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PROVISIONAL VALUES FOR THE THERMODYNAMIC FUNCTIONS OF ETHANE

Robert D. Goodwin

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Cryogenics Division
Institute for Basic Standards
National Bureau of Standards
Boulder, Colorado 80302

June 1, 1974

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Arlington, Virginia 22209

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U.S. DEPARTMENT OF COMMERCE, Frederick B. Dent, Secretary

NATIONAL BUREAU OF STANDARDS, Richard W. Roberts, Director

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PREFACE

The Cryogenics Division of the National Bureau of Standards, with support from the American Gas Association, is engaged in a program to provide input data and computational methods for physical and thermodynamic properties of the constituents of liquefied natural gas mixtures (LNG). These thermophysical properties are the basis of all LNG technology. All operations such as liquefaction, separation, storage, pumping, transport, custodial transfer, and regasification will benefit from accurate data. As the commercial value of LNG depends on its heat of combustion, the densities of LNG mixtures and other requisite properties are important data.

The compositions of LNG mixtures vary widely, depending on the source and selective vaporization during handling. To predict properties of mixtures, it is essential to know accurately the properties of the pure components and of selected binary mixtures, so that the excess property (over the mole-fraction average of the components) can be examined.

The equation of state of pure components is an essential tool in work on mixtures because from this single formulation there can be obtained not only the density but also thermodynamic properties such as the enthalpy and specific heats at any desired temperature and pressure for which the component exists as a fluid.

A major contribution from this laboratory for computations on LNG and its components is the development of a simple, rational equation of state which originates on the liquid-vapor coexistence boundary, and gives a qualitatively correct behavior for derived specific heats, especially about the critical point. A form of this equation was used in our recently completed, comprehensive project on the major

component of LNG, namely methane, "The Thermophysical Properties of Methane from 90 to 500 K at Pressures to 700 bar." NBS Technical Note 653, April, 1974.

In addition to the above publication, this laboratory has provided accurate experimental data on the compressibilities, vapor pressures, saturated liquid densities, specific heats, sound velocities, dielectric constants, refractive indices, and viscosities of compressed and liquid methane at temperatures down to 90 K.

A similar comprehensive project on ethane now is under way. The present report makes use of available physical properties data to obtain tables of thermodynamic functions, and provides the first of such tables available for liquid ethane below its normal boiling point temperature (184.5 K). In this work we use a simplified and more highly constrained version of the equation of state formerly used for methane. Auxiliary functions also are improved to accommodate the enormous range of ethane vapor pressures and saturated vapor densities. The use of these new analytical descriptions of PVT data for ethane does not in any way invalidate the methods used to compute the thermodynamic properties of methane in NBS TN 653. The equation of state used for methane in TN 653 had nine least-squares coefficients, and thereby gives a better representation of some of the experimental PVT data than does the present, more highly constrained equation with only five such coefficients. For ethane, the present equation of state is valuable because the available PVT data are less precise (over the entire $P(\rho, T)$ surface) than those used for methane in TN 653. Further work on the equation of state has been carried out to obtain the simplest possible form, amenable to corresponding states computations on mixtures. This work, "Equation of State for Thermodynamic Properties of Fluids," was submitted to the NBS Journal of Research in October, 1974.

PROVISIONAL VALUES FOR THE THERMODYNAMIC FUNCTIONS OF ETHANE*

Robert D. Goodwin

Thermophysical properties are tabulated at integral temperatures over the entire range of fluid states from 90 to 600 K along isobars to 700 bar. A new, rational equation of state is employed for the first time. Thermodynamic functions in the compressed liquid at $T < T_c$ are obtained by use of specific heats $C_p(T)$ along a high-pressure isobar.

Key words: Densities; enthalpies, entropies; equation of state; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; specific heats; speeds of sound; vapor pressures.

1. INTRODUCTION

The economic importance of methane and ethane, as the major components of liquefied natural gas (LNG), is well known. Our objective is to produce basic thermodynamic information, needed for the prediction of properties of the constituents of liquefied natural gas mixtures. For the wide range of compositions encountered, it will be necessary to utilize accurate thermodynamic properties of the pure components.

We recently have published the properties of methane [25]. The present work on ethane provides background on available physical properties data, and may serve engineering needs for thermodynamic properties until such time as new physical data permit a revision of the tables.

* This work was carried out at the National Bureau of Standards under sponsorship of The American Gas Association.

All of the analytical formulations of physical properties data in this report are new as compared with [25]. The major contribution of present work is development of a rational equation of state. As in [25], our description of the $P(\rho, T)$ surface originates on a given liquid-vapor coexistence boundary (vapor-pressure and orthobaric densities equations). It yields a maximum in the specific heats $C_v(\rho, T)$ at the critical point, and has only five arbitrary coefficients to be found by least squares from experimental P - ρ - T data. We give constants of this equation of state both for methane and for ethane because uniform methods of computation will be helpful with mixtures.

Some recent thermal data have been especially valuable for our computation of the thermodynamic network. These are the ideal gas functions of Chao et al. [8], and the low temperature specific heats $C_p(T)$ of Furtado along isobars [20].

Symbols and units of this report, listed in Appendix A, are the same as for methane [25]. For equation of state (5) the gas constant is $R = (0.0831434) \cdot (d_t)$ bar/K, consistent with use of the dimensionless density, $\rho \equiv d/d_t$.

2. PHYSICAL PROPERTIES AND THEIR REPRESENTATION

2.1 Fixed-Point Constants

These values are listed in Appendix B. For methane, they are taken from [25].

The triple-point temperature and pressure for ethane are from our analysis of ethane vapor pressures [26]. The liquid density is a short extrapolation of the saturated liquid densities of Miller [48]. The vapor density is given by intersection of our present virial equation of state with our vapor-pressure locus [27].

The critical-point temperature and density for ethane were adjusted by examination of the critical isotherm from the present equa-

tion of state. Our value of $T_c = 305.37$ K agrees with the recent experimental observation of Strumpf et al [68-a], namely $T_c = 305.368 \pm 0.005$ K. Our critical density, $d_c = 6.74$ mol/l may be compared with 6.83 ± 0.07 mol/l from [68-a], with 6.79 ± 0.02 mol/l from [49], and with 6.87 mol/l from [14]. Critical densities reviewed in [14, 17, 70] range from 6.75 ± 0.07 to as high as 7.32 mol/l, a spread of 8%.

Our critical pressure of 48.755 bar at $T_c = 305.37$ K may be compared with other authors by use of the slope of the vapor pressure curve at the critical point, namely $dP_c/dT = 1.04$ bar/K. Most recently, for example, Douslin and Harrison [14] give $P_c = 48.718$ bar at $T_c = 305.33$ K.

The reader should note that our "critical density" is essential for the present equation of state to give a critical isotherm with no negative slopes, $(\partial P / \partial \rho)_{T_c} \geq 0$. Our procedure is an altogether new method for finding this characteristic constant, but may depend heavily on the analytical form of the equation of state used [29a]. It follows that our "critical density," d_c , should be regarded as a fitting parameter, and not necessarily as the best value for this characteristic constant.

2.2 Melting Line and Vapor Pressures

For the melting line of ethane we have found only the rough data of Clusius and Weigand to 42 bar [11]. In the Simon equation [25],

$$P = P_t + A \cdot [(T/T_t)^\epsilon - 1]$$

we assumed $\epsilon = 2$, finding $A = (1.01325) \cdot (2840.0)$ bar from their data by averaging $P / [(T/T_t)^\epsilon - 1]$.

The vapor pressure equation (2) for ethane is an extension [26] of our early form [23],

$$\ln(P/P_t) = a \cdot x + b \cdot x^2 + c \cdot x^3 + d \cdot x^4 + e \cdot x \cdot (1-x)^{3/2}, \quad (2)$$

where the argument is $x \equiv (1 - T_t/T) / (1 - T_t/T_c)$, and the coefficients are

Coefficients for Vapor Pressure Equation (2)

	<u>Methane</u>	<u>Ethane</u>
a =	4.7774 8580	10.7954 9166
b =	1.7606 5363	8.3589 9001
c =	-0.5678 8894	-3.1149 0770
d =	0.0	-0.6496 9799
e =	1.3278 6231	6.0734 9549

Table 1 for ethane compares the data.

After the present report was completed, we received the vapor pressures of Regnier [58] from 80 to 135 K. His results for the liquid were described in mm Hg by

$$\log_{10}(P) = 7.75 - 881/T.$$

The following Table 2 compares results from our present vapor pressure equation (2) with his calculated pressures. If we use the ideal gas law to obtain the vapor density, and obtain dP/dT from the above equation, the Clapeyron equation gives the heat of vaporization independent of temperature. The Clapeyron equation is -

$$Q_{\text{vap}} = T \cdot (dP/dT) \cdot (v_g - v_l).$$

From the above vapor pressure equation, $P = \exp[a - b/T]$, one obtains -
 $(dP/dT) = b \cdot P/T^2$

At low pressures, v_l is negligible relative to v_g , hence via the ideal gas law -

$$(v_g - v_l) = R \cdot T/P.$$

Introducing the last two expressions into the first yields

$$Q_{\text{vap}} = b \cdot R = 16.87 \text{ kJ/mol.}$$

The smoothed experimental value of previous workers at 100 K is $17.3 \pm 0.2 \text{ kJ/mol}$ (Table 15). Regnier's duplicate pressure gages agreed to 1% or better, but he makes no estimate of absolute accuracy.

Table 2. Comparison with vapor pressures of Regnier
(Units of bar · 10⁻³)

<u>T, K</u>	<u>This Report</u>	<u>Regnier [58]</u>
89.899	0.0101	0.0119
90	0.0104	0.0122
95	0.0363	0.0399
100	0.1110	0.1161
105	0.3025	0.3051
110	0.7463	0.7342
115	1.689	1.637
120	3.546	3.414
125	6.967	6.713
130	12.92	12.53
135	22.77	22.33

2.3 The Orthobaric Densities

For the saturated liquid and vapor densities, $\rho(T)$, we have developed analytical expressions which are constrained to any given boundaries, namely the triple and critical points [28]. In eqs (3-a) and (3-b) the basic behavior is given by $Y(\rho, T) = \text{const.}$, and polynomials on the right side are selected to describe small deviations.

a) For the saturated liquid, define the variables -

$$\begin{aligned} x(T) &\equiv (T_c - T)/(T_c - T_t), \\ y(\rho) &\equiv (\rho - \rho_c)/(\rho_t - \rho_c), \\ Y(\rho, T) &\equiv (y - x)/(x^e - x), \end{aligned}$$

when the equation is

$$Y \equiv a + b \cdot x^{2/3} + c \cdot x, \quad (3-a)$$

with the following coefficients

	<u>Methane</u>	<u>Ethane</u>
$\epsilon =$	0.36	0.33
$a =$	0.8595 3758	0.7219 0944
$b =$	0.0243 6448	0.2965 7790
$c =$	-0.0268 5285	-0.3003 6548

Table 3 compares data with (3-a).

b) For the saturated vapor, define the variables--

$$\begin{aligned}x(T) &\equiv (T_c/T - 1)/(T_c/T_t - 1), \\y(\rho) &\equiv \ln(\rho_c/\rho)/\ln(\rho_c/\rho_t), \\Y(\rho, T) &\equiv (\dot{y} - x)/(x^\epsilon - x),\end{aligned}$$

when the equation is--

$$Y = A_1 + \sum_{i=2}^5 A_i \cdot x^{i/3}, \quad (3-b)$$

with the following coefficients--

	<u>Methane</u>	<u>Ethane</u>
$\epsilon =$	0.41	0.39
$A_1 =$	0.4171 4211	0.2158 7515
$A_2 =$	-0.5194 9762	-0.0852 2342
$A_3 =$	1.2077 7553	-0.6152 3457
$A_4 =$	-1.4613 0509	0.2545 2490
$A_5 =$	0.5765 8540	0.1517 7230

The data of Table 4 are obtained from the virial and vapor pressure equations [27]. The heading PLANK/KAMB refers to [52]. The data of Table 5 for ethane are compared with (3-b).

c) For the equation of state, we use the liquid-vapor, equilibrium (saturation) temperature $T_\sigma(\rho)$ as a function of density. Densities are obtained from the following expressions for $T_\sigma(\rho)$ by iteration, using eqs (3-a) and (3-b) only to find the initial density. We shall describe $T_\sigma(\rho)$ in two parts, according as $\rho \leq \rho_c$. This simplifies the design of constraints to the boundaries (vapor and liquid triple points). At the critical point the two parts are continuous because the derivatives of all orders n , $d^n T_\sigma / d\rho^n$, from each are zero. For each range the dependent variable is

$$Y(T_\sigma(\rho)) \equiv (T_c/T_\sigma - 1)/(T_c/T_t - 1),$$

and we use the following function,

$$U(\sigma) \equiv -\gamma \cdot (1/x - 1/x_t),$$

where

$$x \equiv |\sigma - 1|, \quad x_t \equiv |\sigma_t - 1|,$$

$$\sigma \equiv d/d_c, \quad \sigma_t \equiv d_t/d_c,$$

and d_t refers to vapor or liquid at the triple point according as $\sigma \gtrless 1$.

For the liquid range at $\sigma \geq 1$ the equation is --

$$\ln(Y) = U(\sigma) + \sum_{i=1}^5 B_i \cdot (\sigma^i - \sigma_t^i). \quad (3-c)$$

For the vapor range at $\sigma \leq 1$ we need a modification for extremely low densities approaching the triple point. The form is selected for

qualitative consistency with the ideal gas law and the basic vapor pressure equation. Define--

$$W(\sigma) \equiv \ln(1+\epsilon/\sigma)/\ln(1+\epsilon/\sigma_t),$$

when the equation is--

$$\begin{aligned} \ln(Y) = & U(\sigma) + A_0 \cdot \ln[W(\sigma)] + A_1 \cdot (\sigma^{1/3} - \sigma_t^{1/3}) \\ & + A_2 \cdot (\sigma^{2/3} - \sigma_t^{2/3}) + \sum_{i=3}^7 A_i \cdot (\sigma^{i-2} - \sigma_t^{i-2}) \end{aligned} \quad (3-d)$$

The coefficients for (3-c) and (3-d) are--

Coefficients for Saturation Temperatures, Eqs. (3-c, d)

	<u>Methane</u>	<u>Ethane</u>
γ	1/2	1/2
ϵ	1/4	1/4
A_0	0.9034 9557	0.8681 0517
A_1	0.0	0.0151 6978
A_2	0.0	-0.7296 0432
A_3	-0.3834 4338	1.0096 5493
A_4	-3.9210 8638	-8.7340 2710
A_5	6.2600 3837	21.1071 2823
A_6	-9.3296 0083	-31.4499 4087
A_7	5.6060 2816	17.8637 0397
B_1	11.4317 7230	23.7245 1840
B_2	-3.8765 9480	-14.8860 5161
B_3	0.5378 8326	5.4317 7443
B_4	0.0	-1.0715 0566
B_5	0.0	0.0913 5183

For ethane the liquid saturation temperatures appear in Table 6, and the vapor temperatures in Table 7. Densities of the freezing liquid are obtained by use of the equation of state in present work.

2.4 The Virial Equation

For the virial equation of state,

$$Pv/RT = 1 + B(T) \cdot \sigma + C(T) \cdot \sigma^2 + \dots, \quad (4)$$

the second and third coefficients $B(T)$, $C(T)$ are dimensionless. We reduce temperature and density of the critical point, $x \equiv T/T_c$, $\sigma \equiv d/d_c$. Following initial research on the representation of these coefficients [27], we now have adopted McGlashan's formula for $B(T)$,

$$B(T) = B_1 + B_2/x + B_3/x^2 + B_4/x^{4.5} \quad (4-a)$$

$$B_1 = 0.552\ 671, \quad B_3 = -0.592\ 947,$$

$$B_2 = -1.106\ 244, \quad B_4 = -0.041\ 944.$$

These constants were obtained with our values for ρ_c , T_c . Data from McGlashan were increased by 0.5 percent in absolute value to improve consistency with the data of Michels and of Douslin near 300 K.

Table 8 compares data and calculated values.

For $C(T)$ our new representation from [27] is,

$$C(T) = \left[C_1/x + C_2/x^3 + C_3/x^5 \right] \cdot (1 - T_o/T), \quad (4-b)$$

$$T_o = 217.8\ \text{K}, \quad C_2 = 0.83253,$$

$$C_1 = 0.24423, \quad C_3 = 0.53488,$$

using critical constants of the present report. Table 9 compares data and calculated values.

Table 10. Summary of P- ρ -T Data

<u>ID</u>	<u>Authors</u>	<u>Range of the Variables</u>				<u>Deviations, %</u>	
		<u>mol/l</u>	<u>T, K</u>	<u>P, bar</u>	<u>N</u>	<u>$\Delta d/d$</u>	<u>$\Delta P/P$</u>
2	Virial equation	0.4 --	230 - 600	7 - 20	38	0.04	0.03
8	Reamer et al.	[57] 0 - 15	310 - 510	50 - 700	176	0.61	1.22
9	Michels et al.	[47] 0.9 - 8	273 - 423	15 - 220	101	0.35	0.14
10	Douslin et al.	[14] 0.7 - 16	248 - 623	12 - 410	298	0.40	0.26
100 ⁺	A. K. Pal	[54] 14 - 19	157 - 320	19 - 700	125	0.08	1.85

2.5 The Equation of State

Data reproduced in the present report are summarized by Table 10. The locus of recent data is shown by Figure 1. From the data of A. K. Pal we selected only twelve isochores at the highest densities, runs Nos. 13 through 24 of Table 12, because they were found to be self-consistent. An increase of all densities by 0.5 percent than made these PVT data compatible with data of other authors (Table 10) via our equation of state. We finally used adjusted data of A. K. Pal kindly provided by Professor R. Kobayashi, J. R. Ely, et al of the Chemical Engineering Department, Rice University. We omitted the data of Reamer et al because those of Douslin and Harrison are believed to be more accurate.

For background on this equation of state, the reader may refer to our work on methane [25]. We consider density to be a parameter in the description of P(T) isochores, Figure 2. (In Figure 3 we show the well-known zero slope and curvature of the critical isotherm.) For any density we obtain the liquid-vapor coexistence temperature from our function for $T_{\sigma}(\rho)$, eqs (3-c, 3-d). Placing this in the vapor pressure equation gives the coexistence pressure. The equation of state thus is defined as a function of density on the coexistence boundary. By subtraction we shift the origin to this boundary. Define the variables--

$$x(T) \equiv T/T_c, \quad x_{\sigma}(\rho) \equiv T_{\sigma}(\rho)/T_c$$

$$Y(P, \rho, T) \equiv (Z-1) \cdot x / \rho, \quad Y_{\sigma}(\rho) \equiv (Z_{\sigma}-1) \cdot x_{\sigma} / \rho,$$

when the equation of state is--

$$(Y - Y_{\sigma}) = B(\rho) \cdot \Phi(\rho, T) + C(\rho) \cdot \Psi(\rho, T) \quad (5)$$

where $B(\rho)$, $C(\rho)$ are polynomial coefficients to be found by least squares, and the temperature-dependent functions are

$$\Phi(\rho, T) \equiv x^{1/2} \cdot \ln[T/T_\sigma(\rho)], \quad (5-a)$$

$$\Psi(\rho, T) \equiv [1-w \cdot \ln(1+1/w)]/x - [1-w_\sigma \cdot \ln(1+1/w_\sigma)]/x_\sigma. \quad (5-b)$$

Each of these functions is zero on the coexistence boundary at $T = T_\sigma(\rho)$. The second gives nonanalytic behavior for $C_v(\rho, T)$ about the critical point by use of the variables,

$$w(\rho, T) \equiv \delta \cdot [T/\theta(\rho) - 1], \quad w_\sigma(\rho) \equiv \delta \cdot [T_\sigma(\rho)/\theta(\rho) - 1],$$

where δ is an adjustable constant and $\theta(\rho)$ is our locus of temperatures inside the coexistence envelope, Figure 4,

$$\theta(\rho) \equiv T_\sigma(\rho) \cdot \exp\left[-\alpha \cdot |\sigma - 1|^3 / (\sigma_t - 1)^3\right]. \quad (5-c)$$

In the above, $\sigma_t = d_t/d_c$ for liquid at the triple point. Figures 5 and 6 show behavior of the functions $\Phi(\rho, T)$ and $\Psi(\rho, T)$.

The coefficients of (5) are--

$$B(\rho) \equiv B_o + B_1 \cdot \rho + B_2 \cdot \rho^2 / (1 + b \cdot \rho^2), \quad (5-d)$$

$$C(\rho) \equiv (\sigma - 1) \cdot (\sigma - C_o) \cdot (C_1 + C_2 \cdot \rho), \quad (5-e)$$

and the constants are--

Constants for Equation of State (5)

	<u>Methane</u>	<u>Ethane</u>
$\alpha =$	2	2
$b =$	1	1
$\delta =$	1/2	1/2
$B_0 =$	1.5082 12989	1.8481 67996
$B_1 =$	0.6544 90304	1.5697 04511
$B_2 =$	4.1320 82291	5.5601 86452
$C_0 =$	1.90	1.90
$C_1 =$	-0.7654 09076	-1.0428 42462
$C_2 =$	-0.0590 88717	+0.2249 78299

Behavior of $B(\rho)$ and $C(\rho)$ for ethane is given by Table 11. For methane the behavior is shown by Figure 7. Figure 8 shows the presumed behavior of $C(\rho)$ for hydrogen, discussed in Appendix C. Deviations of experimental data for ethane appear in Table 12. Appendix C explains the rationale of this equation of state.

2.6 The Ideal Gas Functions

For use in our computations we have represented the internal energies of Chao et al. [8], by the following empirical power series--

$$(E^o - E_o^o)/RT = 3.0 + \sum_{i=1}^9 A_i \cdot (T/100)^{(i+3)/3}, \quad (6)$$

with coefficients

$A_0 =$	21.705 718	$A_5 =$	906.218 4427
$A_1 =$	65.498 641	$A_6 =$	-459.230 2545
$A_2 =$	-362.011 5914	$A_7 =$	143.030 0226
$A_3 =$	853.340 8616	$A_8 =$	-25.074 95605
$A_4 =$	-1123.601 6220	$A_9 =$	1.897 540044

The specific heats are obtained by differentiation,

$$C_v^0(T) = dE^0/dT,$$

and the entropies by integration of C_v^0 ,

$$\Delta S^0 = \int C_v^0 \cdot dT/T$$

The dimensionless integration constant for S^0/R is the value A_0 tabulated above. The concise computations are given by computer subroutine IDEAL, below. Table 13 gives the comparisons, and Table 14 gives values interpolated by means of (6).

We have compared the results of Chao et al [8] with those obtained earlier by Ziegler et al [77]. At temperature, 200 K, (values in Joules, moles, kelvins)-

	$\underline{H^0 - H_0^0}$	$\underline{S^0}$	$\underline{C_p^0}$
Ziegler et al [77]	7281.4	210.72	42.45
Chao et al [8],	7257.6	210.50	42.26

We see a difference of 24 Joules in $(H^0 - H_0^0)$, or 0.3 percent. We have not further compared these independent calculations.

2.7 The Heats of Vaporization

The data of Table 15 are represented as follows,

$$Q_{\text{vap}} = \sum_{i=1}^6 A_i \cdot x^{i/3}, \text{ kJ/mol,} \quad (7)$$

where the argument is $x(T) \equiv (T_c - T)/(T_c - T_t)$

$$T_t = 89.899 \text{ K}$$

$$T_c = 305.37 \text{ K}$$

$$A_1 = 12.102 \ 730$$

$$A_4 = -71.854 \ 695$$

$$A_2 = 11.165 \ 588$$

$$A_5 = 82.166 \ 239$$

$$A_3 = 16.539 \ 265$$

$$A_6 = -32.610 \ 514$$

Comparisons are given in Table 15.

2.8 Specific Heats for Saturated Liquid

Data shown in Table 16 have been represented in J/mol/K with a minimum of arbitrary constants as follows by use of the argument, $x \equiv T/T_c$, ($T_c = 305.37 \text{ K}$) -

$$C_{\sigma}(T) = a + b \cdot x + c \cdot x/(1-x)^{\epsilon}, \text{ J/mol/K,} \quad (8)$$

with these constants,

$$\epsilon = 0.5$$

$$b = -16.5876$$

$$a = 67.3153$$

$$c = 16.3526$$

The form of (8) permits integration,

$$\Delta S_{\sigma} = \int C_{\sigma} \cdot dx/x,$$

giving results in closed form. Comparisons are given in Table 16.

2.9 Specific Heats $C_p(T)$ along Isobar P_b

In our computations of the thermodynamic functions we have entered the compressed liquid region at $T < 340 \text{ K}$ by use of specific heats $C_p(T)$ kindly provided by André Furtado, as obtained with the flow calorimeter at the University of Michigan [20].

Data shown in Table 17 for the isobar at $P_b = 137.895 \text{ bar}$ are represented by use of the argument,

$$x(T) \equiv (T - T_t)/(T_m - T_t),$$

as follows in J/mol/K,

$$C_p(T) = k \cdot [C_m \cdot \exp(Y)] , \quad \text{J/mol/K}, \quad (9)$$

where

$$Y \equiv A_1 + A_2 \cdot x^2/(1-x) + A_3 \cdot x^2 + A_4 \cdot x^3 + A_5 \cdot x^4 ,$$

with constants $T_t = 89.899 \text{ K}$, and--

$$\begin{array}{ll} T_m = 354.0 \text{ K} & A_2 = -0.154 \ 423 \\ C_m = 62.60 & A_3 = -0.141 \ 489 \\ k = 1.874 \ 335 & A_4 = -0.506 \ 438 \\ A_1 = 3.263 \ 288 & A_5 = 0.276 \ 992 \end{array}$$

The data were estimated by the author to be accurate to 0.7% on average, with a few values uncertain by several percent.

3. COMPUTATIONAL METHODS

The numerical values for E and H in this report are on the same absolute basis as those of Tester [70], obtained by use of $E_o^o = (4.1868) \cdot (4827.2) \text{ J/mol}$.

