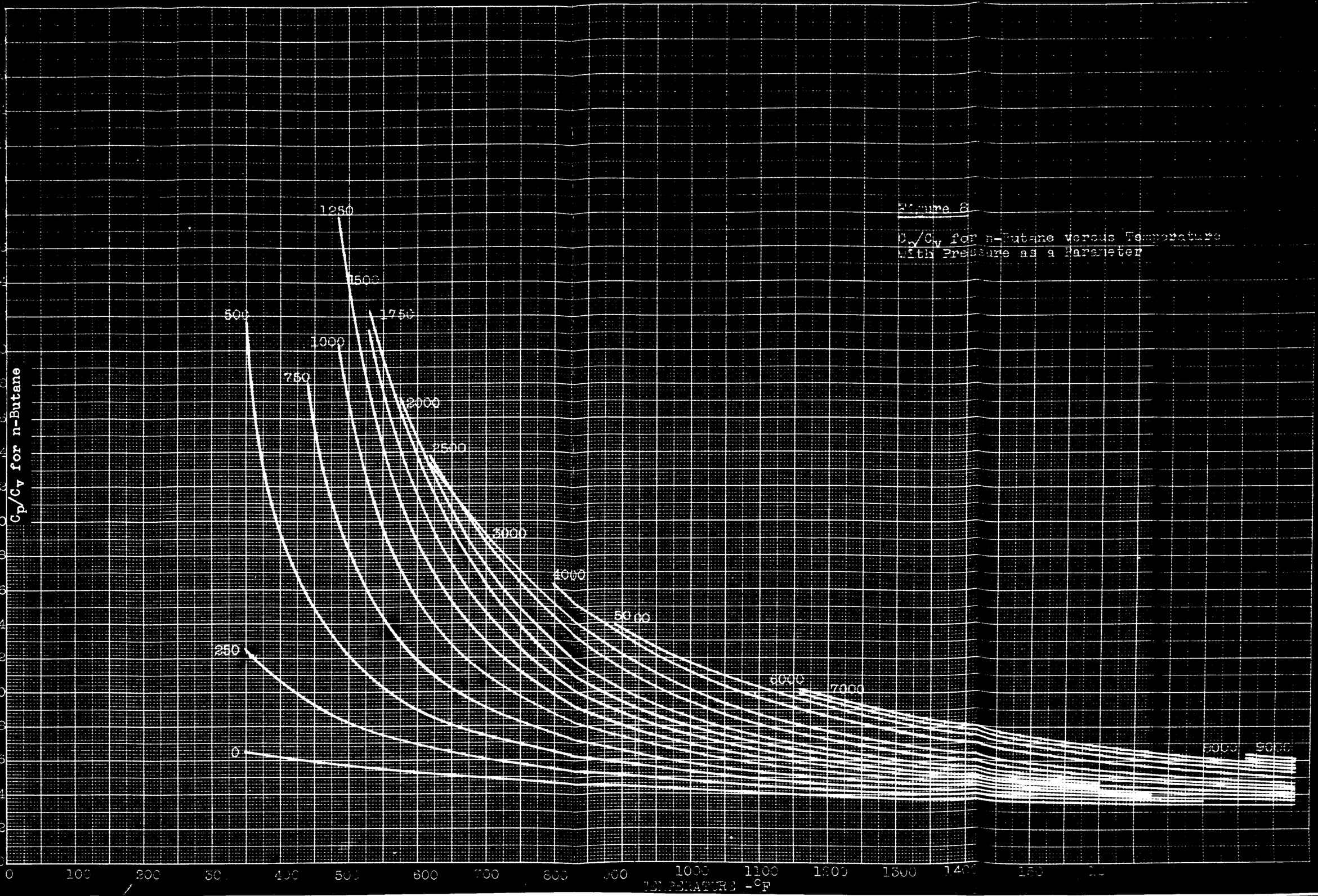


Figure 9

C_p/C_v for Methane versus Pressure with Temperature as a parameter calculated from Edmister's Generalized Correlation