3.1 The Homogeneous Domain

With reference to Figure 9, we start our computations with ideal gas values at zero density, and then integrate along isotherms by use of the equation of state in the following relations,

$$\Delta E = \int [P - T \cdot (\partial P / \partial T)] \cdot d\rho / \rho^2, \quad (10)$$

$$\Delta C_v = -T \cdot \int (\partial^2 P / \partial T^2) \cdot d\rho / \rho^2, \quad (11)$$

$$\Delta S = R \cdot \ln [P^o / (\rho R T)] + \int [R - (\partial P / \partial T) / \rho] \cdot d\rho / \rho. \quad (12)$$

Equation (12) is for use with initial entropies in hypothetical gas states at $P^o = 1 \text{ atm}$. For the compressed liquid at $T < T_b$ and $\rho > \rho_c$

(the cross-hatched region of Figure 9) we start with values of $S(T, P_b)$ on isobar P_b , and then use

$$\Delta S = - \int (\partial P / \partial T) \cdot d\rho / \rho^2 . \quad (12-a)$$

In each (ρ, T) state, reached by above integrations, we compute

$$H = E + P \cdot v , \quad (13)$$

$$C_p = C_v + T \cdot (\partial P / \partial T)^2 / (\partial P / \partial \rho) / \rho^2 , \quad (14)$$

$$W^2 = C_p \cdot (\partial P / \partial \rho) / C_v . \quad (15)$$

3.2 The Vapor-Liquid Transition

As discussed below, we have used this computation only as a check against experimental heats of vaporization, and for closed-loop checks terminating on the saturated liquid.

We traverse the vapor-to-liquid "dome" of Figure 9 by use of the Clapeyron equation, and $\Delta v \equiv (v_l - v_g)$,

$$\Delta H = T \cdot (dP/dT) \cdot \Delta v , \quad (16)$$

$$\Delta E = \Delta H - P \cdot \Delta v , \quad (17)$$

$$\Delta S = \Delta H / T , \quad (18)$$

where (dP/dT) is slope of the vapor pressure curve.

3.3 Compressed Liquid States

Computations along isotherms which pass close to the critical point, Figure 9, cannot be expected to be accurate, as discussed in [25]. For ethane there is an additional problem for use of the Clapeyron equation to enter compressed liquid states. At low temperatures the vapor pressures become so small that they have yet to be measured accurately, and the saturated vapor densities obtained

here are correspondingly uncertain. We therefore have used the following procedure to compute around the critical point into the cross-hatched region of Figure 9:

We use the isobar of specific heats $C_p(T)$ at $P_b = 137.895$ bar from [20]. We then select $T_b = 340$ K, obtaining (by integration along T_b)- - -

$$H(T_b, P_b) = 25\,737.97 \text{ J/mol}, \quad S(T_b, P_b) = 176.4384 \text{ J/mol/K}.$$

By use of our description (9) for $C_p(T, P_b)$ we then integrate down to any $T < T_b$,

$$\Delta H = \int_{T_b}^T C_p \cdot dT, \quad \Delta S = \int_{T_b}^T C_p \cdot dT/T.$$

We finally integrate along isotherm T as described among eqs (10) through (18). On the saturated liquid boundary we compute the specific heat $C_\sigma(T)$ of liquid along the coexistence path from the following relation [61],

$$C_\sigma(T) = C_v(\rho, T) - T \cdot (\partial P / \partial T) \cdot (d\rho_\ell / dT) / \rho_\ell^2, \quad (19)$$

where $(d\rho_\ell / dT)$ is the slope of saturated liquid density vs. T .

4. TESTS AND COMPARISONS

4.1 The P- ρ -T Compressibility Data

Deviations of experimental densities and pressures from the smooth $P(\rho, T)$ surface of the equation of state (5) are given in Table 12, using author identifications from Table 10. The data of Michels [47] and Douslin [14] are highly precise, and the deviations generally are systematic, as might be expected from an equation of state with as little freedom as (5). Any inaccuracies in the liquid-vapor boundary will be propagated along calculated isochores because the equation

of state originates on this boundary. At high densities in the compressed liquid, the derivative $\partial P/\partial \rho$ becomes extremely large, hence pressure deviations should be ignored.

4.2 Calculated $P(\rho)$ Critical Isotherm

Table 18 gives a high-resolution examination of the $P(\rho)$ critical isotherm from equation of state (5). This was obtained by adjusting the assigned critical point (ρ_c, T_c) to eliminate negative slopes $\partial P/\partial \rho$ in the neighborhood of ρ_c . The selected critical point is within the range of values found by previous workers.

4.3 Heats of Vaporization and Closure Computation

The last column of Page 1 of Table 26 gives experimental heats of vaporization from eq (7) for comparison with values in column Q, VAP computed by the Clapeyron equation. The differences are plotted in Figure 10 as $(Q_{\text{xptl}} - Q_{\text{calc}})$.

Table 19 gives loop-closure computations for the saturated liquid. Values for enthalpy in Column H and for entropy in Column S are obtained by computing around the critical point, whereas values in Columns HC and SC are via the Clapeyron equation (see Sections 3.2, 3.3). The enthalpy differences are plotted in Figure 10 as $(H_{\text{calc}} - H_{\text{Furt}})$ in which H_{Furt} refers to computation around the C. P. by use of $C_p(T)$ data of Furtado [20].

Heats of vaporization via the Clapeyron equation at low temperatures are uncertain by several percent (up to about 500 J/mol) due to uncertainty in the vapor-pressure equation and the vapor densities. In Table 16, moreover, we see that experimental heats of vaporization may differ by over 2 percent at 100 K, (about 350 J/mol). The apparently large deviations seen in Figure 10 therefore do not exceed known uncertainties. The heats of vaporization have not been used for present computations.

4.4 Heat Capacity for Saturated Liquid

The last column of the second page of Table 26 gives experimental heat capacities for the saturated liquid from eq (8) for comparison with values in column CS computed as described above in Section 3.3. As seen in eq (19), this is a difficult computation from which to obtain high accuracy. We also have computed $C_\sigma(T) = T \cdot (dS_\sigma/dT)$, but prefer to omit this further complication of present work.

4.5 Specific Heats, $C_p(\rho, T)$

Table 20 compares specific heats of [20] at constant pressure with values calculated by present methods. Except near the sharp maxima in C_p in the critical region, the differences generally do not exceed combined uncertainties of a few percent.

4.6 Comparison of Enthalpies

Table 21 compares our saturated liquid enthalpies (obtained by computation around the critical point) with results of Tester [70]. From low-temperature specific heat data on the solid, and the heat of fusion, he obtained the third-law entropy of liquid at the triple point. He then used experimental $C_\sigma(T)$ data, liquid densities and dP/dT from the vapor-pressure equation to obtain $\Delta H(T)$ on the liquid coexistence path.

Table 22 compares enthalpies of three authors for the homogeneous domain at a few, selected (P, T) points. To make use of the values of Eubank et al., we have added $H^O(T)$ obtained from Tester. This comparison shows that our results from the present very simple equation of state are consistent with the work of other authors.

4.7 Speed of Sound for Saturated Liquid

Figure 11 compares the speed of sound W for saturated liquid from Table 26 of present work with the experimental data of Poole and Aziz [53]. Positive curvature of our calculated results below the boiling point (184.55 K) suggests that derivatives of our $P(\rho, T)$ surface are

not sufficiently accurate in the compressed liquid. Below 105 K the calculated dependence of the saturated liquid densities on the temperature in Table 6 also has a positive curvature, which probably is qualitatively incorrect.

5. TABLES OF PHYSICAL AND THERMODYNAMIC PROPERTIES

5.1 Calculated P- ρ -T Isochores and Isotherms

A selection of calculated isochores and isotherms is given by Tables 23 and 24. They are useful to examine behavior of the surface generated by the equation of state, and to supplement the isobars of Table 27 in obtaining P- ρ -T values and their derivatives.

5.2 The Joule-Thomson Inversion Locus

Table 25 gives our calculated P- ρ -T locus for the J. T. inversion, $(\partial T / \partial P)_H = 0$. These results are obtained from the equation of state under the condition, $T \cdot (\partial P / \partial T) = \rho \cdot (\partial P / \partial \rho)$.

5.3 Thermophysical Properties of the Saturated Liquid

Table 26 gives physical and thermodynamic properties for the saturated liquid. Column headings are interpreted on the first page of this table.

5.4 Thermophysical Properties Along Selected Isobars

Table 27 gives physical and thermodynamic properties on isobars, as computed by methods of Section 3. Explanations for the table are given on the first page. This table is extrapolated beyond the range of P- ρ -T data used for adjusting the equation of state ($P \sim 350$ bar).

6. COMMENTS AND RECOMMENDATIONS

Uncertainty of the saturated liquid densities (Table 3) is estimated to be 0.1 percent from 90 to 140 K. Greatest uncertainty, approaching 0.5 percent, exists in mid-range (160 to 250 K) where no experimental data were found. Whereas several sets of precise data exist approach-

ing the critical temperature, we have not been able to represent them with a function of simple form to better than 0.2 to 0.3 percent [28].

Saturated vapor densities at very low temperatures are uncertain by several percent because they have been estimated by use of the vapor-pressure equation which is uncertain by at least 2 percent at these temperatures [26], and the virial equation of state. The latter is extrapolated below the range of data for the virial coefficients where, however, we approach ideal gas behavior [27].

Our calculated densities (Table 27) over the homogeneous domain ($\rho < \rho_c$, or $T > T_c$) are uncertain by an estimated 0.2 percent, except for the critical region ($\rho_c/3 < \rho < 2 \cdot \rho_c$ at $0.9 \cdot T_c < T < 1.2 \cdot T_c$) where deviations from experimental data may exceed one percent, Table 12. For the compressed liquid at low temperatures, densities probably are uncertain by about 0.2 percent (adjusted P- ρ -T data of A. K. Pal [54]).

Uncertainty of enthalpy differences is most difficult to estimate. Along isotherm T_b of Figure 9, we compute $C_p(\rho, T)$ at point (T_b, P_b) within one percent of the experimental value from [20]. For the homogeneous domain, having an adequate density of P- ρ -T data, therefore, the uncertainty of enthalpy differences probably is comparable with that estimated for methane [25], namely about 2 percent. For compressed liquid, as seen in Section 4 above, however, the uncertainty may be several-fold greater.

The purpose of this report has been, in part, to find the inadequacies in physical properties data needed for thermal computations. Some recommendations can be made, based on the inaccuracies shown in Section 4 above. The possible methods for preparing a thermodynamic network are so numerous and varied, however, that the reader may wish to draw his own conclusions. We make only the following simple observations and recommendations:

1) The melting line is poorly defined. Accurate P - ρ - T data for the freezing liquid would provide a boundary for the equation of state. The triple-point temperatures which have been published are highly discordant. Extrapolation of the $P(T)$ melting line to zero pressure might yield a reliable value. This is needed especially for the vapor pressure equation.

2) More accurate P - ρ - T data (better than 0.1% in density) are needed for the low-temperature compressed liquid. From such data accurate saturated liquid densities may be obtained by intersection with an accurate vapor-pressure line.

3) Accurate densities for the saturated liquid are needed in mid-range where few if any experimental data exist.

4) Accurate vapor pressure measurements apparently exist only from 200 K (2 atm) upwards. These could be extended down to 150 K (0.1 atm) by use of the "air dead-weight gage." Their use might give a vapor pressure equation with more reliable derivatives, dP/dT , over the entire range.

5) Sound velocity measurements over a wide range, as well as additional specific heat measurements, e.g. $C_V(\rho, T)$, would provide further tests of the thermodynamic computations.

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8. BIBLIOGRAPHY

- [1] Amer. Petrol. Inst. Res. Proj. 44, Selected Values of Properties of Hydrocarbons and Related Compounds (loose-leaf). Table 20 k, (Part 1), p. 1, Dec. 31 (1952), (Vapor Pressures).
- [2] C. H. Barkeley, J. L. Valentine and C. O. Hurd, Thermodynamic properties of ethane, Trans. Amer. Inst. Chem. Eng. 43, 25 (1947).
- [3] L. A. Bulavin, Yu. M. Ostanevich, A. P. Simkina, and A. V. Strelkov. Density of ethane near the liquid-vapor critical point, Ukrainain Physics Journal 16, 90 and 183 (1971).
- [4] L. J. Burnett and B. H. Muller, Melting points of ethane and three of its deuterated modifications, J. Chem. and Eng. Data 15(1), 154 (1970).
- [5] L. N. Canjar, P-V-T and related properties for methane and ethane, Chem. Eng. Data Series 3(2), 185 (1958).
- [6] L. N. Canjar, C. M. Tejada and F. S. Manning, Thermo Properties of ethane, Hydrocarbon Processing and Petroleum Refiner, 41(10), 149 (1962).
- [7] F. G. Carruth, Determination of the vapor pressure of n-paraffins and extension of a corresponding states correlation to low reduced temperatures, Thesis, Dept. Chemical Engineering, Rice University, Houston, Texas, (Nov. 1970).
- [8] J. Chao, R. C. Wilhoit, and B. J. Zwolinski, Ideal gas thermodynamic properties of ethane and propane, J. Phys. Chem. Ref. Data 2(2), 427 (1973).
- [9] P. L. Chueh and J. M. Prausnitz, Third virial coefficients of nonpolar gases and their mixtures, A. I. Ch. E. Journal 13(5) 898 (1967).
- [10] C. H. Chui and F. B. Canfield, Liquid density and excess properties of argon + krypton and krypton + xenon binary liquid mixtures, and liquid density of ethane, Trans. Faraday. 67, 2933). (1971).

- [11] K. Clusius and K. Weigand, The melting curves of the gases A. Kr, X, CH₄, CH₃D, CD₄, C₂H₄, C₂H₆, COS, and PH₃ to 200 atm pressure, Z, physikal, Chem. B46(1), 1 (1940).
- [12] R. K. Crawford and W. B. Daniels, Equation of state measurements in compressed argon, J. Chem. Phys. 50(8), 3171 (1969).
- [13] D. E. Diller, The specific heats (C_v) of dense, simple fluids, Cryogenics 11, 186 (June, 1971).
- [14] D. R. Douslin and R. H. Harrison, Pressure-volume-temperature relations of ethane, J. Chem. Thermodynamics, 5(4), 491 (1973).
- [15] N. M. Dykhno, M. V. Tsyruhnikova and M. V. Mochalova, Hydrocarbon vapor pressures at low temperatures, Zh. Fiz. Khim. 42(9), 2310-1 (1968).
- [16] J. H. Dymond and E. B. Smith, The virial coefficients of gases, Oxford Science Research Papers 2, Clarendon Press, Oxford, England, (1969).
- [17] P. T. Eubank, Thermodynamic properties of ethane: vapor-liquid coexistence, Advances in Cryogenic Engineering, 17, 270 (Plenum Pub. Corp., New York, N. Y. 10011, (1971)).
- [18] P. T. Eubank, B. F. Fort, and C. C. Reed, Jr., Thermodynamic properties of ethane: PVT surface and corresponding thermodynamic properties, Advances in Cryogenic Engineering, 17, 282 (1971).
- [19] A. Eucken and A. Parts, Z. Phys. Chem. B20, 184 (1933), (virial coeffs. quoted by Ziegler et al. [77]).
- [20] André Furtado, The measurement and prediction of thermal properties of selected mixtures of methane, ethane, and propane, (Ph.D. Thesis, Dept. of Chemical Engineering, Univ. of Michigan, Ann Arbor, Mich., Dec., (1973)).
- [21] R. D. Goodwin, An equation of state for fluid parahydrogen from the triple-point to 100°K at pressures to 350 atmospheres, J. Res. Nat. Bur. Stand. 71A (3), 203 (1967).
- [22] R. D. Goodwin, Formulation of a nonanalytic equation of state for parahydrogen, J. Res. Nat. Bur. Stand. 73A (6), 585 (1969).

- [23] R. D. Goodwin, Nonanalytic vapor pressure equation with data for nitrogen and oxygen, J. Res. Nat. Bur. Stand. 73A (5), 487 (1969).
- [24] R. D. Goodwin and R. Prydz, Densities of compressed liquid methane, and the equation of state, J. Res. Nat. Bur. Stand. 76A(2), 81 (1972).
- [25] R. D. Goodwin, The thermophysical properties of methane from 90 to 500 K at pressures to 700 bar, NBS Tech. Note 653, April (1974).
- [26] R. D. Goodwin, The vapor pressures of ethane, Unpublished Report, Nat. Bur. Stand., Boulder, Colorado, 9 July, 1973. Appendix D, this report.
- [27] R. D. Goodwin, Ethane virial coefficients and saturated vapor densities, Unpublished Report, Nat. Bur. Stand., Boulder, Colorado, 15 Aug., 1973. Appendix E, this report.
- [28] R. D. Goodwin. The orthobaric densities of ethane, methane, oxygen, and flourine, Unpublished Report., Nat. Bur. Stand., Boulder, Colorado 18 Sept., 1973. Appendix F. this report.
- [29] R. D. Goodwin, Liquid-vapor saturation (orthobaric) temperatures of ethane and methane, Unpublished Report, Nat. Bur. Stand., Boulder, Colorado, 28 Nov., 1973. Appendix G, this report.
- [29a] R. D. Goodwin, Equation of state for thermodynamic properties of fluids, Submitted to J. Res. Nat. Bur. Stand., Boulder, Colorado, October, (1974).
- [30] R. D. Gunn, M. S. Thesis, Univ. Calif. (Berkeley), 1958, quoted by J. A. Huff and T. M. Reed, J. Chem. Eng. Data 8, 306 (1963). (Virial coefficients.)
- [31] K. R. Hall and P. T. Eubank, Experimental technique for direct measurement of interaction second virial coefficients. J. Chem. Phys. 59(2), 709 (1973).
- [32] A. Harmens, Orthobaric densities of liquefied light hydrocarbons, Chem. Eng. Science 20, 813 (1965), 21, 725 (1966).

- [33] A. S. Holmes, W. G. Braun and M. R. Fenske, Bibliography of vapor-pressure data for hydrocarbons, Amer. Petrol. Inst., New York, Bibliog. No. 2, 1964.
- [34] A. E. Hoover, I. Nagata, T. W. Leland and R. Kobayashi, Virial coefficients of methane, ethane, and their mixtures at low temperatures, J. Chem. Phys. 48(6), 2633 (1968).
- [35] J. A. Huff and T. M. Reed, Second virial coefficients of mixtures of nonpolar molecules from correlations on pure components, J. Chem. and Eng. Data 8(3), 306 (1963).
- [36] E. E. Hughes and S. G. Lias, Vapor pressures of organic compounds in the range below one millimeter of mercury, NBS Tech. Note No. 70., Washington, D. C. (Oct., 1960).
- [37] J. G. Hust, A compilation and historical review of temperature scale differences, Cryogenics 9(6), 443 (Dec., 1969).
- [38] J. D. Kemp and K. S. Pitzer, The entropy of ethane and the third law of thermodynamics. Hindered rotation of methyl groups, J. Am. Chem. Soc. 59, 276 (1937).
- [39] G. Klipping and F. Schmidt, Dampfdrucktabellen tiefsiedender gase (V), Kältetechnik 18(11), (Nov. 1966).
- [40] J. Klosek and C. McKinley, Densities of liquified natural gas and of low molecular weight hydrocarbons, paper 22, Session 5, Proc. First Internat. Conf. on LNG, Chicago, April (1968).
- [41] J. D. Lambert, G. A. H. Roberts, J. S. Rowlinson and V. J. Wilkinson, Proc. Roy. Soc., (London) A 196, 113 (1949). (Virial coefficients, quoted by Tester [70].)
- [42] A. G. Loomis and J. E. Walters, The vapor pressure of ethane near the normal boiling point, J. Amer. Chem. Soc. 48, 2051 (1926).
- [43] O. Maass and C. H. Wright, J. Am. Chem. Soc. 43, 1098 (1921). Vapor pressures, quoted by Tester [70].)
- [44] E. A. Mason and T. H. Spurling, The virial equation of state, Pergamon Press, Oxford (England), (1969).

- [45] R. D. McCarty, Least-squares computer subroutine, Unpublished report, Nat. Bur. Stand., Boulder, Colorado, (3 Jan., 1972).
- [46] M. L. McGlashan and D. J. B. Potter, An apparatus for the measurement of the second virial coefficients of vapors; the second virial coefficients of some n-alkanes and of some mixtures of n-alkanes, Proc. Roy. Soc. (London) A267, 478 (1962).
- [47] A. Michels, W. van Straaten and J. Dawson, Isotherms and thermodynamic functions of ethane at temperatures between 0°C and 150°C and pressures up to 200 atm, Physica XX, 17 (1954).
- [48] J. B. Rodosevich and R. C. Miller, Experimental liquid mixture densities for testing and improving correlations for liquefied natural gas, A I Ch E Journal 19(4), 729 (1973).
- [49] V. M. Minovich and G. A. Sorina, P-V-T relations in dilute solutions of propane in ethane in the vicinity of the critical point of ethane. 1. P-V-T relations for ethane in the vicinity of its critical point, Russian J. Phys. Chem. 45, (3) 306 (1971).
- [50] T. Miyazaki, (C_p measurements near the critical point), Ph.D. Thesis, Dept. Chem. Eng., Univ. Michigan, (1974).
- [51] J. Møllerup and J. S. Rowlinson, The prediction of the densities of liquefied natural gas and of lower molecular weight hydrocarbons. Chem. Eng. Sci. 29, 1373 (1974).
- [52] Plank and Kambeitz, Z. Ges. Kälte Ind. 10, 209 (1936), (Saturated vapor densities formula, quoted by Tester [70]).
- [53] G. R. Poole and R. A. Aziz, The law of corresponding states as applied to sound velocity in liquids consisting of elliptical molecules, Canadian J. Phys. 50, 721 (1972).
- [54] G. A. Pope, Calculation of argon, methane, and ethane virial coefficients at low reduced temperature based on data obtained by isochorically coupled Burnett experiments, Thesis, Dept. Chemical Engineering, Rice University, Houston, Texas (July, 1971). (Includes vapor pressure data, also vapor pressures and PVT data of A. K. Pal.)

- [55] G. A. Pope, P. S. Chappelaar, and R. Kobayashi, Virial coefficients of argon, methane, and ethane at low reduced temperatures, *J. Chem. Phys.* 59 (1), 423 (1973).
- [56] Frank Porter, The vapor pressures and specific volumes of the saturated vapor of ethane, *J. Am. Chem. Soc.* 48, 2055 (1926).
- [57] H. H. Reamer, R. H. Olds, B. H. Sage, and W. N. Lacey, Phase equilibria in hydrocarbon systems: Volumetric behavior of ethane, *Ind. Eng. Chem.* 36, 956 (1944).
- [58] J. Regnier, Vapor pressure of ethane between 80 and 135°K, *J. Chim. Phys.* 69(6), 942-4 (June, 1972).
- [59] F. D. Rossini, Report on international practical temperature scale of 1968, *J. Chem. Thermodynamics* 2, 447 (1970).
- [60] J. S. Rowlinson, Molecular theories of liquids and mixtures, *Ind. Eng. Chem.* 59(12), 28 (1967).
- [61] J. S. Rowlinson, Liquids and liquid mixtures, Plenum Press, New York, N. Y., (1969).
- [62] H. Sackmann and F. Sauerwald, The volume change upon melting of organic substances, especially in homologous series, *Z. Physik. Chem. (Leipzig)* A195, 295 (1950).
- [63] B. H. Sage and W. N. Lacey, Thermodynamic Properties of the Lighter Paraffin Hydrocarbons and Nitrogen, American Petroleum Institute, New York (1950).
- [64] C. T. Science, C. P. Colver and C. M. Sliepcevich, Bring your C_1 - C_4 up to date, *Hydrocarbon Process*, 46(9), 173 (1967).
- [65] M. Y. Shana'a and F. B. Canfield, Liquid density and excess volume of light hydrocarbon mixtures at -165°C, *Trans. Faraday Soc.* 64, 2281 (1968).
- [66] P. Sliwinski, The Lorenz-Lorenz function of gaseous and liquid ethane, propane and butane, *Zeit. Phys. Chem. Neue Folge* 63, 263 (1969).
- [67] N. E. Sondak and G. Thodos, Vapor pressures, the aliphatic hydrocarbons, *A.I.Ch.E. Journal* 2, 347 (1956).

- [68] K. E. Starling, Fluid thermodynamic properties for light petroleum systems, Gulf Publishing Co., Houston, Texas (1973).
- [68a] H. J. Strumpf, A. F. Collings and C. J. Pings, Viscosity of Xenon and Ethane in the Critical Region, J. Chem Phys. 60(8), 3109 (1974).
- [69] A. S. Teja and J. S. Rowlinson, The prediction of the thermodynamic properties of fluids and fluid mixtures--IV. Critical and azeotropic states, Chem. Eng. Sci. 28, 529 (1973).
- [70] H. E. Tester, Ethane, in Thermodynamic Functions of Gases, Vol 3, F. Din, Editor, (Butterworths Scientific Publications, London, 1961).
- [71] A. W. Tickner and F. P. Lossing, The measurement of low vapor pressures by means of a mass spectrometer, J. Phys. Colloid Chem. 55, 733 (1951).
- [72] J. R. Tomlinson (Gulf Research and Development Co., Pittsburgh, Pa.), Liquid densities of ethane, propane and ethane-propane mixtures, Tech. Pub. TP-1, Natural Gas Processors Assoc., (808 Home Federal Bldg., Tulsa, Okla. 74103, Feb. 1971).
- [73] R. Wiebe, K. H. Hubbard and M. J. Brevoort, The heat capacity of saturated liquid ethane from the boiling point to the critical temperature and heat of fusion of the solid, J. Am. Chem. Soc. 52, 611 (1930).
- [74] G. M. Wilson, R. G. Clark and F. L. Hyman, Thermodynamic properties of cryogenic fluids, Ind. Eng. Chem. 60(6), 58 (1968).
- [75] R. K. Witt and J. D. Kemp, The heat capacity of ethane from 15°K to the boiling point. The heat of fusion and the heat of vaporization, J. Am. Chem. Soc. 59, 273 (1937).
- [76] W. T. Ziegler, The vapor pressures of some hydrocarbons in the liquid and solid state at low temperatures, NBS Tech. Note 4, (May, 1959).
- [77] W. T. Ziegler, B. S. Kirk, J. C. Mullins and A. R. Berquist, Calculation of the vapor pressure and heats of vaporization and sublimation of liquids and solids below one atmosphere pressure. VII Ethane, Tech. Report No. 2, Proj. A-764, Eng. Expt. Sta., Georgia Inst. Tech., Atlanta, Georgia, (Dec., 1964).

APPENDIX A. Symbols and Units

Subscripts c and t refer to critical and liquid triple points.

Subscripts g and l refer to saturated vapor and liquid.

Subscript σ refers to liquid-vapor coexistence (usually the liquid).

Superscript o refers to ideal gas states.

$\alpha, b, \gamma, \epsilon,$	non-linear constants in the equation of state
$B(\rho), C(\rho),$	density-dependent coefficients in the equation of state
$C_v(\rho, T),$	molal heat capacity at constant volume, $J/(\text{mol} \cdot K)$
$C_p(\rho, T),$	molal heat capacity at constant pressure, $J/(\text{mol} \cdot K)$
$C_\sigma(T),$	molal heat capacity for saturated liquid, $J/(\text{mol} \cdot K)$
$d,$	density, mol/l
$E(\rho, T),$	the internal energy, J/mol
$H(\rho, T),$	the enthalpy, J/mol
$J,$	the joule, $1 \text{ N} \cdot \text{m},$
$l,$	the liter, $10^{-3} \text{ m}^3,$
$\text{mol},$	30.07 grams of ethane ($C^{12} = 12$ scale)
$P,$	pressure in bars, $1 \text{ bar} = 10^5 \text{ N/m}^2$ ($1 \text{ atm} = 1.01325 \text{ bar}$)
$P_\sigma(\rho),$	the vapor pressure, bar
$\Phi(\rho, T),$	function in the equation of state
$\Psi(\rho, T),$	function in the equation of state
$Q_{\text{vap}},$	$\Delta H_{\text{vap}},$ the heat of vaporization
$R,$	the gas constant, $8.31434 \text{ (J/mol)/K}, 0.0831434$ $(\text{bar} \cdot l/\text{mol})/\text{K}$
$\rho,$	$d/d_t,$ density reduced at the liquid triple point
$\sigma,$	$d/d_c,$ density reduced at the critical point
$S(\rho, T),$	the entropy, $(J/\text{mol})/K$
$T,$	temperature, $K,$ (ITS-68) [59]
$T_\sigma(\rho),$	liquid-vapor coexistence temperature, K
$\theta(\rho),$	defined locus of temperatures, Fig. 4

APPENDIX A. (Continued)

$U(\sigma)$,	defined function for eq (3-c)
v ,	$1/d$, molal volume, ℓ/mol
$w(\rho, T)$,	$\delta \cdot [T/\theta - 1]$, for the equation of state
$W(\sigma)$,	defined function for eq (3-d)
$W(\rho, T)$,	the speed of sound, meters/second
$x(T)$,	T/T_c , for the equation of state
Y ,	variously defined functions
Z ,	Pv/RT , the "compressibility factor"

APPENDIX B. Fixed-Point Values

	<u>Methane</u>	<u>Ethane</u>
<u>Triple Point</u>		
<u>Density Mol/ℓ</u>		
Vapor	$1.567\ 865 \cdot 10^{-2}$	$1.35114 \cdot 10^{-6}$
Liquid	28.1470	21.680
Temperature, K	90.680	89.899
Pressure, bar	0.1174 35675	$1.009\ 906 \cdot 10^{-5}$
<u>Critical Point</u>		
Density, mol/ ℓ	10.0	6.74
Temperature, K	190.555	305.37
Pressure, bar	45.988	48.755

APPENDIX C. Exposition of the Equation of State

Equation (5) may be written explicitly--

$$P = P_{\sigma}(\rho) + \rho R [T - T_{\sigma}(\rho)] + \rho^2 R T_c [B(\rho) \cdot \Phi(\rho, T) + C(\rho) \cdot \Psi(\rho, T)]. \quad (5-1)$$

This has only two temperature-dependent terms (in addition to ρRT), which is the minimum number needed to describe the sigmoid shape of isochores [61] in the range $\rho_c < \rho < 2 \cdot \rho_c$, Figure 2. Each of these terms is zero on the coexistence boundary at $T = T_{\sigma}(\rho)$.

The first term, $\Phi(\rho, T)$, is shown by Figure 5. It is linear ($\partial^2 \Phi / \partial T^2 = 0$) on the coexistence boundary. It gives a critical isochore which is linear at the critical point because $C(\rho) = 0$ along this isochore.

The second term, $\Psi(\rho, T)$, is shown by Figure 6. It starts with infinite curvature ($\partial^2 \Psi / \partial T^2$) on the locus of temperatures, $\theta(\rho)$, inside the coexistence envelope of Figure 4. Sufficiently far away from the critical point it behaves like $1/T^2$, found in the well-known Beattie-Bridgeman equation.

The sign of the curvature ($\partial^2 P / \partial T^2$) of isochores at the coexistence boundary is determined uniquely by the sign of $C(\rho)$. Figure 7 shows the behavior of $B(\rho)$ and of $C(\rho)$ for methane. The root in $C(\rho)$ at $\rho/\rho_c = 1.9$ was found by least squares both for methane and for ethane. It then was introduced as the non-linear constant, C_o , in the equation of state. This constraint is valuable. In its absence we quite often have failed to obtain any such root from P - ρ - T data by least squares. Figure 8 shows the presumed behavior of $C(\rho)$ for hydrogen (a double root near $\rho/\rho_c = 1.9$), needed to give the observed positive curvature of isochores in the compressed liquid at the lowest temperatures [13, 21].

APPENDIX C. (Continued)

The critical isotherm from eq. (5) necessarily has zero slope, $\partial P/\partial \rho = 0$, at the critical point, Figure 3. This follows from our definitions of $T_G(\rho)$, $\theta(\rho)$, $\Phi(\rho, T)$ and $\Psi(\rho, T)$. The second derivative, $\partial^2 P/\partial \rho^2$, also is zero because the vapor pressure here is expressed as a function of $T_G(\rho)$. Our detailed examinations of this isotherm show however, that small changes in the assigned critical point (ρ_c, T_c) give rise to irregularities nearby at $\rho \leq \rho_c$. Adjusting the critical density to $\rho_c = 6.74 \text{ mol/l}$ yields a well-behaved critical isotherm having no negative slopes, i. e. $\partial P/\partial \rho \geq 0$.

Specific heats along the critical isotherm of Figure 4 are computed by integrating the curvatures of isochores, $(\partial^2 P/\partial T^2)$, in eq. (11), starting at $\rho = 0$. Curvatures from the term $C(\rho) \cdot \Psi(\rho, T)$ in the equation of state at first increase sharply (with negative sign) as $\rho \rightarrow \rho_c^-$, become zero at $\rho = \rho_c$, then strongly positive at first for $\rho > \rho_c$, finally diminishing at still higher densities. This behavior is seen along the critical isotherm in Table 24. It gives a maximum in $C_v(\rho, T)$ at the critical point via eq. (11).

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The Vapor Pressures of Ethane

NAME R. D. Goodwin

DATE July 9, 1973

This is the first of several reports planned on the physical properties of ethane. Our ultimate purpose is to compute tables of thermodynamic functions over the entire range of fluid states. We first will discover regions where data are inadequate or lacking by attempting to compute provisional tables based on existing data.

Accurate vapor pressures, and a proper analytical representation of these data, are essential for computing heats of vaporization via the Clapeyron equation.

In this note we give a limited bibliography. Not all of these references were available at this writing. We compare several sets of data by use of our new, non-analytic vapor pressure equation. We make a choice of the best for least squares, and we give deviations from this selected equation.

At the triple point near 90 K the vapor pressure of ethane is about 0.00001 atm (10 μ -atm). Experimental methods therefore differ for the range below one atm (184.5K) and for the range of higher pressures to 48 atm at $T_c = 305$ K.

Data to about 1960 are reviewed by Tester [19], who selected the representation of Barkelew et al. [3] for the entire range from triple- to critical point.

Below one atm the data to 1964 are reviewed by Ziegler et al., who give their own, high quality set of data computed for thermodynamic consistency with all related or derived data, in a work for the National Standard Reference Data Program [23]. More recently we have the measurements of Carruth, obtained by the gas saturation flow technique, employing a flame ionization detector for analysis of the gas mixture [4]. See also J. J. Chen et al. (Rice University), paper G-1, 1972 Cryogenic Engineering Conference, on the same technique.

For high pressures the only new data of which we presently are aware are those of Pope (Table 25) [13], and those attributed to Dr. A. K. Pal by Pope [13] in Table 31. For these latter data there is no description of experimental method.

After this note was written we received the new precise measurements of Douslin and Harrison [24], and therefore have recomputed our results including these data. Douslin and Harrison note especially the new, precise measurements of Miniovich and Sorina [25], which were not available to us at this writing.

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Our vapor pressure equation [6] uses the reduced argument,

$$x(T) \equiv (1 - T_t/T)/(1 - T_t/T_c),$$

where subscripts t and c refer to triple- and critical points,

$$\ln(P/P_t) = a \cdot x + b \cdot x^2 + c \cdot x^3 + d \cdot x^4 + e \cdot x \cdot (1-x)^\epsilon \quad (1)$$

and the exponent is $\epsilon = 1.5$ for methane [15] and for oxygen [16]. Originally the term $d \cdot x^4$ was absent. It has been added here to improve representation of the ethane data.

The following discoveries are found with the original equation of four terms. Optimum exponents in the range $1.1 \leq \epsilon \leq 1.9$ are obtained merely by changing the sets of data used for least squares. Hence we must rely on the more precise methane and oxygen data to select $\epsilon = 1.5$. Varying the critical-point temperature within reasonable limits has no significant effect on the overall, rms relative pressure deviations.

By examining numerous results we have selected for least squares only the data of Ziegler at $P \leq 1$ atm [23], and the data of Pope, Pal [13] and Douslin [24] at $P > 1.9$ atm. Whereas the temperature scale of Ziegler may be thermodynamic (the report is not clear), we nevertheless find that deviations (rms in relative P) are minimized by converting both sets of data to T-1968 as if they had been on T-1948 [1]. All T used in the following are T-68.

The triple-point temperature was reviewed by Ziegler et al. Their selection of 89.89 K becomes 89.899 on the 1968 scale. The critical-point temperature 305.42 K of Pope has been changed to 305.33 K for consistency with the data of Douslin [24]. A value $T_c = 305.33 \pm 0.005$ K is given by P. Sliwinski, Zeit. Phys. Chem. 68, 91 (1964) based on analysis of dielectric constants. This was kindly pointed out by D. E. Diller. We obtain pressures at these end points from the vapor pressure equation:

	<u>T, K (1968)</u>	<u>P, atm</u>
Triple point	89.899	$9.616 \cdot 10^{-6}$
Critical point	305.33	48.07695

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The constants for eq (1) were obtained via the data of Ziegler, Pope, Pal and Douslin. They include $\epsilon = 1.6$ as shown at the head of table 1.

$$\begin{aligned} a &= 8.4549\ 8734 & d &= -1.4138\ 6053 \\ b &= 12.4880\ 3978 & e &= 8.5265\ 2253 \\ c &= -4.1042\ 8155 \end{aligned}$$

In the following tables we give the author's ID, his temperature and as converted to T-68, and the published and calculated pressures. Next is the deviation of his temperature from our calculated value,

$$DT \equiv T_{\text{xpt}} - T_{\text{calc}} = - (P_{\text{xpt}} - P_{\text{calc}}) / (dP/dT),$$

and finally his relative pressure deviation,

$$P, \text{ PCT} \equiv 100 \cdot (P_{\text{xpt}} - P_{\text{calc}}) / P_{\text{calc}}.$$

At the bottom of each table we give the number of datum pairs, NP, and the rms of relative pressure deviations in percent.

The source of data in each table is identified by the numerical code, ID, in the first column--

Table No.	I.D.	Authors	Reference
1	4	A. K. Pal	[13]
	7	Ziegler et al.	[23]
	9	G. A. Pope	[13]
	10	Douslin, Harrison	[24]
2	1	Tickner, Lossing	[20]
	2	API Proj. 44	[2]
	3	Carruth	[4]
3	5	Loomis, Walters	[11]
4	6	F. Porter	[14]
	8	Barkelew et al	[3]
5	Calculated vapor pressures (this report)		
6	Reduced v.p. functions (this report)		

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As additional data may be found, we reserve comment on the deviations of individual authors, and omit the labor of preparing deviation plots.

Calculated pressures, slopes and curvatures are given at uniform temperatures by Table 5.

For comparison with functions in our original vapor pressure publication [6], we give these functions in Table 6, as computed via eq (1) namely

$$x(T) \equiv (T - T_t/T)/(1 - T_t/T_c),$$

$$Y(P) \equiv \ln(P/P_t)/\ln(P_c/P_t). \quad (2)$$

These variables range from zero to unity. The equation

$$Y = x \quad (3)$$

represents the basic vapor pressure equation

$$\ln(P) = a - b/T \quad (4)$$

when this is constrained to the end-points (triple and critical). Hence (Y-x) is the deviation of data from (4).

Finally, we give the computer programs used in this work as a means to check for errors, and to facilitate resumption of this research.

Addendum. Following work shows that the second virial coefficient used by Ziegler et al. to obtain vapor pressures is not consistent with our selection. At 200°K his $B(T) = -455$ cc/mol, whereas our $B(T) = -417.5$. We therefore have recomputed our vapor pressure constants using Ziegler's vapor pressure data from his Table IX for "Curve B" of his Figure 1, for which $B(T) = -410$ cc/mol at 200 K. The difference in his vapor pressures at 90 K is $(7.80 - 7.33)/7.33 = 6.4$ percent, the new values being the greater. Our new results for eq (1) are given in Table 7, (pages 20, 21) and tables 8, 9 on pages 22, 23 of this report. We prefer these constants for future use.

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Bibliography

- [1] The International Practical Temperature Scale of 1968, Metrologia 5 (2), 35 (1969).
- [2] Amer. Petrol. Inst. Res. Proj. 44, Selected Values of Properties of Hydrocarbons and Related Compounds (loose-leaf), Table 20 k, (Part 1), p. 1, Dec. 31 (1952).
- [3] C. H. Barkelew, J. L. Valentine and C. O. Hurd, Thermodynamic properties of ethane, Trans. Amer. Inst. Chem. Eng. 43, 25 (1947).
- [4] F. G. Carruth, Determination of the vapor pressure of n-paraffins and extension of a corresponding states correlation to low reduced temperatures, Thesis, Dept. Chemical Engineering, Rice University, Houston, Texas, (Nov. 1970).
- [5] N. M. Dykhno, M. V. Tsyruhnikova and M. V. Mochalova, Hydrocarbon vapor pressures at low temperatures, Zh. Fiz. Khim. 42 (9), 2310-1 (1968).
- [6] R. D. Goodwin, Nonanalytic vapor pressure equation with data for nitrogen and oxygen, J. Res. NBS 73A (5), 487 (1969).
- [7] A. S. Holmes, W. G. Braun and M. R. Fenske, Bibliography of Vapor Pressure Data for Hydrocarbons, Amer. Petrol. Inst., New York, Bibliog. No. 2, (1964).
- [8] E. E. Hughes and S. G. Lias, Vapor Pressures of Organic Compounds in the Range Below one Millimeter of Mercury, NBS Tech. Note 70, Washington, D. C. (Oct., 1960).
- [9] J. G. Hust, A compilation and historical review of temperature scale differences, Cryogenics 9 (6), 443 (Dec., 1969).
- [10] G. Klipping and F. Schmidt, Dampfdrucktabellen Tiefsiedender Gase (V), Kaltetechnik 18 (11), (Nov. 1966).
- [11] A. G. Loomis and J. E. Walters, The vapor pressure of ethane near the normal boiling point, J. Amer. Chem. Soc. 48, 2051 (1926).
- [12] R. E. Perry and G. Thodos, Vapor pressures of the light normal saturated hydrocarbons, Ind. Eng. Chem. 44 (7), 1649 (1952).
- [13] G. A. Pope (quotes v.p. of Dr. A. K. Pal), Calculation of Argon, Methane, and Ethane Virial Coefficients at Low Reduced Temperature Based on Data Obtained by Isochorically Coupled Burnett Experiments, Thesis, Dept. Chemical Engineering, Rice University, Houston, Texas (July, 1971).
- [14] F. Porter, The vapor pressures and specific volumes of the saturated vapor of ethane, J. Amer. Chem. Soc. 48, 2055 (1926).
- [15] R. Prydz and R. D. Goodwin, Experimental melting and vapor pressures of methane, J. Chem. Thermodynamics 4, 127 (1972).
- [16] Rolf Prydz, An improved oxygen vapor pressure representation, Metrologia 8 (1), 1 (1972).

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[17]	C. T. Sciance, C. P. Colver and C. M. Sliepcevich, Bring your C_1-C_4 up to date, Hydrocarbon Process. <u>46</u> (9), 173 (1967).			
[18]	N. E. Sondak, and G. Thodos, Vapor pressures, the saturated aliphatic hydrocarbons, A.I.Ch.E. Journal <u>2</u> , 347 (1956).			
[19]	H. E. Tester, ETHANE, in Thermodynamic Functions of Gases, F. Din, Editor, Butterworths, London (1961).			
[20]	A. W. Tickner and F. P. Lossing, The measurement of low vapor pressures by means of a mass spectrometer, J. Phys. Colloid Chem. <u>55</u> , 733 (1951).			
[21]	G. M. Wilson, R. G. Clark and F. L. Hyman, Thermodynamic properties of cryogenic fluids, Ind. Eng. Chem. <u>60</u> (6), 58 (1968).			
[22]	W. T. Ziegler, The Vapor Pressures of Some Hydrocarbons in the liquid and solid state at low temperatures, NBS Tech. Note 4, (May, 1959).			
[23]	W. T. Ziegler, B. S. Kirk, J. C. Mullins and A. R. Berquist, Calculation of the Vapor Pressure and Heats of Vaporization and Sublimation of Liquids and Solids below One Atmosphere Pressure. VII Ethane, Tech. Rpt. No. 2 Proj. A-764, Eng. Expt. Sta., Georgia Inst. Tech.; Atlanta, Georgia, Dec., 1964.			
[24]	D.R. Douslin and R. H. Harrison, Pressure-Volume-Temperature Relations of Ethane (manuscript for the Journal of Chemical Thermodynamics), 1973.			
[25]	V. M. Miniovich and G. A. Sorina, Russian J. Phys. Chem. <u>45</u> , 306 (1971).			

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Table 1. Data of Pal (4), Ziegler (7), Pope (9), and Douslin (10).

ETHANE VAPOR PRESSURES, E = 1.60

TTRP = 89.899, TCRT = 305.330

PTRP, MUATM = 9.61600, PCRT, ATM = 48.07695

8.454987344 12.488039775 -4.134281551

-1.413865533 8.526522526 0.000000000

ID	T, XPTL	T-68	P, ATM	CALCD	DEL T	P, FCT
7	94.000	94.013	0.0000274	0.0000274	-0.001	0.02
7	98.000	98.012	0.0000693	0.0000694	0.002	-0.05
7	102.000	102.008	0.0001618	0.0001619	0.002	-0.05
7	106.000	106.002	0.0003526	0.0003522	-0.006	0.11
7	110.000	109.998	0.0007207	0.0007205	-0.002	0.03
7	114.000	113.995	0.0013947	0.0013947	-0.000	0.00
7	118.000	117.991	0.0025697	0.0025698	0.000	-0.00
7	122.000	121.988	0.0045303	0.0045293	-0.002	0.02
7	126.000	125.987	0.0076737	0.0076734	-0.000	0.00
7	130.000	129.987	0.012538	0.012540	0.001	-0.01
7	134.000	133.988	0.019830	0.019834	0.002	-0.02
7	138.000	137.990	0.030447	0.030460	0.004	-0.04
7	142.000	141.993	0.045504	0.045527	0.005	-0.05
7	146.000	145.996	0.066355	0.066389	0.006	-0.05
7	150.000	150.000	0.094608	0.094657	0.006	-0.05
7	154.000	154.004	0.13213	0.13220	0.007	-0.05
7	158.000	158.008	0.18109	0.18117	0.005	-0.04
7	162.000	162.012	0.24392	0.24397	0.003	-0.02
7	166.000	166.015	0.32333	0.32330	-0.001	0.01
7	170.000	170.019	0.42230	0.42214	-0.006	0.04
7	174.000	174.023	0.54409	0.54371	-0.011	0.07
7	178.000	178.026	0.69224	0.69145	-0.020	0.11
7	182.000	182.028	0.87047	0.86905	-0.029	0.16
7	184.520	184.550	1.00100	0.99803	-0.036	0.20
9	198.181	198.216	1.9737	1.9758	0.023	-0.11
4	214.302	214.334	3.9209	3.9176	-0.021	0.08
4	224.102	224.130	5.6367	5.6429	0.031	-0.11
4	229.756	229.782	6.8569	6.8629	0.026	-0.09
4	234.558	234.581	8.0335	8.0423	0.034	-0.11
9	234.692	234.715	8.0741	8.0772	0.012	-0.04
10	238.150	238.150	9.0097	9.0108	0.004	-0.01
9	238.771	238.792	9.1843	9.1935	0.032	-0.10
4	239.844	239.864	9.4959	9.5049	0.030	-0.09
4	240.514	240.534	9.6960	9.7032	0.024	-0.07
10	243.150	243.150	10.5063	10.5071	0.003	-0.01
4	243.559	243.577	10.5760	10.5790	0.009	-0.03
4	246.814	246.830	11.7137	11.7183	0.014	-0.04
4	247.816	247.831	12.0502	12.0648	0.042	-0.12
10	248.150	248.150	12.1756	12.1766	0.003	-0.01
4	249.741	249.755	12.7520	12.7512	-0.030	0.08
4	250.146	250.160	12.8985	12.8991	0.002	-0.01
4	251.587	251.600	13.4425	13.4356	-0.018	0.05
4	252.544	252.556	13.8065	13.8008	-0.015	0.04
10	253.150	253.150	14.0310	14.0310	-0.000	0.00
4	254.290	254.301	14.4898	14.4854	-0.011	0.03
4	257.543	257.552	15.8252	15.8264	0.003	-0.01
10	258.150	258.150	16.0835	16.0823	-0.003	0.01

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Table 1--continued.

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ID	T,XPTL	T-68	P,ATM	CALCD	DEL T	P,PCT
10	263.150	263.150	18.3464	18.3433	-0.007	0.02
4	263.380	263.386	18.4543	18.4553	0.002	-0.01
4	267.536	267.539	20.5197	20.5113	-0.016	0.04
10	268.150	268.150	20.8318	20.8274	-0.009	0.02
4	271.749	271.750	22.7661	22.7618	-0.008	0.02
9	272.949	272.949	23.4515	23.4347	-0.030	0.07
10	273.150	273.150	23.5549	23.5488	-0.011	0.03
4	275.922	275.921	25.1584	25.1648	0.011	-0.03
4	276.363	276.362	25.4558	25.4293	-0.044	0.10
4	276.385	276.384	25.4491	25.4425	-0.011	0.03
4	276.514	276.513	25.5472	25.5203	-0.044	0.11
4	277.813	277.811	26.3185	26.3133	-0.008	0.02
10	278.150	278.150	26.5309	26.5233	-0.012	0.03
4	280.541	280.038	27.7139	27.7158	0.019	-0.04
4	282.247	282.243	29.1537	29.1588	0.008	-0.02
10	283.150	283.150	29.7763	29.7681	-0.012	0.03
4	284.635	284.630	30.7664	30.7836	0.025	-0.06
9	284.845	284.840	30.9555	30.9296	-0.037	0.08
4	287.653	287.648	32.9289	32.9340	0.007	-0.02
10	288.150	288.150	33.3116	33.3030	-0.011	0.02
4	288.263	288.257	33.3899	33.3822	-0.010	0.02
4	290.040	290.034	34.6873	34.7148	0.036	-0.08
9	290.214	290.208	34.8748	34.8474	-0.036	0.08
4	292.236	292.229	36.4440	36.4182	-0.033	0.07
4	293.098	293.091	37.0816	37.1044	0.028	-0.06
10	293.150	293.150	37.1583	37.1518	-0.008	0.02
9	293.266	293.259	37.2672	37.2394	-0.035	0.07
4	296.347	296.339	39.7598	39.7842	0.029	-0.06
10	298.150	298.150	41.3494	41.3450	-0.005	0.01
4	299.665	299.657	42.6543	42.6822	0.031	-0.07
9	299.863	299.855	42.8863	42.8606	-0.028	0.06
4	300.205	300.196	43.1650	43.1703	0.006	-0.01
4	301.251	301.242	44.1085	44.1297	0.023	-0.05
10	302.150	302.150	44.9809	44.9778	-0.003	0.01
10	303.150	303.150	45.9327	45.9295	-0.003	0.01
4	303.471	303.462	46.2032	46.2300	0.028	-0.06
4	303.477	303.468	46.2798	46.2358	-0.046	0.10
9	304.012	304.002	46.7736	46.7558	-0.018	0.04
4	304.049	304.039	46.7698	46.7920	0.023	-0.05
10	304.150	304.150	46.9040	46.9010	-0.003	0.01
4	304.365	304.350	47.0931	47.0974	0.004	-0.01
4	304.446	304.435	47.2198	47.1822	-0.038	0.08
4	304.519	304.508	47.2025	47.2544	0.052	-0.11
4	304.734	304.723	47.4310	47.4677	0.037	-0.08
4	304.796	304.785	47.5185	47.5294	0.011	-0.02
4	304.924	304.913	47.6846	47.6572	-0.027	0.06
4	304.960	304.969	47.7131	47.7132	0.000	-0.00
4	305.121	305.110	47.8496	47.8547	0.005	-0.01
4	305.135	305.124	47.8251	47.8688	0.043	-0.09
10	305.150	305.150	47.8992	47.8950	-0.004	0.01
4	305.153	305.142	47.8807	47.8869	0.006	-0.01
10	305.250	305.250	47.9994	47.9959	-0.003	0.01

NP = 93, RMSPCT = 0.061

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SUBJECT

The Vapor Pressures of Ethane

Table 2. Data of Tickner (1), API (2), and Carruth (3).