20.5°F

[illegible]°F

[illegible]°F

[illegible]°F

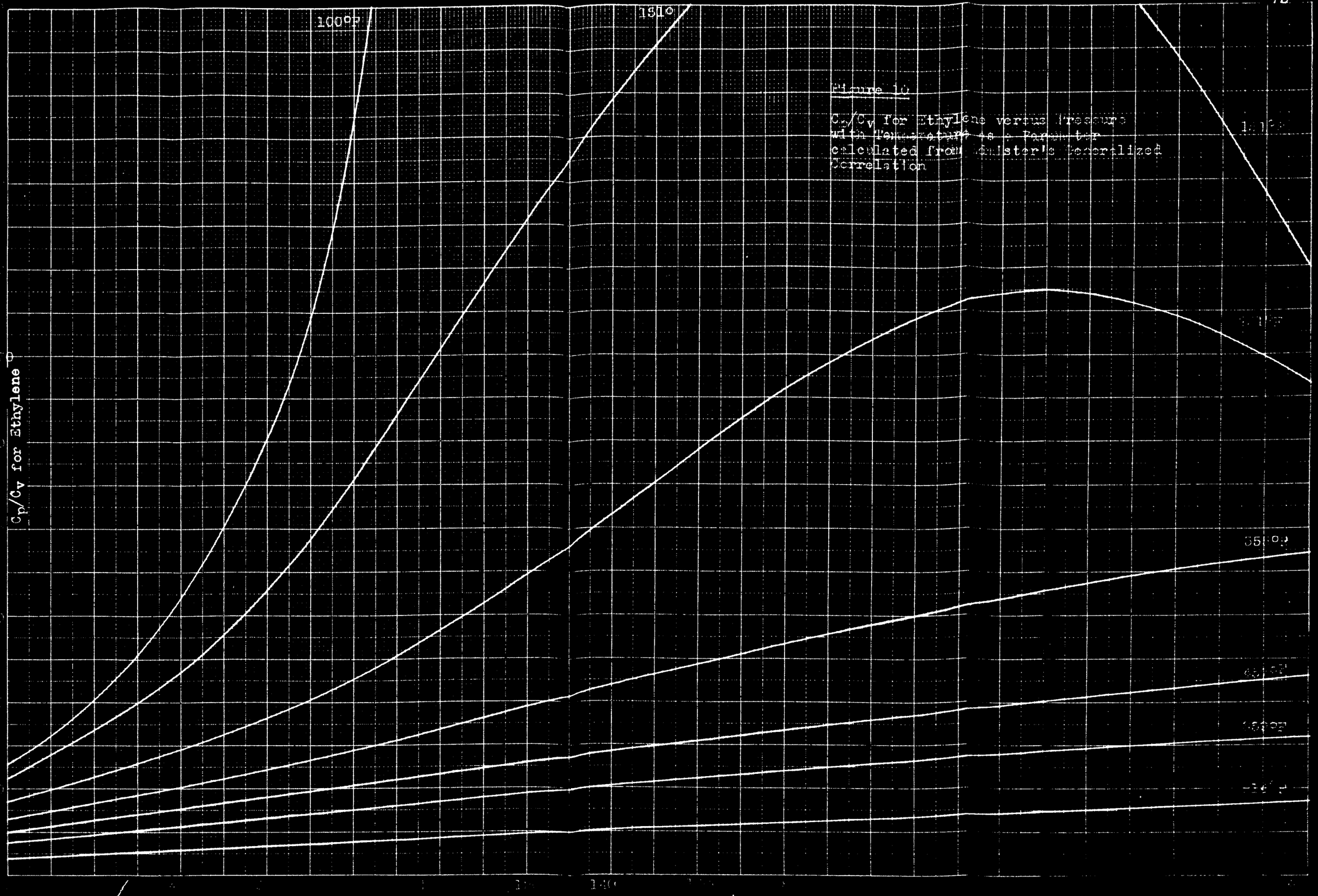


Figure 10

C_p/C_v for Ethylene versus Pressure with Temperature as a Parameter calculated from Edmister's Generalized Correlation

Figure 11.

C_p/C_v for Ethane

1650°F

850°F

530°F

410°F

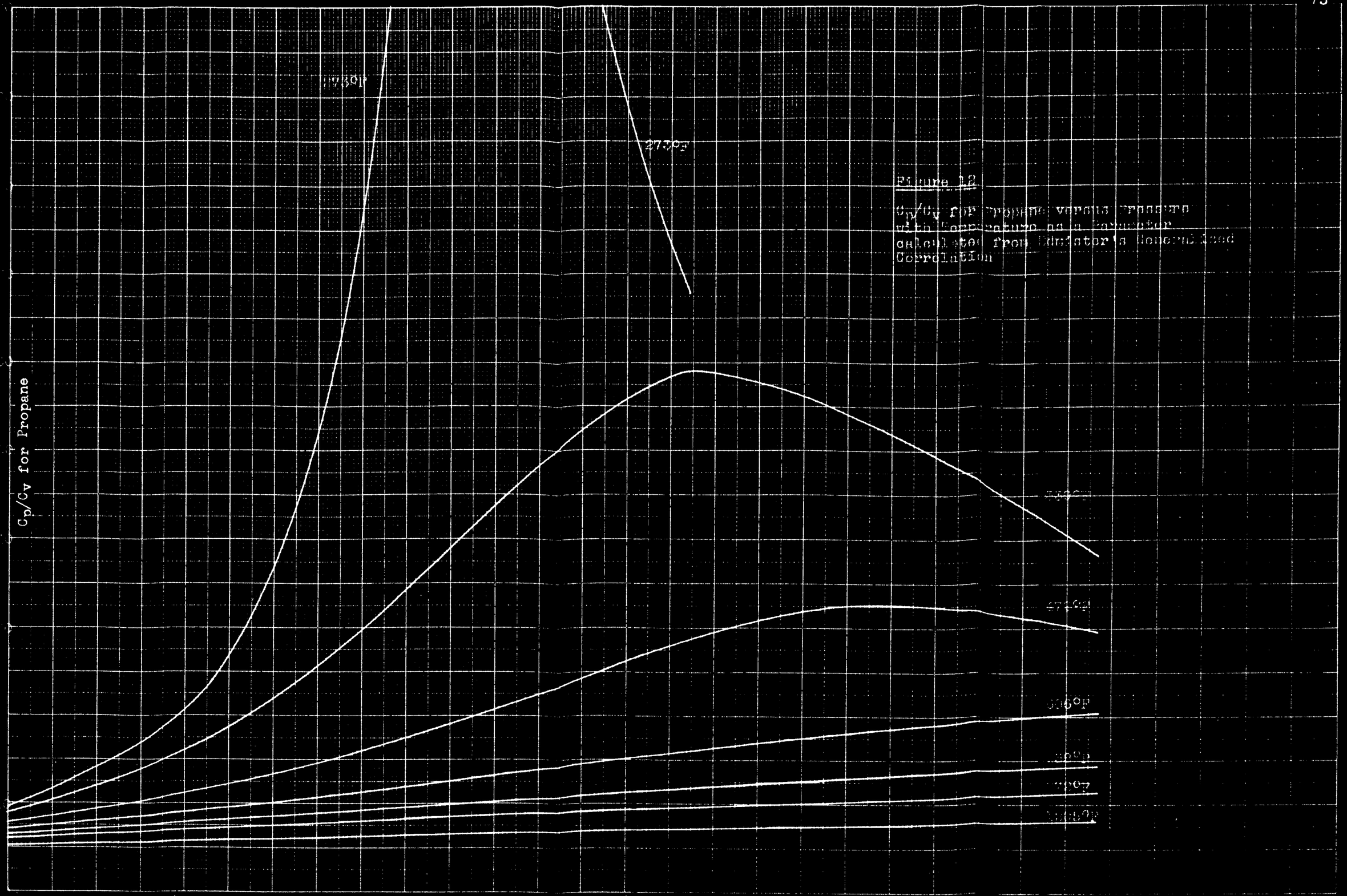


Figure 12

C_d/C_v for propane versus pressure with temperature as a parameter calculated from Edmister's Generalized Correlation