NAME

R. D. Goodwin

DATE

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ID	T,XPTL	T-68	P,ATM	CALCD	DEL T	P,PCT
1	91.350	91.361	0.0000132	0.0000141	0.265	-6.86
1	94.450	94.463	0.0000263	0.0000306	0.582	-13.98
1	98.550	98.562	0.0000658	0.0000783	0.730	-15.98
1	101.850	101.858	0.0001316	0.0001571	0.797	-16.23
1	105.350	105.353	0.0002632	0.0003118	0.825	-15.60
1	110.550	110.548	0.0006579	0.0007914	0.992	-16.87
1	114.650	114.644	0.0013158	0.0015453	0.947	-14.85
1	119.050	119.040	0.0026316	0.0029942	0.839	-12.11
1	125.550	125.537	0.0065789	0.0072450	0.717	-9.19
1	130.650	130.637	0.013158	0.013539	0.240	-2.81

NP = 10, RMSPCT = 13.226

ID	T,XPTL	T-68	P,ATM	CALCD	DEL T	P,PCT
2	130.270	130.257	0.013158	0.012947	-0.138	1.63
2	136.460	136.449	0.026316	0.025909	-0.148	1.57
2	140.410	140.402	0.039474	0.038925	-0.141	1.41
2	143.370	143.364	0.052632	0.051945	-0.139	1.32
2	145.760	145.756	0.065789	0.064946	-0.142	1.30
2	147.790	147.788	0.078947	0.078018	-0.134	1.19
2	151.120	151.121	0.10526	0.10415	-0.127	1.07
2	153.820	153.824	0.13158	0.13028	-0.122	0.99
2	159.030	159.039	0.19737	0.19591	-0.099	0.74
2	162.960	162.973	0.26316	0.26140	-0.094	0.67
2	166.170	166.185	0.32895	0.32708	-0.084	0.57
2	168.900	168.918	0.39474	0.39284	-0.074	0.48
2	173.410	173.432	0.52632	0.52422	-0.064	0.40
2	177.100	177.125	0.65789	0.65574	-0.056	0.33
2	180.250	180.277	0.78947	0.78743	-0.046	0.26
2	183.010	183.039	0.92105	0.91908	-0.039	0.21
2	184.520	184.550	1.00000	0.99803	-0.036	0.20
2	185.480	185.510	1.0526	1.0509	-0.031	0.16
2	187.710	187.741	1.1842	1.1821	-0.034	0.18
2	189.770	189.802	1.3158	1.3143	-0.023	0.11
2	193.440	193.473	1.5789	1.5777	-0.017	0.08
2	198.150	198.185	1.9737	1.9729	-0.008	0.04

NP = 22, RMSPCT = 3.857

ID	T,XPTL	T-68	P,ATM	CALCD	DEL T	P,PCT
3	91.340	91.351	0.0000152	0.0000141	-0.315	8.14
3	93.700	93.712	0.0000270	0.0000255	-0.237	5.80
3	96.240	96.253	0.0000491	0.0000466	-0.235	5.42
3	100.700	100.710	0.0001297	0.0001239	-0.222	4.64
3	105.600	105.603	0.0003263	0.0003268	0.009	-0.16
3	114.240	114.235	0.0014461	0.0014487	0.012	-0.19
3	120.380	120.369	0.0036166	0.0036185	0.023	-0.33
3	129.510	129.797	0.012312	0.012260	-0.036	0.42
3	135.770	135.759	0.024197	0.024065	-0.051	0.55
3	140.550	140.542	0.040211	0.039472	-0.188	1.87
3	144.140	144.135	0.056289	0.055871	-0.080	0.75

NP = 11, RMSPCT = 3.759

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SUBJECT

The Vapor Pressures of Ethane
Table 3. Data (5) of Loomis, Walters [11].

NAME

R. D. Goodwin

DATE

July 9, 1973

ID	T,XPTL	T-68	P,ATM	CALCD	DEL T	P,PCT
5	135.736	135.725	0.024500	0.023977	-0.203	2.18
5	143.267	143.261	0.052200	0.051437	-0.156	1.48
5	147.324	147.321	0.075900	0.074840	-0.158	1.42
5	154.546	154.550	0.14000	0.13816	-0.166	1.33
5	158.385	158.393	0.18860	0.18657	-0.143	1.09
5	162.629	162.641	0.25730	0.25528	-0.110	0.79
5	165.529	165.544	0.31600	0.31300	-0.139	0.96
5	167.336	167.853	0.36930	0.36606	-0.133	0.89
5	169.175	169.193	0.40330	0.40000	-0.126	0.82
5	171.700	171.721	0.47430	0.47084	-0.116	0.74
5	170.602	170.622	0.44300	0.43890	-0.145	0.93
5	174.062	174.085	0.54980	0.54579	-0.119	0.73
5	175.708	175.732	0.60730	0.60338	-0.108	0.65
5	177.623	177.649	0.68040	0.67631	-0.103	0.61
5	178.521	178.647	0.72100	0.71696	-0.097	0.56
5	179.750	179.777	0.76960	0.76525	-0.099	0.57
5	181.506	181.534	0.84990	0.84537	-0.096	0.54
5	182.463	182.492	0.89630	0.89172	-0.093	0.51
5	183.778	183.807	0.96340	0.95860	-0.092	0.50
5	184.539	184.569	1.00400	0.99906	-0.091	0.49
5	185.137	185.167	1.0366	1.0318	-0.087	0.47
5	185.914	185.944	1.0800	1.0755	-0.078	0.42
5	186.609	186.640	1.1208	1.1158	-0.084	0.44
5	187.302	187.333	1.1619	1.1572	-0.077	0.40
5	187.726	187.757	1.1881	1.1831	-0.081	0.42
5	188.379	188.410	1.2289	1.2239	-0.080	0.41
5	189.114	189.146	1.2757	1.2710	-0.072	0.37
5	189.858	189.890	1.3248	1.3202	-0.069	0.35
5	190.791	190.823	1.3885	1.3839	-0.057	0.33
5	191.430	191.463	1.4334	1.4288	-0.064	0.32
5	192.286	192.319	1.4953	1.4908	-0.061	0.30
5	192.777	192.810	1.5318	1.5273	-0.060	0.29
5	196.244	196.278	1.8088	1.8049	-0.046	0.22
5	199.909	199.944	2.1417	2.1384	-0.034	0.15

NP = 34, RMSPCT = 0.789

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SUBJECT

The Vapor Pressures of Ethane
Table 4. Data of Porter (6), and Barkelew (8).

NAME

R. D. Goodwin

DATE

July 9, 1973

ID	T,XPTL	T-68	P,ATM	CALCD	DEL T	P,PCT
6	184.470	184.500	0.99940	0.99534	-0.075	0.41
6	203.490	203.524	2.4960	2.5076	0.106	-0.46
6	205.620	205.653	2.7330	2.7489	0.135	-0.58
6	210.960	210.992	3.4140	3.4308	0.121	-0.49
6	216.310	216.341	4.2250	4.2338	0.054	-0.21
6	221.880	221.910	5.2070	5.2104	0.018	-0.06
6	225.100	225.128	5.8380	5.8456	0.037	-0.13
6	226.180	226.207	6.0730	6.0709	-0.010	0.03
6	234.580	234.603	8.0440	8.0481	0.016	-0.05
6	238.900	238.921	9.2290	9.2305	0.005	-0.02
6	243.220	243.238	10.5360	10.5350	-0.003	0.01
6	248.650	248.665	12.3540	12.3588	0.013	-0.04
6	253.030	253.042	14.0430	13.9889	-0.139	0.39
6	258.800	258.809	16.4210	16.3679	-0.122	0.32
6	263.280	263.286	18.4480	18.4078	-0.085	0.22
6	268.730	268.732	21.1850	21.1317	-0.101	0.25
6	273.090	273.090	23.5440	23.5147	-0.051	0.12
6	278.640	278.638	26.8370	26.8276	-0.015	0.04
6	283.580	283.576	30.1060	30.0575	-0.071	0.16
6	288.260	288.254	33.4680	33.3800	-0.119	0.26

NP = 20, RMSPCT = 0.274

ID	T,XPTL	T-68	P,ATM	CALCD	DEL T	P,PCT
8	110.000	109.998	0.0007600	0.0007205	-0.319	5.49
8	120.000	119.989	0.0034600	0.0034295	-0.063	0.89
8	130.000	129.987	0.012720	0.012540	-0.121	1.44
8	140.000	139.992	0.037850	0.037359	-0.131	1.31
8	150.000	150.000	0.095600	0.094657	-0.116	1.00
8	160.000	160.010	0.21200	0.21068	-0.084	0.63
8	170.000	170.019	0.42360	0.42214	-0.053	0.35
8	180.000	180.027	0.77780	0.77628	-0.034	0.20
8	190.000	190.032	1.3300	1.3297	-0.004	0.02
8	200.000	200.035	2.1462	2.1472	0.011	-0.05
8	210.000	210.033	3.2970	3.2998	0.020	-0.08
8	220.000	220.030	4.8580	4.8639	0.033	-0.12
8	230.000	230.025	6.9120	6.9196	0.032	-0.11
8	240.000	240.020	9.5510	9.5508	-0.001	0.00
8	250.000	250.014	12.8500	12.8456	-0.012	0.03
8	260.000	260.008	16.9100	16.8973	-0.028	0.08
8	270.000	270.001	21.8000	21.8066	0.012	-0.03
8	280.000	279.997	27.6500	27.6895	0.062	-0.14
8	290.000	289.994	34.6500	34.6843	0.045	-0.10

NP = 19, RMSPCT = 1.383

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Table 5. Calculated Ethane Vapor Pressures.

ETHANE VAPOR PRESSURES

T, K	P, ATM	DP/DT	D2P/DT2
89.399	0.0000096	0.0000026	0.00000063
90.000	0.0000099	0.0000026	0.00000064
95.000	0.0000348	0.0000083	0.00000177
100.000	0.0001067	0.0000226	0.00000430
105.000	0.0002918	0.0000555	0.00000942
110.000	0.0007207	0.0001239	0.00001881
115.000	0.0016337	0.0002545	0.00003475
120.000	0.0034347	0.0004868	0.00005997
125.000	0.0067608	0.0008749	0.00009759
130.000	0.012559	0.001489	0.0001508
135.000	0.022167	0.002414	0.0002228
140.000	0.037390	0.003753	0.0003164
145.000	0.060574	0.005618	0.0004339
150.000	0.094659	0.008135	0.0005771
155.000	0.14323	0.01143	0.000747
160.000	0.21052	0.01565	0.000944
165.000	0.30146	0.02091	0.001167
170.000	0.42162	0.02736	0.001415
175.000	0.57722	0.03511	0.001688
180.000	0.77507	0.04428	0.001984
185.000	1.0226	0.0550	0.00230
190.000	1.3276	0.0673	0.00263
195.000	1.6984	0.0813	0.00298
200.000	2.1439	0.0972	0.00335
205.000	2.6731	0.1148	0.00372
210.000	3.2954	0.1344	0.00411
215.000	4.0205	0.1560	0.00451
220.000	4.8585	0.1795	0.00492
225.000	5.8194	0.2052	0.00533
230.000	6.9136	0.2329	0.00576
235.000	8.1519	0.2628	0.00619
240.000	9.5450	0.2948	0.00664
245.000	11.1040	0.3292	0.00710
250.000	12.8406	0.3658	0.00757
255.000	14.7664	0.4049	0.00806
260.000	16.8936	0.4465	0.00858
265.000	19.2357	0.4907	0.00913
270.000	21.8058	0.5378	0.00972
275.000	24.6190	0.5880	0.01036
280.000	27.6914	0.6416	0.01108
285.000	31.0410	0.6990	0.01192
290.000	34.6895	0.7610	0.01294
295.000	38.6612	0.8289	0.01429
300.000	42.9922	0.9053	0.01589
305.000	47.7442	1.0029	0.020894
305.330	48.0770	1.0160	0.020000

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Table 6. Reduced Vapor Pressure Functions.

NAME

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ETHANE REDUCED VAPOR PRESSURE FUNCTIONS

T, K	X	Y	(Y-X)
89.899	0.00	0.00000	0.00000
91.186	0.02	0.02199	0.00199
92.510	0.04	0.04392	0.00392
93.873	0.06	0.06578	0.00578
95.277	0.08	0.08759	0.00759
96.723	0.10	0.10934	0.00934
98.215	0.12	0.13102	0.01102
99.753	0.14	0.15264	0.01264
101.339	0.16	0.17419	0.01419
102.977	0.18	0.19568	0.01568
104.569	0.20	0.21710	0.01710
106.418	0.22	0.23845	0.01845
108.226	0.24	0.25972	0.01972
110.096	0.26	0.28093	0.02093
112.132	0.28	0.30205	0.02205
114.037	0.30	0.32310	0.02310
116.116	0.32	0.34406	0.02406
118.272	0.34	0.36495	0.02495
120.509	0.36	0.38574	0.02574
122.832	0.38	0.40645	0.02645
125.247	0.40	0.42706	0.02706
127.759	0.42	0.44758	0.02758
130.373	0.44	0.46800	0.02800
133.097	0.46	0.48832	0.02832
135.937	0.48	0.50854	0.02854
138.901	0.50	0.52866	0.02866
141.997	0.52	0.54866	0.02866
145.234	0.54	0.56855	0.02855
148.622	0.56	0.58833	0.02833
152.172	0.58	0.60800	0.02800
155.896	0.60	0.62755	0.02755
159.807	0.62	0.64698	0.02698
163.919	0.64	0.66629	0.02629
168.248	0.66	0.68548	0.02548
172.812	0.68	0.70455	0.02455
177.530	0.70	0.72350	0.02350
182.725	0.72	0.74233	0.02233
188.121	0.74	0.76105	0.02105
193.845	0.76	0.77965	0.01965
199.928	0.78	0.79815	0.01815
206.405	0.80	0.81655	0.01655
213.317	0.82	0.83486	0.01486
220.707	0.84	0.85309	0.01309
228.627	0.86	0.87126	0.01126
237.138	0.88	0.88938	0.00938
246.306	0.90	0.90749	0.00749
256.212	0.92	0.92562	0.00562
266.948	0.94	0.94381	0.00381
278.623	0.96	0.96216	0.00216
291.366	0.98	0.98078	0.00078
305.330	1.00	1.00000	0.00000

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PROGRAM PSATFIT
C   ETHANE VAPOR PRESSURES,      X = (1-TT/T)/(1-TT/TC),
C   LN(P/PTRP) = A1*X + A2*X2 + A3*X3 + A4*X4 + A5*X*(1-X)**E.
C   AUTHORS ID = (1)TICKNER, (2)ROSSINI, (3)CARRUTH, (4)PAL/POPE,
C   (5)LOOMIS, (6)PORTER, (7)ZIEGLER, (8)BARKELEW/TESTER
C   (9)POPE, (10)DOUSLIN,PREPRINT(1973).
C
COMMON TTRP,TCRT,PTRP, E,A(9), FZ,F1,F2, DLPDT,D2LPDT2
COMMON/999/NFUN,Y,F(30)
DIMENSION TEMP(130),DELT(130)
DIMENSION IO(999),T(999),TX(999),P(999)
DIMENSION G(30)
1  FORMAT(I5, 2F10.0)
2  FORMAT(1H1 17X *ETHANE VAPOR PRESSURES, E =* F5.2//
1  18X 6HTTRP =F7.3, 8H, TCRT =F8.3//
2  18X 12HPTRP,MUATM =F9.5, 12H, PCRT,ATM =F9.5// 2(15X 3F16.9// )
3  FORMAT(      18X 2HID 4X6HT,XPTL 6X4HT-68 7X5HP,ATM 7X5HCALCD
1  5X5HDEL T  5X5HP,PCT)
4  FORMAT(1H1 17X 2HID 4X6HT,XPTL 6X4HT-68 7X5HP,ATM 7X5HCALCD
1  5X5HDEL T  5X5HP,PCT)
5  FORMAT(15X I5, 2F10.3, 2F12.7, F10.3, F10.2)
6  FORMAT(15X I5, 2F10.3, 2F12.6, F10.3, F10.2)
7  FORMAT(15X I5, 2F10.3, 2F12.5, F10.3, F10.2)
8  FORMAT(15X I5, 2F10.3, 2F12.4, F10.3, F10.2)
9  FORMAT(1H0 17X 4HNP =I4, 10H, RMSPECT =F7.3)
10 FORMAT(F8.0, F9.0, 63X)
11 FORMAT(1H1 16X *ETHANE VAPOR PRESSURES* // 17X3HT,K 6X5HP,ATM
1  6X5HDP/DT 5X7HD2P/DT2 )
12 FORMAT(10X F10.3, 2F11.7, F12.8)
13 FORMAT(10X F10.3, 2F11.6, F12.7)
14 FORMAT(10X F10.3, 2F11.5, F12.6)
15 FORMAT(10X F10.3, 2F11.4, F12.5)
16 FORMAT(1H1 15X *ETHANE REDUCED VAPOR PRESSURE FUNCTIONS* //
1  17X 3HT,K 7X1HX 9X1HY 5X5H(Y-X) )
17 FORMAT(10X F10.3, F8.2, 2F10.5)
18 FORMAT(18X 2HEP 6X2HSS)
19 FORMAT(10X 2F10.4)
C   READ-IN THE T48 - T68 TEMP. CONVERSION TABLE.
20 READ 10, ((TEMP(J),DELT(J)),J=1,130)
21 TTRP=89.899 $ TCRT=305.33 $ PTRP=9.638E-6 $ E=1.5 $ N=0
C
C   READ (7)ZIEGLER, KELVIN, MM HG.
22 DO 24 J=1,99 $ READ 1, IDD,TT,PP $ IF(IDD) 23,25
23 N = N+1 $ ID(N)=IDD $ P(N)=PP/760 $ TX(N)=TT
24 T(N) = T68(TT,DELT,TEMP)
25 NF1 = N
C   READ MIXED (4)PAL, (9)POPE, (10)DOUSLIN DATA.
C   (4)KELVIN,PSIA, (9)KELVIN,ATMOS, (10)CENTIG.,ATMOS.
26 DO 35 J=1,200 $ READ 1, IDD,TT,PP $ IF(IDD) 27,36
27 N = N+1 $ ID(N) = IDD $ IF(IDD-4) 28,30
28 IF(IDD-9) 34,32
30 P(N) = PP/14.69595 $ T(N) = T68(TT,DELT,TEMP)
31 TX(N) = TT $ GO TO 35
32 P(N) = PP $ T(N) = T68(TT,DELT,TEMP)
33 TX(N) = TT $ GO TO 35

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34 P(N) = PP $ T(N) = TX(N) = TT + 273.15
35 CONTINUE
36 NP = N $ NF = 5
C READ (1) DATA, CENTIGRADE, MM HG.
38 DO +3 J=1,99 $ READ 1, IDD,TT,PP $ IF(IDD) 39,41
39 N = N+1 $ ID(N) = IDD $ P(N) = PP/760 $ TX(N) = 273.15 + TT
40 T(N) = T68(TX(N),DELT,TEMP)
41 NP2 = N
C READ (2) DATA, CENTIGRADE, MM HG.
42 DO +4 J=1,99 $ READ 1, IDD,TT,PP $ IF(IDD) 43,45
43 N = N+1 $ ID(N) = IDD $ P(N) = PP/760 $ TX(N) = 273.15 + TT
44 T(N) = T68(TX(N),DELT,TEMP)
45 NP3 = N
C READ (3) DATA, KELVIN, MM HG.
46 DO +8 J=1,99 $ READ 1, IDD,TT,PP $ IF(IDD) 47,49
47 N = N+1 $ ID(N) = IDD $ P(N) = PP/760 $ TX(N) = TT
48 T(N) = T68(TT,DELT,TEMP)
49 NP4 = N
C READ (5) DATA, KELVIN, ATMOS.
50 DO 52 J=1,99 $ READ 1, IDD,TT,PP $ IF(IDD) 51,53
51 N = N+1 $ ID(N) = IDD $ P(N) = PP $ TX(N) = TT
52 T(N) = T68(TT,DELT,TEMP)
53 NP5 = N
C READ (6) DATA, KELVIN, ATMOS.
54 DO 56 J=1,99 $ READ 1, IDD,TT,PP $ IF(IDD) 55,57
55 N = N+1 $ ID(N) = IDD $ P(N) = PP $ TX(N) = TT
56 T(N) = T68(TT,DELT,TEMP)
57 NP6 = N
C READ (8) DATA, KELVIN, ATMOS.
60 DO 62 J=1,99 $ READ 1, IDD,TT,PP $ IF(IDD) 61,63
61 N = N+1 $ ID(N)=IDD $ P(N)=PP $ TX(N)=TT
62 T(N) = T68(TT,DELT,TEMP)
63 NPP = NP7 = N
C
C EXPLORE VALUES FOR PTRP.
79 E = 1.6 $ PRINT 18 $ SSK = 1.0E+010
80 XK = 1 - TTRP/TCRT
81 DO 92 IP=1,26 $ PTR = 9.600 + 0.001*IP $ PTRP = PTR*1.0E-6
82 NFUN = NF $ DO 85 J=1,NP $ X = (1-TTRP/T(J))/XK
83 F(1)=X $ F(2)=X**2 $ F(3)=X**3 $ F(4)=X**4 $ F(5)=X*(1-X)**E
84 Y = LOGF(P(J)/PTRP)
85 CALL FIT $ CALL COEFF $ SS = 0 $ DO 86 K=1,9
86 A(K) = F(K)
87 DO 38 J=1,NP $ PC=PSATF(T(J)) $ SS = SS+(P(J)/PC-1)**2
88 CONTINUE $ SS=100*SQRTF(SS/NP) $ IF(SS.LT.SSK) 89,92
89 SSK=SS $ EK=E $ TCK=TCRT $ TTK=TTRP $ PTK=PTRP
90 DO 31 K=1,9
91 G(K) = F(K)
92 PRINT 19, PTR, SS
93 E=EK $ TCRT=TCK $ TTRP=TTK $ PTRP=PTK $ DO 94 K=1,9
94 A(K) = G(K) $ FCRT = PTRP*EXPF(A(1)+A(2)+A(3)+A(4))
95 PTR = 1.0E6*PTRP

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C   PRINT DEVIATIONS, INCLUDING DT = -DP/(DP/DT).
105 L = 9 $ SS = 0
106 PRINT 2, E, TTRP, TCRT, PTR, PCRT, (A(K), K=1,6) $ PRINT 3
107 DO 125 J=1, NP $ L = L+1 $ IF(L-57) 112, 108
108 L = 0 $ PRINT 4
112 PC = PSATF(T(J)) $ DPDT = PC*DLPDT
113 DP = P(J)-PC $ DT = -DP/DPDT
114 PCT = 100*DP/PC $ SS = SS + PCT**2
117 IF(PC-0.01) 120, 118, 118
118 IF(PC-0.1) 121, 119, 119
119 IF(PC-1.0) 122, 123, 123
120 PRINT 5, ID(J), TX(J), T(J), P(J), PC, DT, PCT $ GOTO 125
121 PRINT 6, ID(J), TX(J), T(J), P(J), PC, DT, PCT $ GOTO 125
122 PRINT 7, ID(J), TX(J), T(J), P(J), PC, DT, PCT $ GOTO 125
123 PRINT 8, ID(J), TX(J), T(J), P(J), PC, DT, PCT
125 CONTINUE
126 SS = SQRTF(SS/NP) $ PRINT 9, NP, SS

C
C   PRINT OTHER DATA DEVIATIONS.
140 K = NP+1 $ SS = N = 0 $ PRINT 4
141 DO 157 J=K, NPP $ IF(J-NPP) 143, 142
142 SS = SQRTF(SS/N) $ PRINT 9, N, SS $ GO TO 158
143 N = N+1 $ PC=PSATF(T(J)) $ DPDT = PC*DLPDT
144 DP = P(J)-PC $ DT = -DP/DPDT
145 PCT = 100*DP/PC $ SS = SS + PCT**2
146 IF(PC-0.01) 150, 147, 147
147 IF(PC-0.1) 151, 148, 148
148 IF(PC-1.0) 152, 153, 153
150 PRINT 5, ID(J), TX(J), T(J), P(J), PC, DT, PCT $ GO TO 155
151 PRINT 6, ID(J), TX(J), T(J), P(J), PC, DT, PCT $ GO TO 155
152 PRINT 7, ID(J), TX(J), T(J), P(J), PC, DT, PCT $ GO TO 155
153 PRINT 8, ID(J), TX(J), T(J), P(J), PC, DT, PCT
155 IF(ID(J+1)-ID(J)) 156, 157
156 SS = SQRTF(SS/N) $ PRINT 9, N, SS $ SS=N=0 $ PRINT 4
157 CONTINUE
158 CONTINUE

C
C   PRINTOUT UNIFORM TABLE FOR PUBLICATION.
200 PRINT 11 $ DO 220 J=1, 46 $ IF(J-1) 202, 201
201 TT = TTRP $ GO TO 205
202 IF(J-46) 204, 203
203 TT = TCRT $ GO TO 205
204 TT = 8J + 5*J
205 PS=PSATF(TT) $ DPDT=PS*DLPDT $ D2PDT2=PS*(DLPDT**2 + D2LDPDT2)
207 IF(PS-0.01) 210, 208, 208
208 IF(PS-0.1) 211, 209, 209
209 IF(PS-1.0) 212, 213, 213
210 PRINT 12, TT, PS, DPDT, D2PDT2 $ GOTO 220
211 PRINT 13, TT, PS, DPDT, D2PDT2 $ GOTO 220
212 PRINT 14, TT, PS, DPDT, D2PDT2 $ GOTO 220
213 IF(J-46) 215, 214
214 D2PDT2 = 0
215 PRINT 15, TT, PS, DPDT, D2PDT2
220 CONTINUE

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C   PRINT UNIFORM REDUCED TABLE.
C   Y = LN(P/PTRP)/YN,   YN = LN(PCRT/PTRP).
C   YC = (A(1)*X + . . . + A(5)*X*(1-X)**E)/YN.
250 XN = 1-TTRP/TCRT $   YN = A(1) + A(2) + A(3) + A(4)
251 PRINT 16 $   DO 270 J=1,51 $   X = 0.02*(J-1)
252 IF(J-1) 254,253
253 TT = TTRP $   GOTO 257
254 IF(J-51) 256,255
255 TT = TCRT $   GOTO 257
256 TT = TTRP/(1-X*XN)
257 IF(J-51) 259,258
258 Z = 0 $   GO TO 260
259 Z = X*(1-X)**E
260 YC = A(5)*Z $   DO 261 K=1,4
261 YC = YC + A(K)*X**K
262 YC = YC/YN $   YX = YC - X
270 PRINT 17, TT, X, YC, YX
999 CONTINUE $   STOP $   END

```

SINGLE-BANK COMPILATION.

FUNCTION PSATF(T)