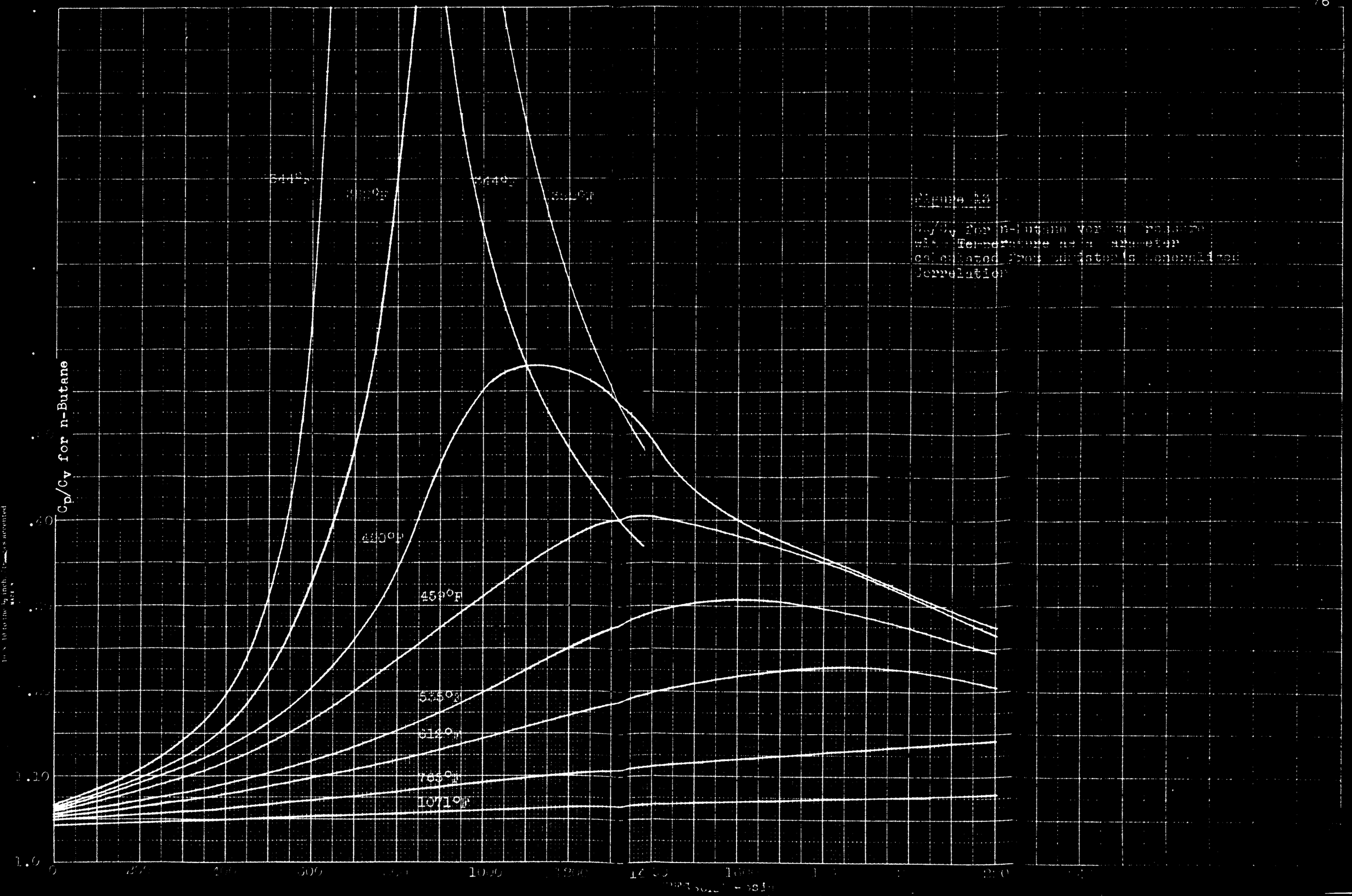


Figure 24

C_p/C_v For n-Butane Vapor at Various Temperatures as a Parameter Calculated From Virial Temperature Correlation

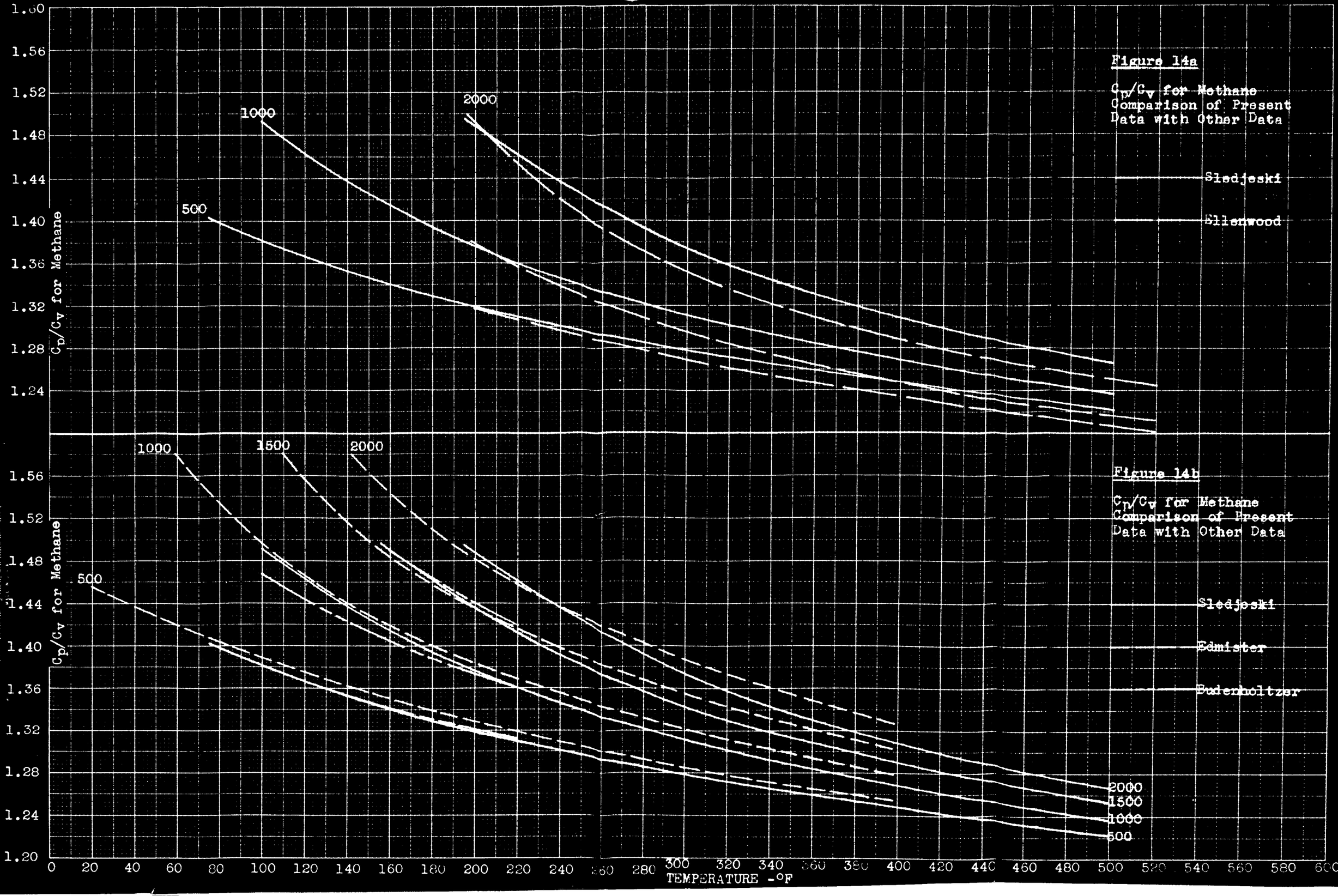

1.60
1.56
1.52
1.48
1.44
1.40
1.36
1.32
1.28
1.24
1.20
Cp/Cv for Methane
2000
1000
500
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600
TEMPERATURE -°F
Figure 14a
Cp/Cv for Methane
Comparison of Present
Data with Other Data
Sledjeski
Ellenwood
1000
1500
2000
500
Figure 14b
Cp/Cv for Methane
Comparison of Present
Data with Other Data
Sledjeski
Edmister
Budenholtzer
2000
1500
1000
500