```

C   LN(P/PTRP) = A1*X + A2*X2 + A3*X3 + A4*X4 + A5*X*(1-X)**E.
C   ARGUMENT, X = (1-TT/T)/(1-TT/TC).
C   YIELDS ALSO DLPDT = (DP/DT)/P, AND D2LPT = (D2P/DT2)/P.
COMMON TTRP,TCRT,PTRP, E,A(9), FZ,F1,F2, DLPDT,D2LPT2
1  FORMAT(1H3 9X *PSATF = 0, T EXCEEDS TCRT. * / )
2  XN=1-TTRP/TCRT $ X=(1-TTRP/T)/XN $ X2=X**2 $ X3=X**3 $ X4=X**4
3  DXDT = TTRP/XN/T**2 $ D2XDT2 = -2*DXDT/T
4  Q = 1-X $ IF(Q) 5,5,7
5  PSATF = DLPDT = D2LPT2 = 0 $ PRINT 1 $ RETURN
6  Z = Z1 = Z2 = 0 $ GOTO 9
7  W = Q**E $ W1 = -E*W/Q $ W2 = (1-E)*W1/Q
8  Z = X*W $ Z1 = X*W1 + W $ Z2 = X*W2 + 2*W1
9  FZ = A(1)*X + A(2)*X2 + A(3)*X3 + A(4)*X4 + A(5)*Z
10 PSATF = PTRP*EXP(FZ)
11 F1 = A(1) + 2*A(2)*X + 3*A(3)*X2 + 4*A(4)*X3 + A(5)*Z1
12 DLPDT = F1*DXDT
13 F2 = 2*A(2) + 6*A(3)*X + 12*A(4)*X2 + A(5)*Z2
15 D2LPT2 = F1*D2XDT2 + F2*DXDT**2 $ RETURN $ END

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FUNCTION T68(X,YMAT,XMAT)
 THIS PROGRAM HAS BEEN CHANGED SO THAT THE OSCILLATING NATURE OF THE MATRIX TO BE INTERPOLATED EXISTS ONLY AT THE UPPER END OF THE TABLE
 THIS ROUTINE WILL TAKE INPUT MATRICES OF UP TO 999 ELEMENTS EACH, ARRANGED SO THAT THE X MATRIX(XMAT) IS IN EITHER ASCENDING OR DESCENDING ORDER, SELECT NMAX OF THESE POINTS, CHOSEN SO THAT SUCESSIVE X VALUES OSCILATE ABOUT THE VALUE OF THE ARGUMENT X UNLESS THE ENDS OF THE XMATRIX INTERFERE (IN THIS CASE THE OSCILLATORY NATURE IS LOST BUT THE PROGRAM WILL STILL PERFORM AN INTERPOLATION), INTERPOLATE ON THESE NMAX PAIRS OF DATA BY AN OSCILATING VARIABLE POINT AITKEN INTERPOLATION ALGORITHM EITHER UNTIL THE PERCENTAGE CHANGE IN THE INTERPOLANT IS LESS THAN THE ACRCY ARGUMENT (THE ARGUMENT NESSY INDICATES THE NUMBER OF THE POINT JUST BEFORE THE LAST ONE CHECKED) OR UNTIL THE NMAX POINTS ARE ALL USED. IT IS SUGGESTED THAT NMAX BE LESS THAN 10, AND OF COURSE LESS THAN NELMTS. NELMTS INDICATES THE NUMBER OF ELEMENTS IN XMAT OR YMAT.
 IF NESSY IS ZERO IT INDICATES THAT THE INTERPOLATION REQUIREMENT HAS NOT BEEN SATISFIED. IF NESSY IS 1 IT MEANS THAT THE VALUE OF X LIES OUT SIDE THE RANGE OF XMAT.
 DIMENSION YMAT(999), XMAT(999), A(21,20)
 100 FORMAT(42HINTERPOLATION REQUIREMENT NOT SATISFIED(X=,E16.8,1H)/33H
 1 LAST 2 APPROXIMATIONS OF Y ARE(Y=,E16.8,1H,,E16.8,1H))
 200 FORMAT(55HTHIS REPRESENTS AN EXTRAPOLATION OF THE XMAT MATRIX(X=, 1E16.8,1H)/33HNO CALCULATION HAS BEEN PERFORMED)
 300 FORMAT(24HNELMTS IS LESS THAN NMAX)
 400 FORMAT(22HNMAX IS LARGER THAN 20)
 NELMTS=130 \$ NMAX=9 \$ ACRCY=0.01
 IF(NMAX-20)71,71,69
 69 WRITE OUTPUT TAPE 6,4)0
 T68 = X \$ RETURN
 71 IF(NMAX-NELMTS)75,75,73
 73 WRITE OUTPUT TAPE 6,3)0
 T68 = X \$ RETURN
 75 CONTINUE
 FIRST TWO SUCCESSIVE VALUES OF THE XMATRIX THAT STRADDLE THE VALUE X WILL BE SOUGHT
 JJ1=NELMTS-1
 DO 2) I=1,JJ1
 DIF1=X-XMAT(I)
 DIF2=XMAT(I+1)-X
 IF(DIF1)16,15,16
 15 T68 = X + YMAT(I)
 NESSY =NMAX
 RETURN
 16 IF(DIF2)18,17,18
 17 T68 = X + YMAT(I+1)
 NESSY =NMAX
 RETURN
 18 RATIO=DIF1/ DIF2
 IF(RATIO)20,20,19
 19 IMID=I
 GO TO 32
 20 CONTINUE

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AT THIS POINT ONE COULD PRINT THE FOLLOWING STATEMENT
WRITE OUTPUT TAPE 6,200,X
NESSY=1
T68 = X $ RETURN
32 CONTINUE
NOTE THAT RATIO IS POSITIVE IF THE TWO POINTS STRADDLE X
REGARDLESS WHICH IS LARGER
JJJ=IMID
JUP=IMID
JDN=IMID
IF(JJJ+NMAX-NELMTS+1)38,98,102
98 DO 201 J=1,NMAX
   JJJ=IMID+J-1
   A(1,J)=XMAT(JJJ)
201 A(2,J)=YMAT(JJJ)
   GO TO 203
102 DO 41 J=1,NMAX
   JJ=J/2
   JOE=J-2*JJ
   JOE IS 0 IF J IS EVEN AND 1 IF J IS ODD
   IF(J-1)33,40,33
33 IF(JDN-1)34,36,34
34 IF(JUP-NELMTS)35,37,35
35 IF(JOE)37,36,37
36 JUP=JUP+1
   JJJ=JUP
   GO TO 40
37 JDN=JDN-1
   JJJ=JDN
   GO TO 40
40 A(1,J)=XMAT(JJJ)
   A(2,J)=YMAT(JJJ)
41 CONTINUE
203 NNN=NMAX+1
   DO 6 J=3,NNN
   L=J-1
   DO 5 K=L,NMAX
   J IS THE COLUMN NUMBER
   K IS THE ROW NUMBER
   A(J,K)=(A(J-1,K)-A(J-1,J-2))*(X-A(1,J-2))/(A(1,K)-A(1,J-2))
1     +A(J-1,J-2)
   IF(K-L)3,2,3
2 IF(ABS((A(J,L)-A(J-1,L-1))/A(J,L))-ACRCY/100.0)7,7,3
3 CONTINUE
5 CONTINUE
6 CONTINUE
NESSY=0
AT THIS POINT ONE COULD PRINT OUT THE FOLLOWING STATEMENT.
WRITE OUTPUT TAPE 6,100,X,A(NNN,NMAX),A(NNN-1,NMAX-1)
T68 = X + A(NNN,NMAX)
RETURN
7 NESSY=J-1
T68 = X + A(J,L) $ RETURN $ END

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*This program by
Rolf Prydz.*

APPENDIX D. (Continued)

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ETHANE VAPOR PRESSURES, E = 1.50 TTRP = 89.899, TCRT = 305.330 PTRP, MUATM = 9.96700, PCRT, ATM = 48.07723							
10.806922651 8.344715938 -3.119603823 -0.642995191 6.059966098 0.000000000							
7/31/73							
ID	T, XPTL	T-68	P, ATM	CALCD	DEL T	P, PCT	
7	90.000	90.010	0.0000103	0.0000103	0.000	-0.01	
7	100.000	100.010	0.0001098	0.0001098	-0.001	0.01	
7	110.000	109.998	0.0007364	0.0007363	-0.001	0.02	
7	120.000	119.989	0.0034934	0.0034939	0.001	-0.01	
7	130.000	129.987	0.012728	0.012732	0.003	-0.04	
7	140.000	139.992	0.037792	0.037803	0.003	-0.03	
7	150.000	150.000	0.095474	0.095476	0.000	-0.00	
7	160.000	160.010	0.21196	0.21192	-0.003	0.02	
7	170.000	170.019	0.42387	0.42369	-0.007	0.04	
7	180.000	180.027	0.77824	0.77783	-0.009	0.05	
7	184.520	184.550	1.00000	0.99944	-0.010	0.06	
9	198.181	198.216	1.9737	1.9761	0.027	-0.12	
4	214.302	214.334	3.9209	3.9159	-0.032	0.13	
4	224.102	224.130	5.6367	5.6402	0.017	-0.06	
4	229.756	229.782	6.8569	6.8598	0.012	-0.04	
4	234.558	234.581	8.0335	8.0392	0.022	-0.07	
9	234.692	234.715	8.0741	8.0741	-0.000	0.00	
10	238.150	238.150	9.0097	9.0077	-0.007	0.02	
9	238.771	238.792	9.1843	9.1905	0.021	-0.07	
4	239.844	239.864	9.4959	9.5019	0.020	-0.06	
4	240.514	240.534	9.6960	9.7003	0.014	-0.04	
10	243.150	243.150	10.5063	10.5045	-0.006	0.02	
4	243.359	243.377	10.5760	10.5764	0.001	-0.00	
4	246.814	246.830	11.7137	11.7162	0.007	-0.02	
4	247.816	247.831	12.0502	12.0628	0.036	-0.10	
10	248.150	248.150	12.1756	12.1747	-0.003	0.01	
4	249.741	249.755	12.7620	12.7496	-0.034	0.10	
4	250.146	250.160	12.8985	12.8976	-0.002	0.01	
4	251.587	251.600	13.4425	13.4344	-0.022	0.06	
4	252.544	252.556	13.8065	13.7997	-0.018	0.05	
10	253.150	253.150	14.0310	14.0301	-0.002	0.01	
4	254.290	254.301	14.4898	14.4848	-0.012	0.03	
4	257.543	257.552	15.8252	15.8266	0.003	-0.01	
10	258.150	258.150	16.0835	16.0827	-0.002	0.00	
10	263.150	263.150	18.3464	18.3452	-0.003	0.01	
4	263.380	263.386	18.4543	18.4573	0.006	-0.02	
4	267.536	267.539	20.5197	20.5145	-0.010	0.03	
10	268.150	268.150	20.8318	20.8308	-0.002	0.00	
4	271.749	271.750	22.7661	22.7662	0.000	-0.00	
9	272.949	272.949	23.4515	23.4394	-0.021	0.05	
10	273.150	273.150	23.5549	23.5536	-0.002	0.01	
4	275.922	275.921	25.1584	25.1702	0.020	-0.05	
4	276.363	276.362	25.4558	25.4347	-0.035	0.08	
4	276.385	276.384	25.4491	25.4479	-0.002	0.00	
4	276.514	276.513	25.5472	25.5257	-0.036	0.08	
4	277.813	277.811	26.3185	26.3189	0.001	-0.00	
10	278.150	278.150	26.5309	26.5290	-0.003	0.01	

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ID	T, XPTL	T-68	P, ATM	CALCD	DEL T	P, PCT
4	280.041	280.038	27.7039	27.7217	0.028	-0.06
4	282.247	282.243	29.1537	29.1647	0.016	-0.04
10	283.150	283.150	29.7763	29.7739	-0.003	0.01
4	284.635	284.630	30.7664	30.7893	0.033	-0.07
9	284.845	284.840	30.9555	30.9353	-0.029	0.07
4	287.653	287.648	32.9289	32.9392	0.014	-0.03
10	288.150	288.150	33.3110	33.3080	-0.004	0.01
4	288.263	288.257	33.3899	33.3872	-0.004	0.01
4	290.040	290.034	34.6873	34.7192	0.042	-0.09
9	290.214	290.208	34.8748	34.8518	-0.030	0.07
4	292.236	292.229	36.4440	36.4216	-0.028	0.06
4	293.098	293.091	37.0816	37.1074	0.032	-0.07
10	293.150	293.150	37.1583	37.1547	-0.005	0.01
9	293.266	293.259	37.2672	37.2422	-0.031	0.07
4	296.347	296.339	39.7598	39.7852	0.030	-0.06
10	298.150	298.150	41.3494	41.3446	-0.005	0.01
4	299.665	299.657	42.6543	42.6808	0.030	-0.06
9	299.863	299.855	42.8863	42.8591	-0.030	0.06
4	300.205	300.196	43.1650	43.1686	0.004	-0.01
4	301.251	301.242	44.1085	44.1274	0.020	-0.04
10	302.150	302.150	44.9809	44.9751	-0.006	0.01
10	303.150	303.150	45.9327	45.9268	-0.006	0.01
4	303.471	303.462	46.2032	46.2273	0.025	-0.05
4	303.477	303.468	46.2798	46.2331	-0.048	0.10
9	304.012	304.002	46.7736	46.7533	-0.021	0.04
4	304.049	304.039	46.7698	46.7896	0.020	-0.04
10	304.150	304.150	46.9040	46.8987	-0.005	0.01
4	304.360	304.350	47.0931	47.0953	0.002	-0.00
4	304.446	304.435	47.2198	47.1802	-0.040	0.08
4	304.519	304.508	47.2025	47.2525	0.050	-0.11
4	304.734	304.723	47.4310	47.4661	0.035	-0.07
4	304.796	304.785	47.5185	47.5280	0.009	-0.02
4	304.924	304.913	47.6846	47.6560	-0.028	0.06
4	304.980	304.969	47.7131	47.7122	-0.001	0.00
4	305.121	305.110	47.8496	47.8541	0.004	-0.01
10	305.150	305.150	47.8992	47.8945	-0.005	0.01
4	305.153	305.142	47.8807	47.8864	0.006	-0.01
10	305.250	305.250	47.9994	47.9958	-0.004	0.01

NP = 85, RMS PCT = 0.050

 $\epsilon = 1.5 \text{ } 7/31/73$

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LABORATORY NOTE		2750364	73-3	22
SUBJECT	The Vapor Pressures of Ethane		NAME	R. D. Goodwin
			DATE	July 9, 1973
ETHANE VAPOR PRESSURES				
T, K	P, ATM	DP/DT	D2P/DT2	
89.899	0.0000100	0.0000027	0.00000064	
90.000	0.0000102	0.0000027	0.00000066	
95.000	0.0000358	0.0000085	0.00000181	
100.000	0.0001095	0.0000232	0.00000439	
105.000	0.0002985	0.0000567	0.00000960	
110.000	0.0007365	0.0001264	0.00001915	
115.000	0.0016670	0.0002592	0.00003529	
120.000	0.0034991	0.0004948	0.00006077	
125.000	0.0068762	0.0008875	0.00009864	
130.000	0.012752	0.001507	0.0001521	
135.000	0.022468	0.002439	0.0002242	
140.000	0.037834	0.003785	0.0003177	
145.000	0.061192	0.005656	0.0004350	
150.000	0.095478	0.008177	0.0005776	
155.000	0.14426	0.01148	0.000747	
160.000	0.21176	0.01569	0.000942	
165.000	0.30288	0.02095	0.001165	
170.000	0.42317	0.02738	0.001412	
175.000	0.57882	0.03511	0.001684	
180.000	0.77662	0.04426	0.001979	
185.000	1.0239	0.0549	0.00229	
190.000	1.3287	0.0672	0.00263	
195.000	1.6991	0.0812	0.00298	
200.000	2.1440	0.0970	0.00334	
205.000	2.6726	0.1147	0.00372	
210.000	3.2943	0.1343	0.00411	
215.000	4.0188	0.1558	0.00451	
220.000	4.8561	0.1794	0.00492	
225.000	5.8165	0.2051	0.00534	
230.000	6.9105	0.2329	0.00577	
235.000	8.1487	0.2628	0.00620	
240.000	9.5420	0.2949	0.00665	
245.000	11.1016	0.3293	0.00711	
250.000	12.8390	0.3660	0.00758	
255.000	14.7659	0.4052	0.00807	
260.000	16.8947	0.4468	0.00858	
265.000	19.2381	0.4910	0.00913	
270.000	21.8098	0.5381	0.00971	
275.000	24.6242	0.5882	0.01034	
280.000	27.6972	0.6416	0.01105	
285.000	31.0467	0.6989	0.01187	
290.000	34.6934	0.7607	0.01288	
295.000	38.6630	0.8283	0.01425	
300.000	42.9905	0.9046	0.01657	
305.000	47.7433	1.0055	0.03283	
305.330	48.0772	1.0228	0.00000	

7/31/73, Via Ziegler "Type B" data

APPENDIX D. (Continued)

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SUBJECT	The Vapor Pressures of Ethane		NAME	R. D. Goodwin
			DATE	July 9, 1973
ETHANE REDUCED VAPOR PRESSURE FUNCTIONS				
T, K	X	Y	(Y-X)	
89.899	0.00	0.00000	0.00000	
91.186	0.02	0.02190	0.00190	
92.510	0.04	0.04376	0.00376	
93.873	0.06	0.06558	0.00558	
95.277	0.08	0.08734	0.00734	
96.723	0.10	0.10906	0.00906	
98.215	0.12	0.13073	0.01073	
99.753	0.14	0.15234	0.01234	
101.339	0.16	0.17389	0.01389	
102.977	0.18	0.19538	0.01538	
104.669	0.20	0.21680	0.01680	
106.418	0.22	0.23816	0.01816	
108.226	0.24	0.25945	0.01945	
110.096	0.26	0.28066	0.02066	
112.032	0.28	0.30180	0.02180	
114.037	0.30	0.32285	0.02285	
116.116	0.32	0.34382	0.02382	
118.272	0.34	0.36471	0.02471	
120.509	0.36	0.38551	0.02551	
122.832	0.38	0.40621	0.02621	
125.247	0.40	0.42682	0.02682	
127.759	0.42	0.44733	0.02733	
130.373	0.44	0.46774	0.02774	
133.097	0.46	0.48805	0.02805	
135.937	0.48	0.50825	0.02825	
138.901	0.50	0.52835	0.02835	
141.997	0.52	0.54833	0.02833	
145.234	0.54	0.56820	0.02820	
148.622	0.56	0.58796	0.02796	
152.172	0.58	0.60760	0.02760	
155.896	0.60	0.62713	0.02713	
159.807	0.62	0.64654	0.02654	
163.919	0.64	0.66583	0.02583	
168.248	0.66	0.68501	0.02501	
172.812	0.68	0.70406	0.02406	
177.630	0.70	0.72301	0.02301	
182.725	0.72	0.74184	0.02184	
188.121	0.74	0.76056	0.02056	
193.845	0.76	0.77917	0.01917	
199.928	0.78	0.79769	0.01769	
206.405	0.80	0.81611	0.01611	
213.317	0.82	0.83445	0.01445	
220.707	0.84	0.85272	0.01272	
228.627	0.86	0.87093	0.01093	
237.138	0.88	0.88910	0.00910	
246.306	0.90	0.90726	0.00726	
256.212	0.92	0.92544	0.00544	
266.948	0.94	0.94369	0.00369	
278.623	0.96	0.96208	0.00208	
291.366	0.98	0.98074	0.00074	
305.330	1.00	1.00000	0.00000	

7/31/73, Via
Ziegler "Type B"
data

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SUBJECT		NAME R. D. Goodwin		
Ethane Virial Coefficients and Saturated Vapor Densities		DATE August 14, 1973		

1. Introduction

The virial equation of state for low densities is needed for thermal computations to generate P-c-T data, and to obtain saturated vapor densities via the vapor pressure equation.

In this report we develop analytical representations for the virial coefficients of ethane and obtain the corresponding saturated vapor densities.

In the truncated virial equation,

$$Z(T, d) \equiv P/(R \cdot T \cdot d) = 1 + B(x) \cdot \sigma + C(x) \cdot \sigma^2 + D(x) \cdot \sigma^3, \quad (1)$$

P is pressure, R the gas constant, T the absolute temperature, d the density, and $\sigma \equiv d/d_c$ is reduced density. The second, third, and fourth coefficients B(x), C(x), D(x) are dimensionless functions of reduced temperature $x \equiv T/T_c$. We use $T_c \equiv 305.33$ K, and $V_c \equiv 1/d_c = 145.56$ cc/mol from Douslin [2]. In the tables we use symbols B*, C* and D* for the coefficients of (1).

2. The Second Virial Coefficient

Data for B(x) through about 1960 are reviewed by Tester [16]. Since then we have data from Gunn [8], Hoover [9], Pope [15], McGlashan [12], and Douslin [2]. Data of Gunn and of Douslin extend from 273 K upwards to 623 K. McGlashan gives outstanding experimental work on the hydrocarbon series (but not on ethane) down to $T/T_c = 0.5$. From his formulations he concludes that the low-temperature data of Eucken and Parts [4] are wrong. This suspicion also was expressed by Ziegler et al. [17].

For least squares we have selected for low temperatures only the data from McGlashan's formula because all other data diverge widely therefrom (Table 2). For high temperatures we have selected Douslin's recent data because the experimental work [2] was executed with great care. Table 2 shows that Michels (1D=3) and Gunn (1D=8) are in substantial agreement with Douslin. For consistency with Douslin, we have increased the absolute values of McGlashan's data by one percent, well within the uncertainty of his $V_c = 148$ cc/mol.

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Ethane Virial Coefficients and Saturated Vapor Densities

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Our formula for $B(x)$, selected from many variations, finally is similar to that developed for methane [6],

$$B(x) = \left[B_1 + B_2/x^{1/4} + B_3/x + B_4/x^2 + B_5/x^3 \right] \cdot \left[1 - (T_0/T)^{1/4} \right], \quad (2)$$

$$T_0 = 740.0 \text{ K},$$

$$B_3 = 9.21 \ 7322,$$

$$B_1 = 7.99 \ 3156,$$

$$B_4 = -2.48 \ 1668,$$

$$B_2 = -10.67 \ 2497,$$

$$B_5 = 0.84 \ 2328.$$

Table 1 gives results for (2) with the data used for least squares: (6) McGlashan; (10) Douslin. Data not used for $\ell.s.$ are compared with (2) in Table 2: (1) Eucken; (2) Lambert; (3) Michels; (4) Hoover; (5) Pope; (8) Gunn.

3. The Third Virial Coefficient

For $C(x)$ relatively few data are known to us. The data of Michels [13] and Hoover [9] were generalized in 1967 by Chueh [1], using a formula similar to that developed by Goodwin [5]. In 1971 Pope [15] gave five low-temperature values from 210 to 306 K. For temperatures above 273 K we are fortunate to have the recent, carefully-derived data of Douslin [2].

A comparison of Chueh's generalized function with Douslin's data at $T/T_c = 2$ shows $C^* = 0.20$ (Chueh), and $C^* = 0.15$ (Douslin). Whereas the Chueh formula gives nearly constant values at high temperatures, the Douslin data are trending asymptotically toward zero.

For least squares we have selected the data of Douslin at high temperatures, and data generated by Chueh's formula at low temperatures. For consistency we have diminished these latter values by two percent. (Chueh fails to give his critical densities.) At low temperatures the third virial coefficient is not important in the computation of eq (1) because the maximum possible density (saturated vapor) is diminishing exponentially with temperature, $e^{-\gamma/T}$, (see Table 4).

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Ethane Virial Coefficients and Saturated Vapor Densities		R. D. Goodwin		
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Our formula for $C(x)$ is much simpler than that of Chueh, and is similar to that developed for methane [6],

$$C(x) = \left[C_1/x + C_2/x^3 + C_3/x^5 \right] \cdot (1 - T_o/T), \quad (3)$$

$$T_o = 217.80 \text{ K}, \quad C_2 = 0.865 \ 299,$$

$$C_1 = 0.253 \ 773, \quad C_3 = 0.556 \ 075.$$

Least squares results are in the upper part of Table 3: (7) Chueh; (10) Douslin. Other data in the lower part are: (4) Hoover; (5) Pope.

4. The Fourth Virial Coefficient

Recent data of Douslin [2] are plotted in Figure 1. The general behavior expected for D^* is shown in the book by Mason and Spurling [11]. As present data exist only at $T > T_c$, we use the simple formula,

$$100 \cdot D^* = x^{-1/4} \cdot \exp[a - b/(x-1)], \quad (4)$$

where $x \equiv T/T_c$, and $a = 4.00$, $b = 1.84$ from Figure 1.

5. Examination of the Virial Equation

It is valuable to know the relative importance of the terms of eq (1). In Table 4 we compute these for the saturated vapor, using densities from the formula of Plank and Kambeitz quoted by Tester [16]. We have increased the P.K. densities by 0.088% to agree with the virial equation at 90 K. Pressures are from our vapor pressure equation [7].

In the fourth column of Table 4 we give the ratio DI/DN of ideal gas density to the P.K. calculated densities. Fifth and sixth columns give $B(x) \cdot \sigma$ and $C(x) \cdot \sigma^2$. If all data were accurate, we should expect $Z(T,d)$ in the last column to be the same as DI/DN .

The vapor pressures of Ziegler [17] were based on second virial coefficients of Eucken and Parts [4], the accuracy of which Ziegler questioned. Our selection for B^* also disagrees with Eucken and Parts. We therefore have recomputed our vapor

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Ethane Virial Coefficients and Saturated Vapor Densities

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pressure constants using alternate vapor pressure data of Ziegler, as shown in the addendum to our Laboratory Note [7]. This revised vapor pressure equation is used in the following to obtain the densities of saturated vapor.

6. Derivation of the Saturated Vapor Densities

For a given temperature we iterate density in the virial equation to obtain a pressure therefrom which is the same as the vapor pressure. Results are in Table 5. In previous work we have found that this method gives acceptable results at densities up to about $\rho_c/3$, which for ethane occurs near $T = 286$ K. We see that data from the Plank-Kambeitz formula diverge increasingly from our results on approach to T_c . The highest temperature at which our results are accurate remains to be seen by comparison with data from other sources. Figure 2 shows, however, that in the region of overlap with Douslin's vapor densities [2], our results (the filled circles) appear reasonable.

Figure 3 shows the results at lower temperatures. We see that powers of $(1/T)$ greater than the first will be needed to describe these data.

7. Discussion of Uncertainties

Experimental uncertainties for virial coefficients vary inversely as the significance of these coefficients in giving departure from ideal gas behavior, see Table 4. For the second coefficient only, for example,

$$\delta B/B = \frac{\delta Z}{Z} \cdot \frac{Z}{Z-1} ,$$

where δB and δZ are small variations in B and Z . Assume a tolerable error of 0.01 percent in Z . From Table 4 we compute the approximate tolerable uncertainty in B , neglecting the effect of $C(T)$,

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<u>T, K</u>	<u>mol/l</u>	<u>$\delta B/B, \%$</u>
100	0.000013	357.0
120	0.000349	21.6
140	0.00327	3.37
160	0.01626	0.915
180	0.05434	0.352
200	0.1401	0.170
220	0.3035	0.096
240	0.5864	0.060
260	1.057	0.040

Not all authors give estimates of uncertainty for experimental virial coefficients. Hoover et al, however, give these estimates for ethane,

<u>T, K</u>	<u>$\delta B/B, \%$</u>	<u>$\delta C/C, \%$</u>
215	1.0	10.0
240	0.4	4.0
273	0.1	1.0

and we believe these to be reasonable estimates for very careful work. In Table 2, however, we see that Hoover's data, ID=4, differ from our selection by up to five percent at low temperatures (215 and 240 K).

Our derived densities depend on the vapor pressure equation. This we estimate to be uncertain by several percent at the lowest temperatures approaching the triple point. The virial equation, on the other hand, approaches ideal gas behavior at these low temperatures. At the higher temperatures above 270 K, we believe the virial coefficients and vapor pressures of Douslin to be accurate as can be derived from the best of PVT measurements.

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8. Bibliography

- [1] P. L. Chueh and J. M. Prausnitz, Third virial coefficients of non polar gases and their mixtures, *AIChE Journal* 13 (5) 896 (1967).
- [2] D. R. Douslin and R. H. Harrison, Pressure-volume-temperature relations of ethane, (U.S. Bureau of Mines, Bartlesville, Okla. 74003). Manuscript for *J. Chem. Thermodynamics*, July, 1973.
- [3] J. H. Dymond and E. B. Smith, *The Virial Coefficients of Gases*, Oxford Science Research Papers 2, Clarendon Press, Oxford, England, (1969).
- [4] A. Eucken and A. Parts, *Z. Phys. Chem.* B20, 184 (1933).
- [5] R. D. Goodwin, D. E. Diller, H. M. Roder, L. A. Weber, Second and third virial coefficients for hydrogen, *J. Res. NBS* 68A (1), 121 (1964).
- [6] R. D. Goodwin, Thermophysical Properties of Methane from 90 to 500 K at Pressures to 700 Bar, NBS Tech. Note, manuscript, April, 1973.
- [7] The Vapor Pressures of Ethane, Laboratory Note 73-3, July 9, 1973.
- [8] R. D. Gunn, M. S. Thesis, University. Calif. (Berkeley), 1958, quoted by J. A. Huff and T. M. Reed, *J. Chem. Eng. Data* 8, 306 (1963).
- [9] A. E. Hoover, I. Nagata, T. W. Leland, R. Kobayashi, Virial coefficients of methane, ethane, and their mixtures at low temperatures, *J. Chem. Phys.* 48 (6), 2633 (1968).
- [10] J. D. Lambert, G. A. H. Roberts, J. S. Rowlinson, V. J. Wilkinson, *Proc. Roy. Soc. (London)* A 196, 113 (1949).
- [11] E. A. Mason and T. H. Spurling, *The Virial Equation of State*, Pergamon Press, Oxford (England), 1969.
- [12] M. L. McGlashan and D. J. B. Potter, An apparatus for the measurement of the second virial coefficients of some n-alkanes and of some mixtures of n-alkanes, *Proc. Roy. Soc. (London)* A267, 478 (1962).
- [13] A. Michels, W. van Straaten and J. Dawson, *Physica* 20, 17 (1954).
- [14] Plank and Kambeitz, *Z. Ges. Kälte Ind.* 10, 209 (1936), quoted by Tester.
- [15] G. A. Pope, Calculation of Argon, Methane and Ethane Virial Coefficients, etc., Thesis, Rice Univ., July 1971.
- [16] H. E. Tester, *ETHANE*, in *Thermodynamic Functions of Gases*, F. Din, Editor, vol. 3, Butterworths, London, 1961.

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- [17] Ziegler, Kirk, Mullins, Berquist, Calculation of the vapor pressures, etc., VII Ethane, Eng. Expt. Sta., Georgia Inst. Tech., Atlanta, Ga., Dec. 1964.
- [18] F. Porter, J. Am. Chem. Soc. 48, 2055 (1926).
- [19] P. Sliwinski, Z. Phys. Chem. 63 263 (1969).
- [20] K. R. Hall and P. T. Eubank, Experimental technique for direct measurement of interaction second virial coefficients, J. Chem. Phys. 59(2), 709 (1973).
- [21] R. D. Goodwin, Estimation of critical constants T_c , ρ_c from the $\rho(T)$ and $T(\rho)$ relations at coexistence, J. Res. NBS 74A(2), 221 (1970).

Table Captions

Table 1. Second virial data of (6) McGlashan, (10) Douslin.

Table 2. Second virial, (1) Eucken, (2) Lambert, (3) Michels, (4) Hoover, (5) Pope, (8) Gunn.

Table 3. Third virial, (7) Chueh, (10) Douslin, (4) Hoover, (5) Pope.

Table 4. Terms of the virial equation for saturated vapor.

Table 5. Saturated vapor densities derived via V.P. and virial equations.

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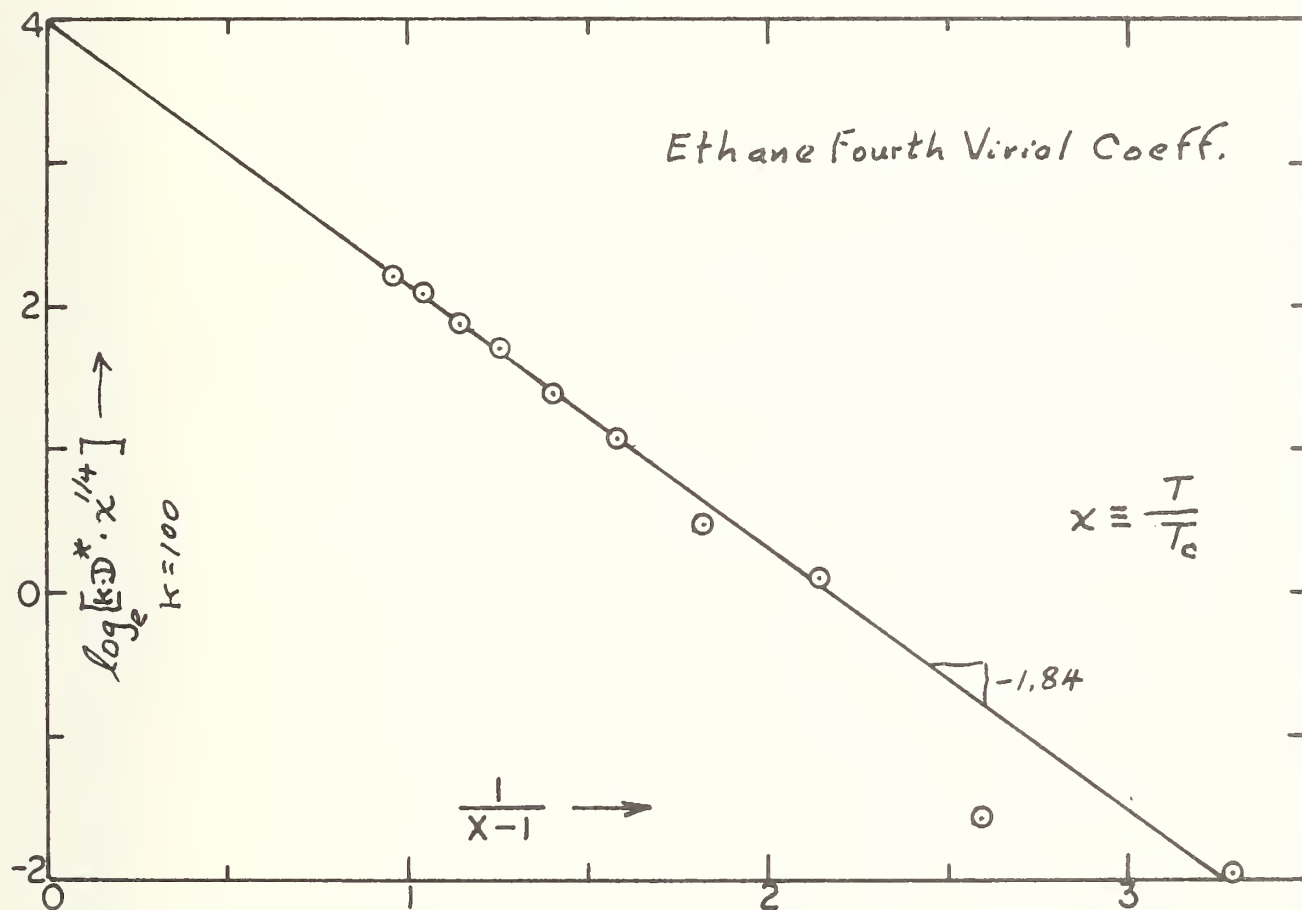


Figure 1. Ethane fourth virial coefficients of Douslin [2],

$$100 \cdot D^* = x^{-1/4} \cdot \exp[4.0 - 1.84/(x-1)].$$

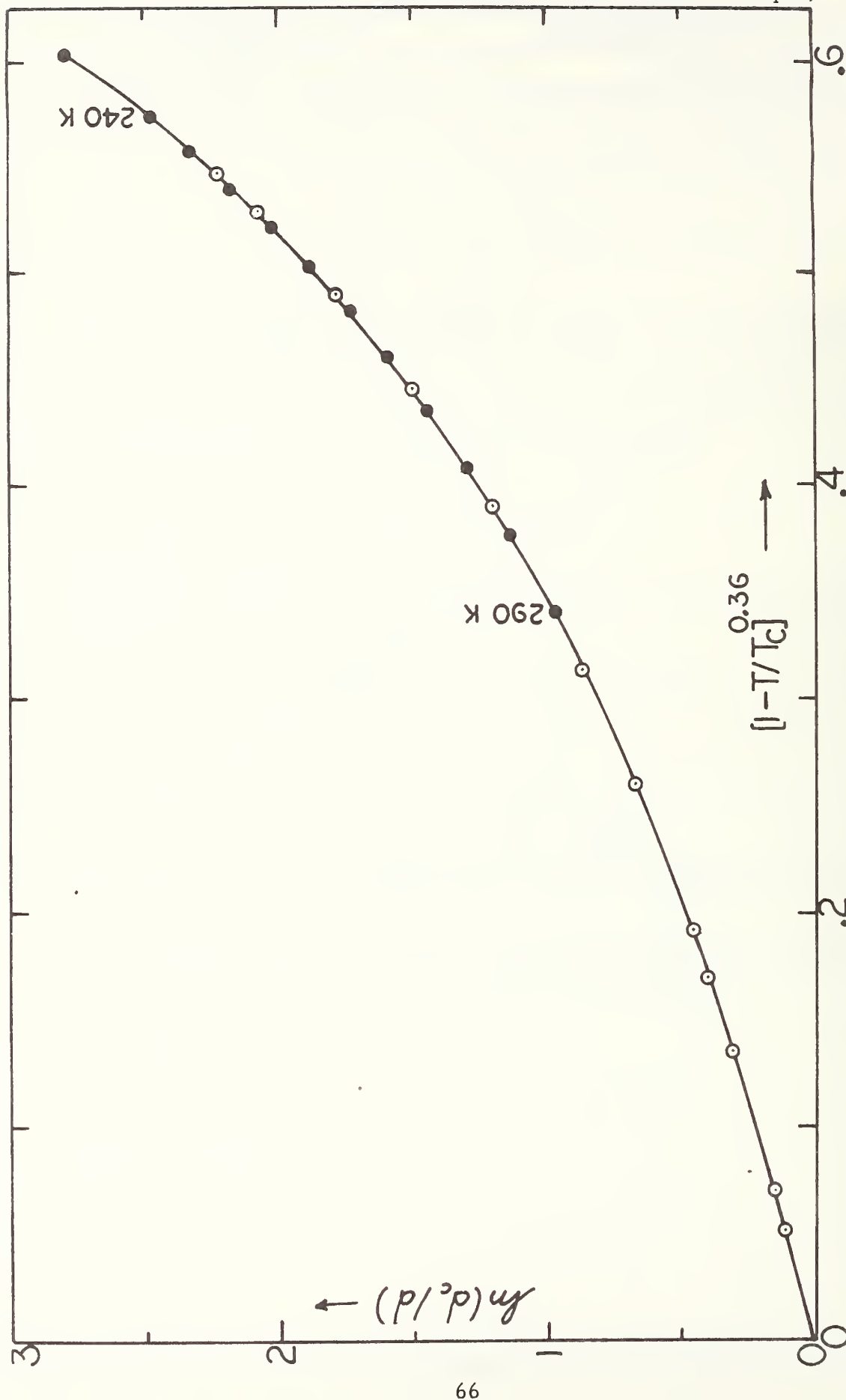


Figure 2. Ethane saturated vapor densities. Open circles from Douslin [2]; filled circles from Table 5, this report.

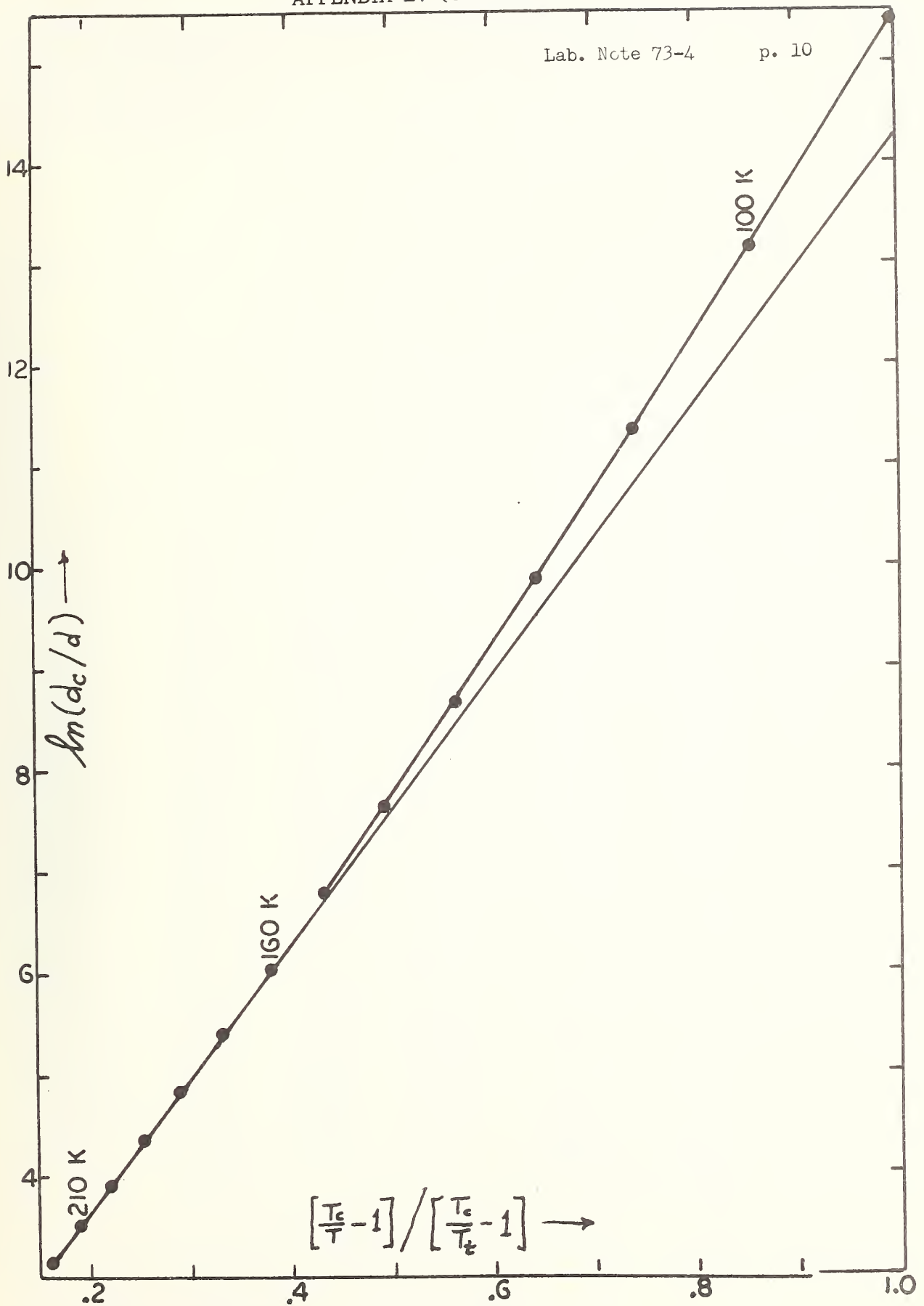


Figure 3. Ethane saturated vapor densities from Table 5, this report.

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Table 1. Second virial data of (6) McGlashan, (10) Douslin.

ETHANE SECOND VIRIAL COEFFICIENT

$$EB = 0.250, TZ = 740.0$$

7.993156 -10.672497 9.217322 -2.481668 0.842328

ID	T, K	T/TC	B*	CALC	DIFF	PCNT
6	150.000	0.4913	-5.309	-5.310	0.001	0.01
6	160.000	0.5240	-4.598	-4.597	-0.001	-0.01
6	170.000	0.5568	-4.031	-4.030	-0.001	-0.02
6	180.000	0.5895	-3.569	-3.569	-0.000	-0.01
6	190.000	0.6223	-3.188	-3.188	0.000	0.01
6	200.000	0.6550	-2.868	-2.869	0.001	0.02
6	210.000	0.6878	-2.597	-2.597	0.001	0.03
6	220.000	0.7205	-2.353	-2.364	0.001	0.03
6	230.000	0.7533	-2.161	-2.162	0.000	0.02
6	240.000	0.7860	-1.984	-1.984	-0.000	-0.00
6	250.000	0.8188	-1.828	-1.828	-0.001	-0.04
6	250.000	0.8515	-1.690	-1.688	-0.002	-0.09
10	273.150	0.8946	-1.527	-1.527	0.001	0.06
10	298.150	0.9765	-1.276	-1.275	-0.001	-0.08
10	303.150	0.9929	-1.232	-1.232	-0.001	-0.05
10	323.150	1.0584	-1.077	-1.076	-0.001	-0.06
10	348.150	1.1402	-0.914	-0.914	0.001	0.08
10	373.150	1.2221	-0.780	-0.781	0.001	0.10
10	398.150	1.3040	-0.668	-0.670	0.001	0.16
10	423.150	1.3859	-0.574	-0.575	0.000	0.06
10	448.150	1.4678	-0.493	-0.493	0.000	0.10
10	473.150	1.5496	-0.423	-0.422	-0.000	-0.08
10	498.150	1.6315	-0.360	-0.360	-0.000	-0.01
10	523.150	1.7134	-0.306	-0.305	-0.001	-0.27
10	548.150	1.7953	-0.256	-0.256	-0.000	-0.19
10	573.150	1.8771	-0.212	-0.212	-0.001	-0.30
10	598.150	1.9590	-0.172	-0.172	-0.000	-0.02
10	623.150	2.0409	-0.135	-0.135	0.001	0.53
NP = 28, MEANPCT = 0.088						

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Table 2. Second Virial, (1) Eucken, (2) Lambert, (3) Michels, (4) Hoover
(5) Pope, (8) Gunn.

ID	T, K	T/TC	B*	CALC	DIFF	PCNT
1	200.000	0.6550	-3.112	-2.869	-0.243	-8.48
2	200.000	0.6550	-3.119	-2.869	-0.250	-8.72
5	209.534	0.6863	-2.533	-2.609	0.076	2.93
1	210.000	0.6878	-2.817	-2.597	-0.219	-8.44
2	210.000	0.6878	-2.817	-2.597	-0.219	-8.44
4	215.000	0.7042	-2.340	-2.477	0.137	5.52
1	220.000	0.7205	-2.542	-2.364	-0.178	-7.52
2	220.000	0.7205	-2.576	-2.364	-0.212	-8.97
1	230.000	0.7533	-2.288	-2.162	-0.126	-5.84
2	230.000	0.7533	-2.343	-2.162	-0.181	-8.38
5	238.763	0.7820	-1.972	-2.005	0.033	1.63
1	240.000	0.7860	-2.095	-1.984	-0.111	-5.61
2	240.000	0.7860	-2.116	-1.984	-0.132	-6.65
4	240.000	0.7860	-1.900	-1.984	0.085	4.26
1	250.000	0.8188	-1.924	-1.828	-0.096	-5.26
2	250.000	0.8188	-1.944	-1.828	-0.117	-6.39
5	254.807	0.8345	-1.733	-1.759	0.026	1.45
1	250.000	0.8515	-1.759	-1.688	-0.070	-4.17
2	250.000	0.8515	-1.786	-1.688	-0.098	-5.80
1	270.000	0.8843	-1.614	-1.564	-0.051	-3.23
2	270.000	0.8843	-1.649	-1.564	-0.085	-5.43
3	273.150	0.8946	-1.521	-1.527	0.006	0.39
4	273.150	0.8946	-1.535	-1.527	-0.007	-0.48
5	273.150	0.8946	-1.507	-1.527	0.020	1.33
8	273.200	0.8948	-1.527	-1.527	0.000	0.02
1	280.000	0.9170	-1.470	-1.452	-0.018	-1.25
2	280.000	0.9170	-1.511	-1.452	-0.059	-4.09
2	290.000	0.9498	-1.408	-1.351	-0.058	-4.26
3	298.138	0.9764	-1.275	-1.275	0.000	0.03
8	298.200	0.9766	-1.284	-1.275	-0.009	-0.71
2	300.000	0.9825	-1.305	-1.259	-0.046	-3.68
5	306.062	1.0024	-1.204	-1.207	0.003	0.27
3	322.748	1.0570	-1.078	-1.079	0.001	0.07
8	323.200	1.0585	-1.082	-1.076	-0.006	-0.60
3	347.652	1.1386	-0.916	-0.917	0.002	0.19
3	372.522	1.2201	-0.784	-0.784	0.001	0.09
8	377.600	1.2367	-0.752	-0.760	0.008	1.10
3	397.844	1.3030	-0.671	-0.671	-0.001	-0.08
8	410.900	1.3458	-0.616	-0.619	0.004	0.61
3	422.700	1.3844	-0.576	-0.576	-0.000	-0.04
8	444.300	1.4551	-0.508	-0.505	-0.003	-0.69
8	477.600	1.5642	-0.423	-0.411	-0.013	-3.09
8	510.900	1.6733	-0.350	-0.331	-0.019	-5.83

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Table 3. Third virial, (7) Chueh, (10) Douslin, (4) Hoover, (5) Pope.

THIRD VIRIAL,

217.800 0.253773 0.865299 0.556075 0.000000

ID	T,K	T/TCRT	C*	CALCD	DIFF
7	210.000	0.5878	-0.251	-0.247	-0.004
7	220.000	0.7205	0.055	0.055	0.000
7	230.000	0.7533	0.249	0.247	0.002
7	240.000	0.7860	0.367	0.366	0.001
7	250.000	0.8188	0.436	0.438	-0.002
7	260.000	0.8515	0.472	0.477	-0.006
10	273.150	0.8946	0.489	0.499	-0.010
10	298.150	0.9765	0.500	0.489	0.011
10	303.150	0.9929	0.491	0.483	0.008
10	323.150	1.0584	0.455	0.453	0.003
10	348.150	1.1402	0.409	0.410	-0.001
10	373.150	1.2221	0.364	0.369	-0.004
10	398.150	1.3040	0.328	0.332	-0.003
10	423.150	1.3859	0.295	0.299	-0.004
10	448.150	1.4678	0.268	0.271	-0.003
10	473.150	1.5496	0.250	0.247	0.002
10	498.150	1.6315	0.228	0.227	0.002
10	523.150	1.7134	0.212	0.209	0.004
10	548.150	1.7953	0.195	0.193	0.002
10	573.150	1.8771	0.182	0.180	0.002
10	598.150	1.9590	0.167	0.168	-0.001
10	623.150	2.0409	0.154	0.157	-0.003

NP = 22, MEANDIFF = 0.004

ID	T,K	T/TCRT	C*	CALCD	DIFF
5	209.534	0.5863	-2.770	-0.264	-2.506
4	215.000	0.7042	-3.356	-0.079	-3.277
5	238.769	0.7820	0.175	0.354	-0.180
4	240.000	0.7860	-0.121	0.366	-0.487
5	254.807	0.8345	0.401	0.460	-0.059
5	273.150	0.8946	0.489	0.499	-0.010
4	273.150	0.8946	0.501	0.499	0.002
4	273.150	0.8946	0.537	0.499	0.038
4	298.138	0.9764	0.507	0.489	0.017
5	306.062	1.0024	0.473	0.479	-0.006
4	322.748	1.0570	0.456	0.453	0.003
4	347.652	1.1386	0.405	0.411	-0.006
4	372.522	1.2201	0.364	0.370	-0.006
4	397.844	1.3030	0.330	0.332	-0.002
4	422.700	1.3844	0.301	0.300	0.001

APPENDIX E. (Continued)

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Table 4. Terms of the virial equation for saturated vapor.