Figure 15

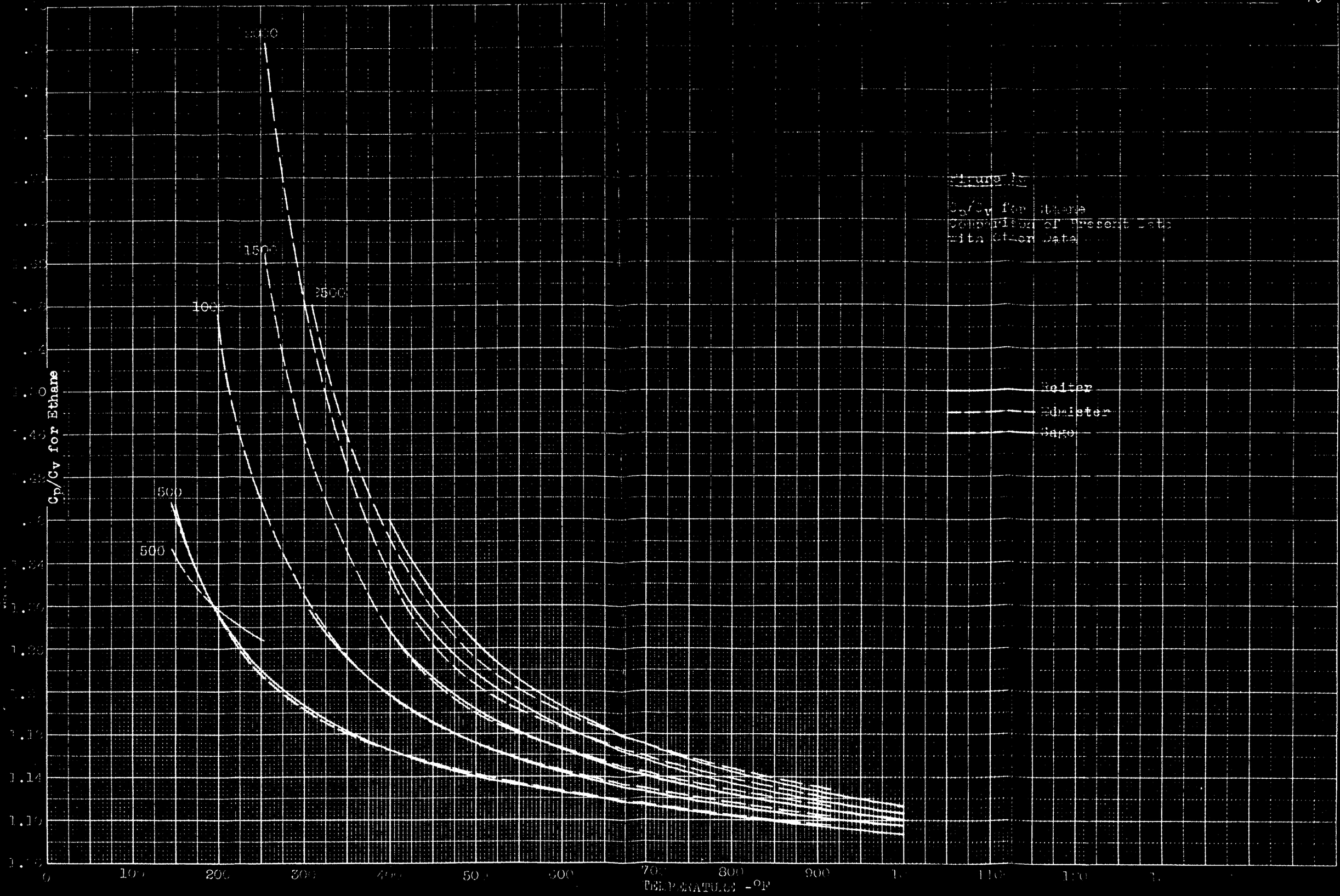
C_p/C_v for Ethylene
Comparison of Present Data
with Other Data