TERMS OF THE VIRIAL EQUATION FOR SATURATED VAPOR

T, K	P, ATM	MOL/L	DI/DN	B*S	C*S2	Z(T,D)
90	0.0000099	0.0000013	0.999996	-0.000004	-0.000000	0.999996
95	0.0000348	0.0000045	0.999987	-0.000011	-0.000000	0.999989
100	0.0001057	0.0000130	0.999966	-0.000028	-0.000000	0.999972
105	0.0002916	0.0000338	0.999920	-0.000064	-0.000000	0.999936
110	0.0007207	0.0000799	0.999831	-0.000133	-0.000000	0.999867
115	0.0016337	0.0001732	0.999670	-0.000256	-0.000000	0.999744
120	0.0034347	0.0003490	0.999398	-0.000462	-0.000000	0.999538
125	0.0067608	0.0006598	0.998969	-0.000787	-0.000000	0.999213
130	0.0125592	0.0011793	0.998323	-0.001276	-0.000001	0.998723
135	0.0221670	0.0020063	0.997397	-0.001982	-0.000002	0.998016
140	0.0373903	0.0032674	0.996119	-0.002961	-0.000005	0.997034
145	0.0605738	0.0051196	0.994420	-0.004276	-0.000009	0.995715
150	0.0946592	0.0077508	0.992228	-0.005991	-0.000016	0.993994
155	0.1432275	0.0113809	0.989479	-0.008171	-0.000026	0.991803
160	0.2105236	0.0162608	0.986113	-0.010882	-0.000042	0.989077
165	0.3014633	0.0226721	0.982082	-0.014185	-0.000063	0.985752
170	0.4216243	0.0309256	0.977343	-0.018141	-0.000090	0.981769
175	0.5772221	0.0413607	0.971866	-0.022806	-0.000124	0.977070
180	0.7750743	0.0543439	0.965625	-0.028233	-0.000164	0.971603
185	1.0225573	0.0702692	0.958606	-0.034470	-0.000206	0.965324
190	1.3275563	0.0895573	0.950796	-0.041563	-0.000248	0.958189
195	1.6984137	0.1126577	0.942186	-0.049554	-0.000281	0.950164
200	2.1438785	0.1400503	0.932771	-0.058485	-0.000299	0.941217
205	2.6730575	0.1722494	0.922541	-0.068395	-0.000287	0.931318
210	3.2953721	0.2098093	0.911484	-0.079325	-0.000230	0.920445
215	4.0205218	0.2533319	0.899587	-0.091321	-0.000107	0.908571
220	4.8584553	0.3034770	0.886826	-0.104432	0.000108	0.895676
225	5.8193516	0.3609763	0.873177	-0.118715	0.000448	0.881732
230	6.9136108	0.4266509	0.858605	-0.134238	0.000952	0.866714
235	8.1518573	0.5014347	0.843069	-0.151085	0.001671	0.850586
240	9.5449551	0.5864036	0.826523	-0.169358	0.002667	0.833309
245	11.1040386	0.6828144	0.808912	-0.189185	0.004017	0.814832
250	12.8405603	0.7921552	0.790174	-0.210725	0.005818	0.795093
255	14.7663588	0.9162120	0.770240	-0.234180	0.008194	0.774014
260	16.8937542	1.0571595	0.749033	-0.259804	0.011305	0.751500
265	19.2356771	1.2176851	0.726466	-0.287925	0.015361	0.727436
270	21.8058475	1.4011641	0.702440	-0.318963	0.020642	0.701679
275	24.6190249	1.6119133	0.676839	-0.353469	0.027531	0.674063
280	27.6913739	1.8555713	0.649528	-0.392177	0.036563	0.644386
285	31.0410283	2.1396901	0.620339	-0.436086	0.048505	0.612418
290	34.6890345	2.4747097	0.589059	-0.486600	0.064498	0.577898
295	38.6611522	2.8756823	0.555393	-0.545771	0.086320	0.540549
300	42.9921502	3.3657409	0.518891	-0.616818	0.116916	0.500098
305	47.7441963	3.9859334	0.478608	-0.705645	0.161805	0.456160

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Table 5. Saturated vapor densities derived via V.P. and virial equations.

ETHANE SATD. VAPOR DENSITIES VIA V.P. AND VIRIAL EQNS.

ID	T,K	P,ATM	PLANK/KAMB	MOL/L	PCT
1	89.899	9.9670-006	1.3511-006	1.3511-006	0.00
1	90.000	1.0238-005	1.3863-006	1.3863-006	0.00
1	95.000	3.5808-005	4.5936-006	4.5936-006	0.00
1	100.000	1.0952-004	1.3347-005	1.3347-005	0.00
1	105.000	2.9851-004	3.4649-005	3.4648-005	0.00
1	110.000	7.3654-004	8.1615-005	8.1612-005	0.00
1	115.000	1.6670-003	1.7671-004	1.7670-004	0.01
1	120.000	3.4991-003	3.5558-004	3.5552-004	0.01
1	125.000	6.8762-003	6.7110-004	6.7093-004	0.02
1	130.000	1.2752-002	1.1974-003	1.1970-003	0.04
1	135.000	2.2468-002	2.0336-003	2.0323-003	0.06
1	140.000	3.7834-002	3.3064-003	3.3033-003	0.09
1	145.000	6.1192-002	5.1721-003	5.1653-003	0.13
1	150.000	9.5478-002	7.8184-003	7.8043-003	0.18
1	155.000	1.4426-001	1.1464-002	1.1436-002	0.24
1	160.000	2.1176-001	1.6358-002	1.6308-002	0.31
1	165.000	3.0288-001	2.2781-002	2.2694-002	0.38
1	170.000	4.2317-001	3.1042-002	3.0899-002	0.46
1	175.000	5.7882-001	4.1479-002	4.1252-002	0.55
1	180.000	7.7662-001	5.4457-002	5.4111-002	0.64
1	185.000	1.0239+000	7.0359-002	6.9860-002	0.73
1	190.000	1.3287+000	8.9635-002	8.8911-002	0.81
1	195.000	1.6991+000	1.1271-001	1.1171-001	0.89
1	200.000	2.1440+000	1.4006-001	1.3872-001	0.97
1	205.000	2.6726+000	1.7222-001	1.7047-001	1.03
1	210.000	3.2943+000	2.0973-001	2.0750-001	1.08
1	215.000	4.0186+000	2.5321-001	2.5043-001	1.11
1	220.000	4.8561+000	3.0331-001	2.9993-001	1.13
1	225.000	5.8165+000	3.6077-001	3.5674-001	1.13
1	230.000	6.9105+000	4.2642-001	4.2173-001	1.11
1	235.000	8.1487+000	5.0120-001	4.9585-001	1.08
1	240.000	9.5420+000	5.8618-001	5.8025-001	1.02
1	245.000	1.1102+001	6.8262-001	6.7626-001	0.94
1	250.000	1.2839+001	7.9203-001	7.8551-001	0.83
1	255.000	1.4766+001	9.1618-001	9.0997-001	0.68
1	260.000	1.6895+001	1.0572+000	1.0522+000	0.48
1	265.000	1.9238+001	1.2179+000	1.2154+000	0.21
1	270.000	2.1810+001	1.4016+000	1.4041+000	-0.18
1	275.000	2.4624+001	1.6125+000	1.6245+000	-0.74
1	280.000	2.7697+001	1.8563+000	1.8861+000	-1.58
1	285.000	3.1047+001	2.1404+000	2.2047+000	-2.91
1	290.000	3.4693+001	2.4754+000	2.6108+000	-5.19

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PROGRAM VIRUS

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C  ETHANE VIRIAL COEFFICIENTS,  X = T/TCRT,  Q = X**1/2,
C  BV = (B1 + B2/X**EB + B3/X + B4/X2 + B5/X3)*(1-(TZ/T)**1/4).
C  CV = (C1/X**EC + C2/X3 + C3/X5)*(1-TZ/T).
C  I), (1)EUCKEN, (2)LAMBERT, (3)MICHELS, (4)HOOVER, (5)POPE,
C  (6)MCGLASHAN, (7)CHUEH, (8)GUNN, (10)DOUSLIN, PREPRINT.
C  VCRT, CC/MOL, ROSSINI(1953)/MCGLASHAM=148, EUBANK/POPE=146.2,
C  TESTER(1961)=141.7, DOUSLIN(1973)=145.56.
COMMON/1/M,EB,EC,TZB,TZC,BVS,CVS,B(5),C(4)
COMMON/3/ DPSDT
COMMON/999/NP,NF,H(15),Y(200),G(200,15)
DIMENSION ID(200),T(200),BV(200),CV(200),X(200),XQ(200)
1  FORMAT(I5, 2F10.0)
2  FORMAT(1H1 13X 1HM 5X54E(BC) 8X2HTZ 8X2HSS)
3  FORMAT(10X I5, 2F10.3, F10.4)
4  FORMAT(1H1 17X *ETHANE SECOND VIRIAL COEFFICIENT*//
1  18X4HEB =F6.3, 5H, TZ =F6.1// 15X 5F12.6//
2  18X2HID 7X3HT,K 5X4HT/TC 7X2HB* 5X4HCALC 5X4HDIFF 5X4HPCNT)
5  FORMAT(15X I5, F10.3, =9.4, 3F9.3, F9.2)
6  FORMAT(1H117X*THIRD VIRIAL, M =*I2, 6H, EC =F6.3// 16X F10.3,
1  4F11.6// 18X2HID 7X3HT,K 4X6HT/TCRT 8X24C* 5X5HCALCD 6X4HDIFF )
7  FORMAT(15X I5, F10.3, F10.4, 3F10.3)
8  FORMAT(18X 4HNP =I3, 12H, MEANDIFF = F7.3)
9  FORMAT(18X 4HNP =I3, 11H, MEANPCT =F6.3)
10 FORMAT(1H1 15X*TERMS OF THE VIRIAL EQUATION FOR SATURATED VAPOR*//
1  17X3HT,K 7X5HP,ATM 7X5HMOL/L 5X5HDI/DN
2  7X3HB*S 5X4HC*S2 4X6HZ(T,D) )
11 FORMAT(10X F10.0, 2F12.7, 4F10.6)
12 FORMAT(1H1 17X 24ID 7X3HT,K 5X4HT/TC 7X2HB* 5X4HCALC
1  5X4HDIFF 5X4HPCNT)
13 FORMAT(1H117X2HID 7X3HT,K 4X6HT/TCRT 8X2HC* 5X5HCALCD 6X4HDIFF)
15 TTR=89.899 $ TCRT=305.33 $ DCRT=1.0/145.56
C  GENERATE MCGLASHAM DATA FOR BV(T), CC/MOL.
C  INCREASE ABS(MCGLASHAM) BY ONE PERCENT (148/145.56 = 1.017).
16 N=0 $ DO 19 J=1,12 $ N = N+1 $ TT = T(N) = 140 + 10*J
17 X(N)=TT/TCRT $ XQ(N)=SQRTF(X(N)) $ ID(N) = 6
18 BV(N) = 1.01*GLABF(TT) $ Y(N) = BV(N)*DCRT
19 CONTINUE
C  READ DOUSLIN(1973) DATA, CC/MOL.
20 DO 23 J=1,99 $ READ 1, IDD,TT,BB $ IF(IDD) 21,24
21 N = N+1 $ ID(N)=IDD $ T(N)=TT $ BV(N)=BB
22 X(N)=TT/TCRT $ XQ(N)=SQRTF(X(N)) $ Y(N)=BB*DCRT
23 CONTINUE
24 NP = N $ NF = 5 $ SSK = 1.0E+010
C  READ SECOND VIRIAL DATA.
25 DO 28 J=1,99 $ READ 1, IDD,TT,BB $ IF(IDD) 26,29
26 N = N+1 $ ID(N)=IDD $ T(N)=TT $ BV(N)=BB
27 X(N)=TT/TCRT $ XQ(N)=SQRTF(X(N)) $ Y(N)=BB*DCRT
28 CONTINUE
29 NPP = N $ M = 0
C  EXPLORE VALUES FOR EB AND FOR TZB.
C  MCGLASHAM TZB NEAR 2.7*TCRT = 824 K.
30 EB = 0.25 $ TZ = TZB = 740 $ PRINT 2
31 DO 44 IE=1,3 $ EB = 0.25*IE
32 DO 44 IT=1,17 $ TZ = 640 + 10*IT

```

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33 DO 36 J=1,NP $ U=X(J) $ Q=XQ(J) $ W = 1-(TZ/T(J))**0.25
34 G(J,1)=W $ G(J,2)=W/U**EB $ G(J,3)=W/U $ G(J,4)=W/U**2
35 G(J,5)=W/U**3
36 CONTINUE $ CALL EGENFT $ SS = 0
37 DO 39 J=1,NP $ YC = 0 $ DO 38 K=1,NF
38 YC = YC + H(K)*G(J,K)
39 SS = SS + ABSF(Y(J)/YC-1) $ SS = 100*SS/NP
40 IF(SS.LT.SSK) 41,44
41 SSK=SS $ EK=EB $ TK=TZ $ DO 42 K=1,5
42 B(K) = H(K)
44 PRINT 3, M,EB,TZ,SS $ EB=EK $ TZ=TK $ SS = 0
C   USE SAVED CONSTANTS FOR DEVIATIONS.
45 PRINT 4, EB, TZ, (B(K),K=1,5)
46 DO 51 J=1,NPP $ U=X(J) $ Q=XQ(J) $ W = 1-(TZ/T(J))**0.25
47 YC = W*(B(1) + B(2)/U**EB + B(3)/U + B(4)/U**2 + B(5)/U**3)
48 DIF=Y(J)-YC $ PCT=-100*DIF/YC $ SS=SS+ABSF(PCT)
49 PRINT 5, ID(J),T(J),X(J),Y(J),YC,DIF,PCT $ IF(J-NP) 51,50
50 SS = SS/NP $ PRINT 9, NP,SS $ PRINT 12
51 CONTINUE $ N = 0
C   GENERATE THIRD VIRIAL DATA VIA CHUEH(1967), ID = 7.
C   DIMINISH CHUEH DATA BY 2 PERCENT.
52 DO 55 J=1,5 $ N = N+1 $ TT = T(N) = 200 + 10*J
53 X(N)=TT/TCRT $ XQ(N)=SQRTF(X(N)) $ ID(N) = 7
54 CV(N) = 0.98*CHUCF(TT) $ Y(N) = CV(N)*DCRT**2
55 CONTINUE $ K = N + 1
C   READ DOUSLIN(1973) DATA, (CC/MOL)**2.
56 DO 58 J=K,99 $ READ 1, ID(J),T(J),CV(J) $ IF(ID(J)) 57,59
57 X(J)=T(J)/TCRT $ XQ(J)=SQRTF(X(J)) $ Y(J)=CV(J)*DCRT**2
58 CONTINUE
59 NP = J-1 $ NF = 3 $ SSK = 1.0E+010
C   READ THIRDO VIRIAL DATA. TZC NEAR 220 K.
60 K = NP+1 $ DO 63 J=K,99
61 READ 1, ID(J),T(J),CV(J) $ IF(ID(J)) 62,64
62 X(J) = T(J)/TCRT $ XQ(J)=SQRTF(X(J)) $ Y(J)=CV(J)*DCRT**2
63 CONTINUE
64 NPP = J-1 $ EC = 1.0 $ PRINT 2
C   EXPLORE VALUES FOR EC AND FOR TZ.
C   65 DO 76 IE=1,4 $ EC = 0.5*IE
66 DO 76 IT=1,11 $ TZ = 217.60 + 0.05*IT
67 DO 59 J=1,NP $ U = X(J) $ W = 1-TZ/T(J)
68 G(J,1)=W/U**EC $ G(J,2)=W/U**3 $ G(J,3)=W/U**5
69 CONTINUE $ CALL EGENFT $ SS = 0
70 DO 72 J=1,NP $ YC = 0 $ DO 71 K=1,NF
71 YC = YC + H(K)*G(J,K)
72 SS = SS + ABSF(Y(J)-YC) $ SS = SS/NP
73 IF(SS.LT.SSK) 74,76
74 SSK=SS $ TK=TZ $ EK=EC $ MK=M $ DO 75 K=1,4
75 C(K) = H(K)
76 PRINT 3, M,EC,TZ,SS $ M = MK
77 TZC = TZ $ EC = EK $ SS = 0
C   USE SAVED CONSTANTS FOR DEVIATIONS.
79 PRINT 6, M,EC,TZ, (C(K),K=1,4)
80 DO 85 J=1,NPP $ U = X(J) $ W = 1-TZ/T(J)
81 YC = W*(C(1)/U**EC + C(2)/U**3 + C(3)/U**5)
82 PCT = Y(J)-YC $ SS = SS + ABSF(PCT)

```

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APPENDIX E. (Continued)

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83 PRINT 7, ID(J),T(J),X(J),Y(J),YC,PCT \$ IF(J-NP) 85,84

84 SS = SS/NP \$ PRINT 8, NP,SS \$ PRINT 13

85 CONTINUE

C NOW EXAMINE TERMS OF THE VIRIAL EQUATION AT SATURATION.

C THE IDEAL GAS DENSITY IS $DI = P/(R*T)$,

90 PRINT 10 \$ DO 95 J=1,44 \$ TT = 85 + 5*J

91 PS=PSATF(TT) \$ DN=DNGSF(TT) \$ Z = ZIPF(TT,DN)

92 DI = PS/TT/0.082056156 \$ DR = DI/DN

95 PRINT 11, TT,PS,DN, DR, BVS,CVS, Z

99 STOP \$ END

SINGLE-BANK COMPILATION.

FUNCTION CHUCF(T)

C ETHANE THIRD VIRIAL VIA CHUEH FORMULA(1967), (CC/MOL)**2.

C $CV(T)/VCRT**2 = FA*FB + FC$, $FA = A/Q + B/X5$,C $FB = 1 - EXP(1-AL*X2)$, $FC = EXP(-C + D*X - E*X2)$, $X = T/TCRT$.

DATA (TCRT=305.33), (VCRT=145.56), (AL=1.89)

DATA (A=0.232), (B=0.468), (C=2.49), (D=2.30), (E=2.70)

1 X=T/TCRT \$ Q=SQRTE(SQRTE(X)) \$ X2=X**2 \$ X5=X**5

2 FA = A/Q + B/X5 \$ FB = 1 - EXPF(1-AL*X2)

3 FC = EXPF(-C + D*X - E*X2)

4 CHUCF = (FA*FB+FC)*VCRT**2 \$ RETURN \$ END

FUNCTION DNGSF(T)

C $P \text{ LANC/KAMBEITZ VIA TESTER (P.171)/DIN. VALID 170 TO 305 K.}$ C $V = R*T/P - C1/X**A - C2*P**2/X**B$, $X = T/100$,

C V IN CC/GRAM, T IN KELVINS, P IN KG/CM**2,

C 1 AT1 = 1.03323 KG/CM**2, R=2.822, C1=89.0, C2=27.9, A=2.4, B=9.0

DATA (R=2.822), (C1=89.0), (C2=27.9), (A=2.4), (B=9.0), (WM=30.07)

1 P = PSATF(T) \$ P = 1.03323*P \$ P2 = P**2

2 X = T/100 \$ XA = X**A \$ XB = X**B

3 V = R*T/P - C1/XA - C2*P2/XB

4 DNGSF = 1000.88/V/WM \$ RETURN \$ END

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FUNCTION GLABF(T)

C ETHANE SECOND VIRIAL COEFF. VIA MC GLASHAM FORMULA (1962).
 C MC G. BELIEVES EUCKEN/PARTS ARE WRONG.
 C $3V(T)/VCRT = B1 - B2/X - B3/X^2 - B4/X^{**4.5}$, $X = T/TCRT$.
 DATA (TCRT=305.4), (VCRT=148.0)
 DATA (B1=0.430), (B2=0.886), (B3=0.694), (B4=0.0375)
 1 $X=T/TCRT$ \$ $X2=X^{**2}$ \$ $X4=X^{**4.5}$
 2 $F = B1 - B2/X - B3/X^2 - B4/XN$
 9 GLABF = VCRT*F \$ RETURN \$ END

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FUNCTION PSATF(T)

C $LN(P/PTRP) = A*X + B*X^2 + C*X^3 + D*X^4 + E*X*(1-X)^{**EP}$.
 COMMON/3/ DPSDT
 DATA (TTRP=89.899), (TCRT=305.33), (PTRP=9.616E-6), (EP=1.6)
 DATA (A=8.454987344), (B=12.488039775), (C=-4.104281551),
 1 (D=-1.413860533), (E=8.526522526)
 1 FORMAT(1H0 9X *PSATF = 0, T EXCEEDS TCRT. * /)
 2 $XN=1-TTRP/TCRT$ \$ $X=(1-TTRP/T)/XN$ \$ $X2=X^{**2}$ \$ $X3=X^{**3}$ \$ $X4=X^{**4}$
 3 $DXDT = TTRP/XN/T^{**2}$ \$ $Q = 1-X$ \$ IF(Q) 4,5,6
 4 PSATF = DPSDT = J \$ PRINT 1 \$ RETURN
 5 Z = Z1 = 0 \$ GO TO 7
 6 $W = Q^{**EP}$ \$ $W1 = -EP*W/Q$ \$ $Z = X*W$ \$ $Z1 = W + X*W1$
 7 $F = A*X + B*X^2 + C*X^3 + D*X^4 + E*Z$
 8 $F1 = A + 2*B*X + 3*C*X^2 + 4*D*X^3 + E*Z1$
 9 PSATF=PTRP*EXPF(F) \$ DPSDT=F1*PSATF*DXDT \$ RETURN \$ END

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FUNCTION ZIPF(T,J)

C $Z(T,J) = 1 + BV(T)*S + 3V(T)*S^{**2}$, $S = D/DCRT$, $X = T/TCRT$.
 C $BV = (B1 + B2/X^{**EB} + B3/X + B4/X^2 + B5/X^3)*(1-(TZ/T)^{**1/4})$.
 C $3V = (C1/X^{**EC} + C2/X^3 + C3/X^5)*(1-TZ/T)$.
 COMMON/1/M,EB,EC,TZB,TZC, BVS,CVS, B(5),C(4)
 DATA (TCRT=305.33), (VCRT=0.14556)
 1 $S=D*VCRT$ \$ $X=T/TCRT$ \$ $Q=SQRTF(X)$ \$ $R=X^{**EC}$
 2 $X2=X^{**2}$ \$ $X3=X^{**3}$ \$ $X4=X^{**4}$ \$ $X5=X^{**5}$
 3 $ZB = 1 - (TZB/T)^{**0.25}$ \$ $ZC = 1 - TZC/T$
 4 $BV = ZB*(B(1) + B(2)/X^{**EB} + B(3)/X + B(4)/X^2 + B(5)/X^3)$
 5 $CV = ZC*(C(1)/R + C(2)/X^3 + C(3)/X^5)$
 6 $BVS = BV*S$ \$ $CVS = CV*S^{**2}$
 7 ZIPF = 1 + BVS + CVS \$ RETURN \$ END

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PROGRAM VAPORDEN

```

C   ETHANE SATVAPORDEN VIA V.P. AND VIRIAL EQNS.
C   ON ISOTHERMS, ITERATE DEN IN VIRIAL EQN. TO MINIMIZE (P-PSAT).
COMMON/3/ DPSOT
1  FORMAT(18X *ETHANE SATD. VAPOR DENSITIES VIA V.P. AND VIRIAL EQNS.
1  *//18X2HID 7X3HT,K 7X5HP,ATM 2X10HPLANK/KAMB 7X5HMOL/L 7X3HPCT)
2  FORMAT(15X I5, F10.3, 3E12.4, F10.2)
3  FORMAT(I5, F10.3, 2E15.5)
19 ID = 1 $ TTRP = 89.893 $ PRINT 1
20 DO 30 J=1,42 $ IF(J-1) 23,22
22 I = TTRP $ GO TO 24
23 T = 30 + 5*J
24 DI = DNGSF(T) $ P = PSATF(T) $ DEN = FINDF(T,P,DI)
25 PUNCH 3, ID, T, DEN, P
27 DIF = DI-DEN $ PCT = 100*DIF/DEN
29 PRINT 2, ID, T, P, DI, DEN, PCT
30 CONTINUE $ STOP $ END

```

SINGLE-BANK COMPILATION.

FUNCTION FINDF(T,P,DI)

```

C   ON ISOTHERM T, ITERATE DEN TO MINIMIZE (P-PCALC).
COMMON JZDS
DATA (GK=0.082056156), (VCRT=0.14556)
1  FORMAT(1H0 9X *FINDF = 0, FAILS TO CONVERGE.* / )
2  D = DI $ GT = GK*T $ DO 9 J=1,50
3  Z = ZIPF(T,D) $ PC = D*GT*Z $ DP = P-PC $ AP = ABSF(DP)
4  Q = AP/P-1.0E-6 $ IF(Q) 10,10,5
5  DPDD = GT*(Z + D*JZDS*VCRT) $ ADP = ABSF(DPDD)
6  Q = AP/ADP/D-1.0E-6 $ IF(Q) 10,10,7
7  D = D + DP/DPDD $ IF(D) 8,8,9
8  D = P/T/GK
9  CONTINUE $ FINDF = 0 $ PRINT 1 $ RETURN
10 FINDF = D $ RETURN $ END

```


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```

FUNCTION DNGSF(T)
C PLANK/KAMBEITZ VIA TESTER.
  DATA (R=2.822), (C1=39.0), (C2=27.9), (A=2.4), (IB=9), (WM=30.07)
  1 P = 1.03323*PSATF(T) $ P2 = P**2
  2 X = T/100 $ XA = X**A $ XB = X**IB
  3 V = R*T/P - C1/XA - C2*P2/XB
  4 DNGSF = 1000.88/V/WM $ RETURN $ END

```

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```

FUNCTION PSATF(T)
C LN(P/PTRP) = A*X + B*X2 + C*X3 + D*X4 + E*X*(1-X)**EP.
COMMON/3/ DPSDT
C CONSTANTS VIA ZIEGLER TYPE B V.P. DATA.
  DATA (TTRP=89.899), (TCRT=305.33), (PTRP=9.967E-6), (EP=1.5)
  DATA (A=10.806922651), (B=8.344715938), (C=-3.119603823)
  DATA (D=-0.642995191), (E=6.059966098)
  1 FORMAT(1H0 9X *PSATF = 0, T EXCEEDS TCRT. * / )
  2 XN=1-TTRP/TCRT $ X=(1-TTRP/T)/XN $ X2=X**2 $ X3=X**3 $ X4=X**4
  3 DXDT = TTRP/XN/T**2 $ Q = 1-X $ IF(Q) 4,5,6
  4 PSATF = DPSDT = 0 $ PRINT 1 $ RETURN
  5 Z = Z1 = 0 $ GO TO 7
  6 W = Q**EP $ W1 = -EP*W/Q $ Z = X*W $ Z1 = W + X*W1
  7 F = A*X + B*X2 + C*X3 + D*X4 + E*Z
  8 F1 = A + 2*B*X + 3*C*X2 + 4*D*X3 + E*Z1
  9 PSATF=PTRP*EXP(F) $ DPSDT=F1*PSATF*DXDT $ RETURN $ END

```

```

FUNCTION ZIPF(T,D)
C Z(T,D) = 1 + BV(X)*S + CV(X)*S**2.
C BV = (B1 + B2/Q + B3/X + B4/X2 + B5/X3)*(1-(TZB/T)**1/4).
C CV = (C1/X + C2/X3 + C3/X5)*(1-TZC/T).
COMMON DZDS
  DATA (TCRT=305.33), (VCRT=0.14556), (TZB=740.0), (TZC=217.8),
  1 (B1=7.993156), (B2=-10.672497), (B3=9.217322), (B4=-2.481668),
  2 (B5=0.342328), (C1=0.253773), (C2=0.865299), (C3=0.556075)
  1 S=U*VCRT $ X=T/TCRT $ Q=X**0.25 $ X2=X**2 $ X3=X**3 $ X5=X**5
  2 ZB = 1 - (TZB/T)**0.25 $ ZC = 1 - TZC/T
  3 BV = ZB*(B1 + B2/Q + B3/X + B4/X2 + B5/X3)
  4 CV = ZC*(C1/X + C2/X3 + C3/X5)
  5 ZIPF = 1 + BV*S + CV*S**2 $ DZDS = BV + 2*CV*S
  6 RETURN $ END

```

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DATE

Sept. 18, 1973

1. Introduction.

These densities, and accurate analytical descriptions thereof, are essential for the computation of thermodynamic functions, in particular to obtain heats of vaporization via the Clapeyron equation, and to formulate the equation of state which originates on this locus [4].