1000
3000
1500
500
5000
3000
500
1000

Denney
Edminster
Elsenwood

C_p/C_v for Ethylene

1.50
1.46
1.42
1.38
1.34
1.30
1.26
1.22
1.18
1.14
1.10


Cp/Cv for Ethane
1500
1000
500
500
1.40
1.30
1.20
1.14
1.10
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
TEMPERATURE - °F
Reiter
Edmister
Sage

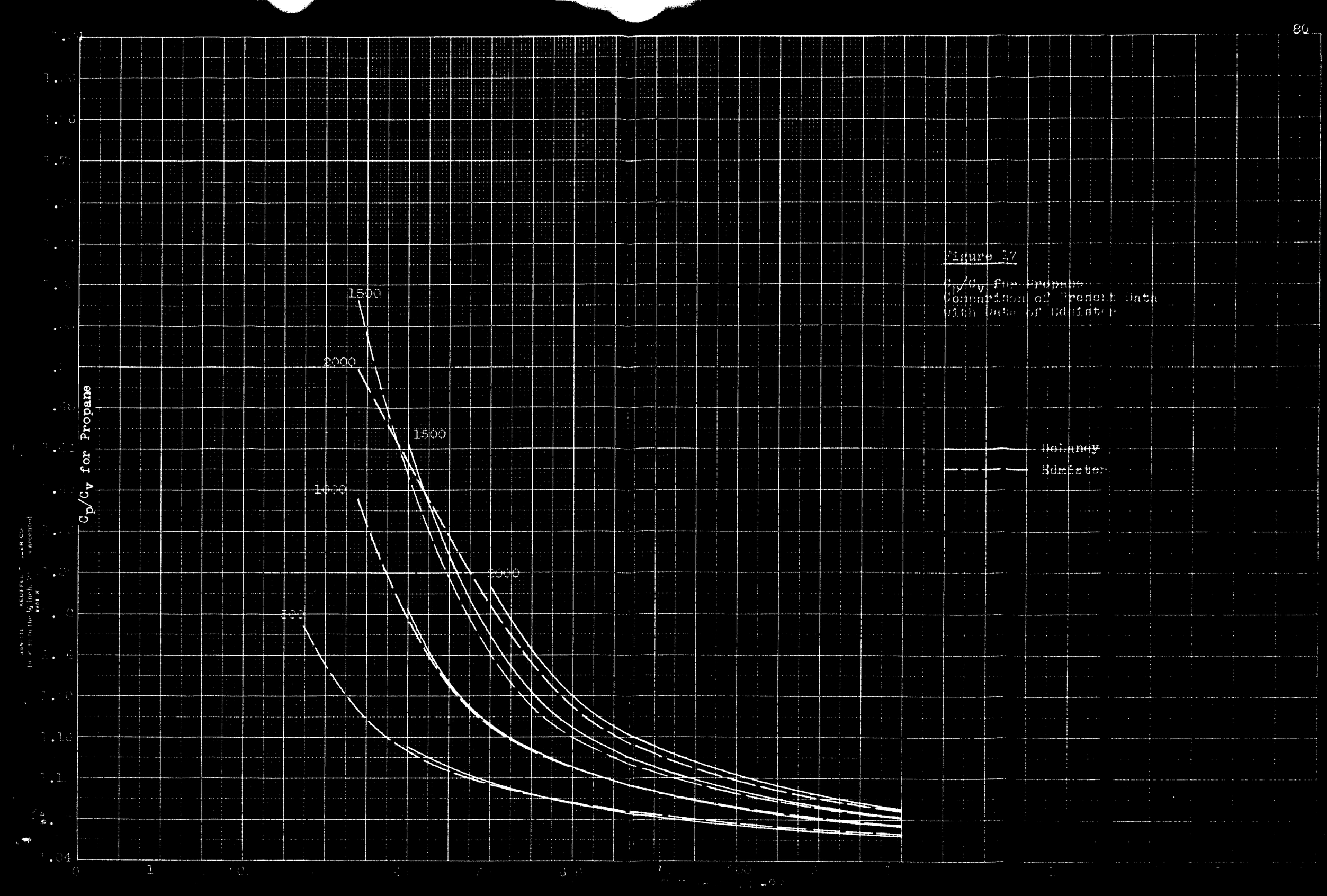
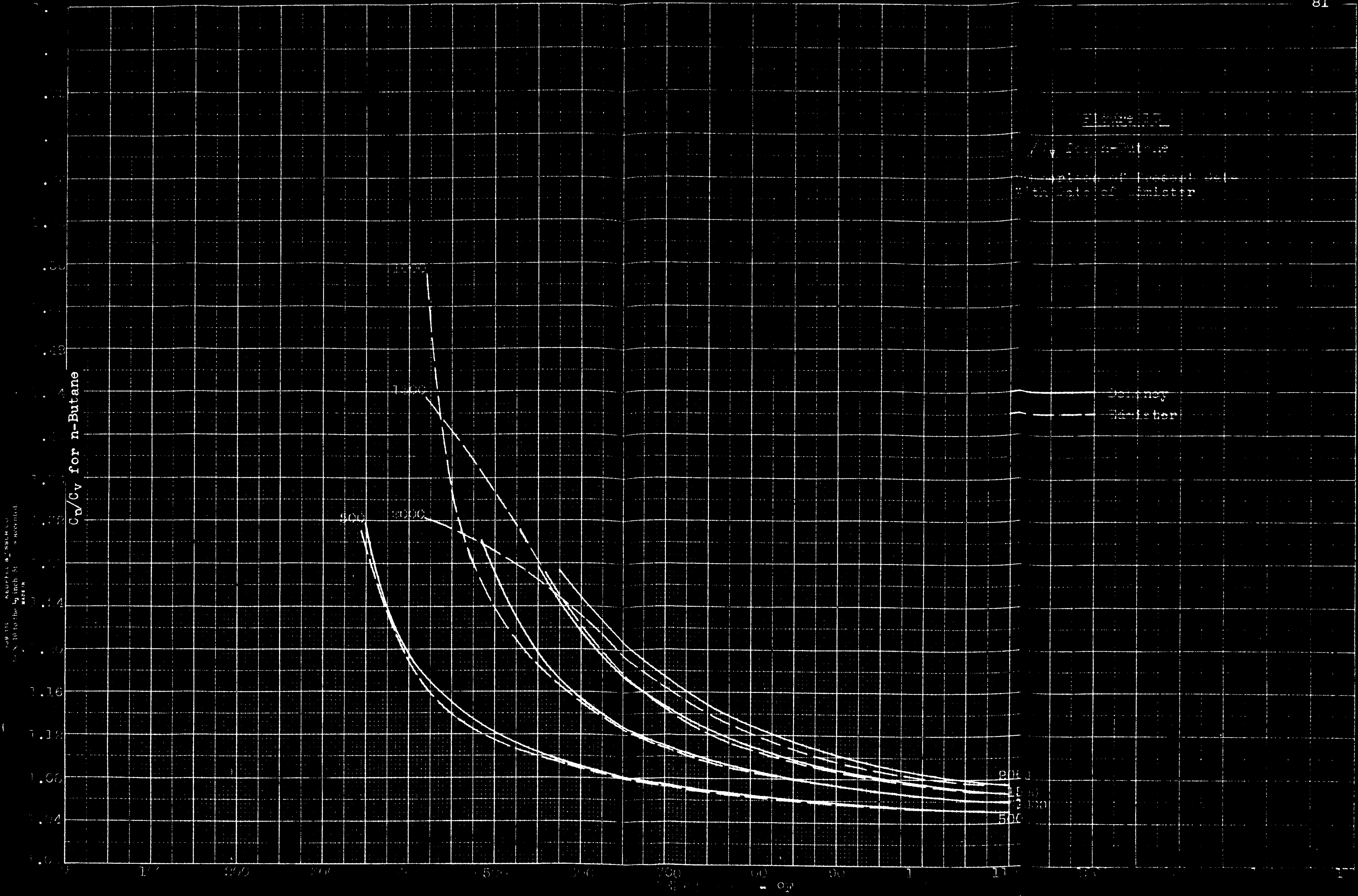


Figure 27

C_p/C_v for Propane
Comparison of Present Data
with Data of Holmatev


C_p/C_v for n-Butane
1.16
1.12
1.08
1000
1400
2000
500
Edmister