We have had difficulties in representing the available ethane data, and therefore have returned to fundamentals. For comparison we shall include oxygen [18], fluorine [13], and methane [4]. Previous formulations occur in [4, 7]. We start with the saturated liquid densities because their representation is much simpler than that of the saturated vapor densities.

2. The Saturated Liquids.

It is well known that these densities are described near the critical point by the form

$$\rho = \rho_c + a \cdot (T_c - T) + b \cdot (T_c - T)^e \quad (1)$$

wherein the first two terms are the rectilinear diameter, and the exponent is near $e = 0.35$.

Let us constrain (1) at the boundaries by use of the variables,

$$x(T) \equiv (T_c - T)/(T_c - T_t), \quad (2)$$

$$W(\rho) \equiv (\rho - \rho_c)/(\rho_t - \rho_c), \quad (3)$$

where subscripts c and t refer to critical and triple points. Equation (1) now becomes,

$$W(\rho) = a \cdot x + b \cdot x^e, \quad (4)$$

and the constraint requires that $a + b = 1$. If we solve this for the constant b, we may expect to obtain a function $Y(\rho, x)$ which is nearly constant over the entire range $0 \leq x \leq 1$,

$$Y(\rho, x) \equiv [W(\rho) - x]/(x^e - x). \quad (5)$$

This sensitive function is useful for examining data.

In past work we found that three arbitrary coefficients are required to describe saturated liquid densities. We now find the following results via many exploratory computations. For the smoothed data used here for oxygen and fluorine, the use of five arbitrary coefficients gives an improvement in the "fit". For the rough experimental data used here for methane and ethane, the use of five arbitrary coefficients gives virtually no improvement in the "fit" as compared with only three coefficients. With only three, the first equation used was,

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$$Y(\rho, x) = A_1 + A_2 \cdot x + A_3 \cdot x^\alpha, \quad (6)$$

and we found exponent $\alpha = 4/3$ for oxygen, fluorine and methane, but $\alpha = 8/3$ for ethane. After much exploration we have selected the following representation,

$$Y(\rho, x) = A_1 + A_2 \cdot x^{2/3} + A_3 \cdot x \quad (7)$$

Table 1 gives the fixed-point constants. Table 2A gives the exponent ϵ found by trial, the least-squares coefficients, the rms of relative density deviations in percent, and the number of datum pairs, NP.

Tables 3, 4, 5, 6 compare calculated with experimental densities. No temperature-scale adjustments have been made in present work. Column YX gives the experimental value of $Y(\rho, x)$ via (5), whereas column YC gives the value calculated by the right side of (7). Table 7 compares ethane data not used for least squares.

Tables 8, 9, 10, 11 give saturated liquid densities computed by (7) at uniform temperatures, and also their slopes and curvatures.

The small deviations for oxygen and fluorine necessarily are systematic because the data were smoothed by the authors. The overall methane deviation is large because experimental data from various sources are included in the critical region.

The low-temperature ethane data of Miller were used to estimate the triple-point liquid density. Other data are from Canfield et al., and from Klosek/McKinley. The high-temperature "data" of Eubank are a correlation of available experimental data down to the boiling point 184.5 K, ($x = 0.561$). We estimate uncertainty in our calculation of these densities to be about 0.1 percent over the entire range.

Concerning assignment of critical densities, we at first found both ρ_c and exponent ϵ simultaneously by trial to minimize the overall deviation. The results are rough because these two parameters are mutually compensating for data in the critical region. Hence we have adjusted ρ_c one step at a time for both saturated liquid and saturated vapor, examining the values of ϵ found by trial. We select that value of ρ_c which yields reasonable exponents ϵ for both liquid and vapor. For methane it thus is necessary to select $\rho_c = 10.2 \text{ mol/l}$, at the upper limit of uncertainty in the experimental values [4].

3. The Saturated Vapors

Densities of the ethane vapors range thru a factor of about 10^6 . We have given reasons for using the logarithm of vapor densities, with arguments in powers of $(1/T)$, [7]. Define the normalized variables

$$z(T) \equiv (T_c/T - 1)/(T_c/T_t - 1), \quad (8)$$

$$W(\rho) \equiv \ln(\rho_c/\rho)/\ln(\rho_c/\rho_t). \quad (9)$$

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We write the vapor densities equation for the critical region as follows,

$$-W(\rho) = (b-1) \cdot z - b \cdot z^c \quad (10)$$

wherein the minus sign on the left arises merely from our definition of $W(\rho)$. Solving (10) for $\underline{b}$ yields the dependent variable,

$$Y(\rho, z) \equiv [W(\rho) - z] / (z^c - z) . \quad (11)$$

For the present work we have explored all kinds of representations, finally selecting the expression,

$$Y(\rho, z) = A_1 + \sum_{i=2}^5 A_i \cdot z^{i/3} . \quad (12)$$

Table 2B gives results for (12), analogous to table 2A for the liquid. Tables 12, 13, 14, 15 compare calculated with experimental vapor densities. Column YX is the experimental value of $Y(\rho, z)$ via (11), whereas YC is calculated by the right side of (12). Table 16 compares ethane data not used for least squares. Tables 17, 18, 19, 20 give uniformly computed densities and derivatives via (12).

Computer programs used in this work are attached as an appendix.

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4. Bibliography

- [1] C.H. Chui and F. B. Canfield, Trans. Faraday Soc. 67, 2933 (1971).
- [2] D. R. Douslin and R. H. Harrison, Pressure-volume-temperature relations for ethane, (U.S. Bureau of Mines, Bartlesville, Okla. 74003, Manuscript for J. Chem. Thermodynamics, 1973).
- [3] P. T. Eubank, Thermodynamic properties of ethane: vapor-liquid coexistence, Advances in Cryogenic Engineering 17, 270 (Plenum Pub. Corp., New York, N.Y. 10011, 1971).
- [4] R. D. Goodwin, The Thermophysical Properties of Methane from 90 to 500 K at Pressures to 700 Bar, NBS IR 73-342, October, 1973. Also, NBSIR 73-300, February, 1973.
- [5] R. D. Goodwin, The Vapor Pressures of Ethane, Laboratory Note 73-3, July 9, 1973.
- [6] R. D. Goodwin, Ethane Virial Coefficients and Saturated Vapor Densities, Lab. Note 73-4, Aug. 15, 1973.
- [7] R. D. Goodwin, Estimation of critical constants T_c , ρ_c from the $q(T)$ and $T(\rho)$ relations at coexistence, J. Res. NBS 74A (2), 221 (1970).
- [8] A. Harmens, Orthobaric densities of liquefied light hydrocarbons, Chem. Engrng. Science 20, 813 (1965); 21, 725 (1966).
- [9] J. Klosek and C. McKinley, Densities of liquefied natural gas and of low molecular weight hydrocarbons, paper 22, Session 5, Proc. First Internat. Conf. on LNG, Chicago, April (1968).
- [10] O. Maass and C. H. Wright, J. Am. Chem. Soc. 43, 1098 (1921).
- [11] Reid C. Miller, Ann. Rpt. to AGA, "Experimental Liquid Mixture Densities for Testing and Improving Correlations of LNG," Proj. BR-76-1, Univ. Wyoming, July 1, 1972.
- [12] Frank Porter, The vapor pressures and specific volumes of the saturated vapor of ethane, J. Am. Chem. Soc. 48, 2055 (1926).
- [13] Rolf Prydz and G. C. Straty, The Thermodynamic Properties of Compressed Gaseous and Liquid Fluorine, NBS Tech. Note 392, October, 1970.
- [14] M. J. Shana'a and F. B. Canfield, Trans. Faraday Soc. 64, 2281 (1968).

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[15] P. Sliwinski, The Lorenz-Lorenz function of gaseous and liquid ethane, propane, and butane, *Zeit. Phys. Chem. Neue Folge* 63, 263 (1969).

[16] H. E. Tester, ETHANE, in Thermodynamic Functions of Gases, vol. 3, F. Din, Editor (Butterworths, London, 1961).

[17] J. R. Tomlinson (Gulf Res. and Devel. Co., Pittsburgh, Pa.), Liquid Densities of Ethane, Propane, and Ethane-Propane Mixtures, Tech. Pub. TP-1, Nat. Gas Processors Assoc. (808 Home Federal Bldg., Tulsa, Okla. 74103, Feb. 1971).

[18] Lloyd A. Weber, P-V-T, thermodynamic and related properties of oxygen from the triple point to 300 K at pressures to 33 MN/m², NBS J. Res. 74A (1), 93 (1970).

[19] David Zudkevitch (Esso Res. & Engrng. Co., Florham Park, N.J.), The importance of accuracy in physical and thermodynamic data to chemical plant design, October, 1972. (Offered for publication in the Proceedings of the NBS.)

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<u>ID*</u>	<u>Author(s)</u>	<u>Reference</u>
1	Goodwin (Virial + V.P.)	[6]
6	Porter	[12]
9	Tester	[16]
10	Douslin	[2]
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Table 1. The fixed-point constants.

	<u>Oxygen</u>	<u>Fluorine</u>	<u>Methane</u>	<u>Ethane</u>
T_t , K	54.3507	53.4811	90.680	89.899
T_c , K	154.576	144.310	190.555	305.330
ρ_c , mol/l	13.63	15.15	10.20	6.87
ρ_t , liquid	40.830	44.8623	28.147	21.680
ρ_t , vapor	$3.36122 \cdot 10^{-4}$	$5.670 \cdot 10^{-4}$	$1.567865 \cdot 10^{-2}$	$1.35114 \cdot 10^{-6}$

Table 2A. Constants for liquid equation (7)

	<u>Oxygen</u>	<u>Fluorine</u>	<u>Methane</u>	<u>Ethane</u>
ϵ	0.349	0.354	0.361	0.350
A_1	0.758 8805	0.791 3438	0.837 0910	0.761 7350
A_2	0.228 3200	0.112 9132	0.084 1613	0.298 6535
A_3	-0.230 4342	-0.100 6980	-0.074 7858	-0.327 6239
rms, %	0.014	0.010	0.084	0.142
NP	50	46	49	29

Table 2B. Constants for vapor equation (12)

	<u>Oxygen</u>	<u>Fluorine</u>	<u>Methane</u>	<u>Ethane</u>
ϵ	0.382	0.362	0.382	0.362
A_1	0.277 3707	0.257 1572	0.374 1014	0.192 7743
A_2	-0.338 6621	-0.227 0644	-0.261 5731	0.041 5501
A_3	0.769 0708	0.605 3864	0.675 3322	-0.789 2263
A_4	-1.576 1185	-1.391 6332	-1.012 2063	0.357 6675
A_5	0.939 8713	0.792 5719	0.439 8834	0.124 5438
rms, %	0.052	0.134	0.148	0.104
NP	50	46	96	29

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Table 3. Comparison of oxygen liquid densities.

TCRT = 154.576, TTRP = 54.3507

DCRT = 13.630, DTRP = 40.8300

7.5888052-001 2.2832003-001 -2.3043415-001
0.0000000+000 0.0000000+000 0.0000000+000

E = 0.349

ID	T,K	MOL/L	CALC	PCNT	X	YX	YC	YDIF
99	56.000	40.601	40.663	-0.00	0.98354	0.75202	0.75805	-0.00603
99	58.000	40.323	40.326	-0.01	0.96359	0.75397	0.75958	-0.00561
99	60.000	40.048	40.049	-0.00	0.94363	0.76038	0.76109	-0.00072
99	62.000	39.777	39.770	0.02	0.92368	0.76779	0.76258	0.00520
99	64.000	39.494	39.491	0.01	0.90372	0.76630	0.76405	0.00225
99	66.000	39.216	39.210	0.01	0.88377	0.76840	0.76550	0.00291
99	68.000	38.926	38.928	-0.00	0.86381	0.76610	0.76692	-0.00081
99	70.000	38.655	38.644	0.03	0.84386	0.77243	0.76831	0.00411
99	72.000	38.358	38.358	-0.00	0.82390	0.76966	0.76969	-0.00002
99	74.000	38.081	38.071	0.03	0.80395	0.77392	0.77103	0.00289
99	76.000	37.779	37.782	-0.01	0.78399	0.77145	0.77235	-0.00090
99	78.000	37.495	37.491	0.01	0.76404	0.77482	0.77364	0.00118
99	80.000	37.202	37.197	0.01	0.74408	0.77614	0.77490	0.00124
99	82.000	36.900	36.901	-0.00	0.72413	0.77599	0.77613	-0.00014
99	84.000	36.603	36.602	0.00	0.70417	0.77750	0.77733	0.00017
99	86.000	36.298	36.301	-0.01	0.68422	0.77788	0.77850	-0.00061
99	88.000	35.997	35.996	0.00	0.66426	0.77979	0.77963	0.00016
99	90.000	35.689	35.688	0.00	0.64431	0.78081	0.78073	0.00007
99	92.000	35.373	35.377	-0.01	0.62435	0.78118	0.78180	-0.00061
99	94.000	35.063	35.062	0.00	0.60440	0.78305	0.78282	0.00023
99	96.000	34.734	34.742	-0.02	0.58444	0.78261	0.78381	-0.00120
99	98.000	34.412	34.418	-0.02	0.56449	0.78376	0.78475	-0.00099
99	100.000	34.083	34.090	-0.02	0.54453	0.78472	0.78565	-0.00093
99	102.000	33.750	33.756	-0.02	0.52458	0.78563	0.78651	-0.00088
99	104.000	33.411	33.417	-0.02	0.50462	0.78659	0.78732	-0.00072
99	106.000	33.069	33.072	-0.01	0.48467	0.78772	0.78807	-0.00035
99	108.000	32.712	32.720	-0.02	0.46471	0.78783	0.78878	-0.00098
99	110.000	32.362	32.361	0.00	0.44476	0.78960	0.78943	0.00017
99	112.000	31.990	31.995	-0.02	0.42480	0.78946	0.79101	-0.00056
99	114.000	31.616	31.620	-0.01	0.40485	0.79005	0.79054	-0.00049
99	116.000	31.236	31.236	-0.02	0.38489	0.79038	0.79100	-0.00062
99	118.000	30.845	30.842	0.01	0.36494	0.79169	0.79138	0.00031
99	120.000	30.441	30.438	0.01	0.34498	0.79208	0.79169	0.00039
99	122.000	30.021	30.021	-0.00	0.32503	0.79190	0.79192	-0.00001
99	124.000	29.595	29.591	0.01	0.30507	0.79239	0.79205	0.00034
99	126.000	29.146	29.147	-0.00	0.28512	0.79203	0.79209	-0.00006
99	128.000	28.686	28.685	0.00	0.26516	0.79210	0.79201	0.00008
99	130.000	28.209	28.205	0.01	0.24521	0.79216	0.79182	0.00033
99	132.000	27.709	27.704	0.02	0.22525	0.79192	0.79150	0.00042
99	134.000	27.181	27.179	0.01	0.20530	0.79129	0.79103	0.00026
99	136.000	26.631	26.625	0.02	0.18534	0.79103	0.79039	0.00063
99	138.000	26.042	26.037	0.02	0.16539	0.78999	0.78956	0.00043
99	140.000	25.413	25.410	0.01	0.14543	0.78883	0.78851	0.00032
99	142.000	24.734	24.733	0.01	0.12548	0.78733	0.78719	0.00014
99	144.000	23.992	23.993	-0.00	0.10552	0.78549	0.78555	-0.00006
99	146.000	23.164	23.170	-0.02	0.08557	0.78287	0.78350	-0.00063
99	148.000	22.227	22.230	-0.01	0.06561	0.78057	0.78090	-0.00033
99	150.000	21.106	21.108	-0.01	0.04566	0.77724	0.77753	-0.00029
99	152.000	19.646	19.647	-0.00	0.02570	0.77280	0.77284	-0.00004
99	154.000	17.106	17.104	0.01	0.00575	0.76528	0.76488	0.00040

NP = 50, RMSPCT = 0.014

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						DATE	Sept. 18, 1973	
Table 4. Comparison of fluorine liquid densities.								
E = 0.354								
TCRT = 144.310, TTRP = 53.4811								
DCRT = 15.150, DTRP = 44.8623								
7.9134383-001 1.1291315-001 -1.0069804-001								
0.0000000+000 0.0000000+000 0.0000000+000								
ID	T,K	MOL/L	CALC	PCNT	X	YX	YC	YDIF
98	54.000	44.781	44.781	0.00	0.99429	0.80556	0.80370	0.00186
98	56.000	44.465	44.464	0.00	0.97227	0.80524	0.80425	0.00099
98	58.000	44.146	44.146	0.00	0.95025	0.80550	0.80479	0.00071
98	60.000	43.825	43.825	0.00	0.92823	0.80574	0.80532	0.00042
98	62.000	43.501	43.501	0.00	0.90621	0.80603	0.80583	0.00021
98	64.000	43.174	43.174	-0.00	0.88419	0.80632	0.80633	-0.00000
98	66.000	42.845	42.845	-0.00	0.86217	0.80662	0.80681	-0.00019
98	68.000	42.512	42.513	-0.00	0.84015	0.80693	0.80728	-0.00034
98	70.000	42.176	42.177	-0.00	0.81813	0.80728	0.80773	-0.00045
98	72.000	41.836	41.838	-0.01	0.79611	0.80760	0.80817	-0.00056
98	74.000	41.493	41.496	-0.01	0.77409	0.80796	0.80859	-0.00063
98	76.000	41.146	41.149	-0.01	0.75207	0.80831	0.80899	-0.00068
98	78.000	40.795	40.799	-0.01	0.73005	0.80863	0.80938	-0.00069
98	80.000	40.440	40.444	-0.01	0.70803	0.80903	0.80974	-0.00071
98	82.000	40.081	40.085	-0.01	0.68602	0.80941	0.81009	-0.00068
98	84.000	39.717	39.720	-0.01	0.66400	0.80977	0.81042	-0.00065
98	86.000	39.347	39.351	-0.01	0.64198	0.81011	0.81073	-0.00061
98	88.000	38.973	38.976	-0.01	0.61996	0.81047	0.81101	-0.00054
98	90.000	38.592	38.596	-0.01	0.59794	0.81080	0.81127	-0.00047
98	92.000	38.206	38.209	-0.01	0.57592	0.81112	0.81151	-0.00039
98	94.000	37.813	37.815	-0.01	0.55390	0.81143	0.81172	-0.00029
98	96.000	37.413	37.415	-0.00	0.53188	0.81171	0.81191	-0.00019
98	98.000	37.005	37.006	-0.00	0.50986	0.81197	0.81206	-0.00009
98	100.000	36.590	36.590	0.00	0.48784	0.81220	0.81219	0.00001
98	102.000	36.165	36.164	0.00	0.46582	0.81240	0.81229	0.00012
98	104.000	35.731	35.729	0.01	0.44380	0.81256	0.81235	0.00021
98	106.000	35.286	35.283	0.01	0.42178	0.81268	0.81238	0.00030
98	108.000	34.829	34.826	0.01	0.39976	0.81274	0.81236	0.00038
98	110.000	34.361	34.356	0.01	0.37774	0.81276	0.81231	0.00045
98	112.000	33.878	33.873	0.01	0.35572	0.81272	0.81221	0.00050
98	114.000	33.379	33.374	0.02	0.33370	0.81261	0.81206	0.00055
98	116.000	32.864	32.858	0.02	0.31168	0.81243	0.81186	0.00056
98	118.000	32.330	32.324	0.02	0.28967	0.81218	0.81161	0.00057
98	120.000	31.774	31.768	0.02	0.26765	0.81183	0.81129	0.00055
98	122.000	31.193	31.188	0.02	0.24563	0.81139	0.81090	0.00049
98	124.000	30.584	30.579	0.02	0.22361	0.81086	0.81042	0.00043
98	126.000	29.942	29.939	0.01	0.20159	0.81020	0.80986	0.00034
98	128.000	29.262	29.260	0.01	0.17957	0.80942	0.80920	0.00022
98	130.000	28.535	28.534	0.00	0.15755	0.80850	0.80842	0.00009
98	132.000	27.750	27.751	-0.00	0.13553	0.80742	0.80749	-0.00007
98	134.000	26.891	26.894	-0.01	0.11351	0.80617	0.80638	-0.00022
98	136.000	25.935	25.939	-0.01	0.09149	0.80470	0.80506	-0.00036
98	138.000	24.839	24.843	-0.02	0.06947	0.80300	0.80343	-0.00043
98	140.000	23.521	23.524	-0.01	0.04745	0.80096	0.80137	-0.00040
98	142.000	21.769	21.770	-0.00	0.02543	0.79843	0.79855	-0.00012
98	144.000	18.327	18.328	-0.00	0.00341	0.79340	0.79356	-0.00016
NP = 46, RMSPCT = 0.010								

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Table 5. Comparison of methane liquid densities.

E = 0.361

TCRT = -190.555, TTRP = 90.6800

DCRT = 10.200, DTRP = 28.1470

E = 0.361

8.3709103-001 8.4161267-002 -7.4785753-002
0.0000000+000 0.0000000+000 0.0000000+000

ID	T,K	MOL/L	CALC	PCNT	X	YX	YC	YDIF
1	93.512	27.910	27.912	-0.01	0.97164	0.84050	0.84699	-0.00649
1	97.173	27.605	27.605	0.00	0.93499	0.84830	0.84764	0.00066
1	101.434	27.243	27.240	0.01	0.89233	0.85043	0.84836	0.00207
1	105.165	26.916	26.916	0.00	0.85497	0.84900	0.84896	0.00003
1	109.611	26.527	26.521	0.02	0.81045	0.85231	0.84964	0.00267
1	113.772	26.146	26.144	0.01	0.76879	0.85112	0.85023	0.00089
1	117.746	25.782	25.775	0.03	0.72900	0.85327	0.85074	0.00252
1	121.893	25.388	25.380	0.03	0.68748	0.85373	0.85123	0.00249
1	125.825	24.999	24.995	0.02	0.64811	0.85272	0.85165	0.00107
1	129.657	24.611	24.610	0.01	0.60974	0.85236	0.85201	0.00035
101	133.000	24.558	24.575	-0.07	0.60631	0.84803	0.85204	-0.00400
1	133.773	24.186	24.182	0.01	0.56853	0.85313	0.85233	0.00080
1	133.878	24.176	24.171	0.02	0.56748	0.85338	0.85234	0.00104
102	135.000	24.041	24.052	-0.05	0.55625	0.85002	0.85242	-0.00240
1	139.352	23.578	23.579	-0.00	0.51267	0.85249	0.85266	-0.00017
103	140.000	23.500	23.507	-0.03	0.50618	0.85132	0.85269	-0.00137
104	145.000	22.932	22.934	-0.01	0.45612	0.85255	0.85285	-0.00030
1	145.448	22.880	22.881	-0.00	0.45163	0.85272	0.85286	-0.00013
105	150.000	22.329	22.328	0.01	0.40606	0.85315	0.85287	0.00027
601	150.000	22.332	22.328	0.02	0.40606	0.85357	0.85287	0.00070
1	151.553	22.130	22.132	-0.01	0.39051	0.85255	0.85285	-0.00030
106	155.000	21.686	21.682	0.02	0.35599	0.85341	0.85274	0.00067
1	157.199	21.379	21.383	-0.02	0.33398	0.85201	0.85263	-0.00062
107	160.000	20.991	20.986	0.02	0.30593	0.85311	0.85242	0.00069
1	163.659	20.428	20.438	-0.05	0.26930	0.85048	0.85205	-0.00157
108	165.000	20.234	20.227	0.03	0.25587	0.85289	0.85188	0.00102
1	169.326	19.492	19.502	-0.05	0.21256	0.84962	0.85117	-0.00155
109	170.000	19.387	19.382	0.03	0.20581	0.85180	0.85104	0.00076
110	175.000	18.417	18.414	0.01	0.15574	0.85022	0.84981	0.00042
602	175.000	18.420	18.414	0.03	0.15574	0.85080	0.84981	0.00100
1	175.053	18.390	18.403	-0.07	0.15521	0.84777	0.84979	-0.00203
111	180.000	17.249	17.250	-0.00	0.10568	0.84786	0.84800	-0.00014
603	180.000	17.254	17.250	0.02	0.10568	0.84867	0.84800	0.00067
112	184.000	16.054	16.061	-0.04	0.06563	0.84466	0.84588	-0.00121
604	184.000	16.060	16.061	-0.00	0.06563	0.84575	0.84588	-0.00013
6	185.030	15.710	15.688	0.14	0.05532	0.84922	0.84517	0.00405
113	186.000	15.286	15.299	-0.08	0.04561	0.84203	0.84442	-0.00240
6	186.030	15.302	15.286	0.11	0.04530	0.84765	0.84440	0.00325
6	187.031	14.836	14.826	0.07	0.03528	0.84572	0.84351	0.00221
5	187.489	14.582	14.589	-0.05	0.03070	0.84158	0.84305	-0.00147
114	188.000	14.284	14.298	-0.10	0.02558	0.83922	0.84248	-0.00327
6	188.031	14.285	14.279	0.04	0.02527	0.84388	0.84245	0.00143
6	189.032	13.578	13.578	0.00	0.01525	0.84114	0.84113	0.00002
5	189.031	13.300	13.315	-0.11	0.01226	0.83640	0.84065	-0.00425
5	189.707	12.879	12.920	-0.31	0.00849	0.82667	0.83996	-0.01329
6	190.032	12.474	12.477	-0.02	0.00524	0.83812	0.83924	-0.00111
5	190.068	12.397	12.418	-0.17	0.00488	0.83082	0.83915	-0.00833
7	190.070	12.440	12.415	0.20	0.00486	0.84908	0.83914	0.00994
7	190.170	12.270	12.235	0.28	0.00385	0.85369	0.83887	0.01482

NP = 49, RMSPT = 0.084

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						DATE Sept. 18, 1973					

Table 6. Comparison of ethane liquid densities.

ID	T,K	MOL/L	CALC	PCNT	X	YX	YC	YDIF
14	91.010	21.639	21.640	-0.00	0.99484	0.72131	0.73343	-0.001212
14	100.020	21.313	21.315	-0.01	0.95302	0.73294	0.73873	-0.000579
14	108.110	21.025	21.024	0.01	0.91547	0.74474	0.74338	0.00136
12	108.150	21.026	21.022	0.02	0.91528	0.74831	0.74341	0.00490
13	110.928	20.915	20.922	-0.03	0.90239	0.73724	0.74498	-0.00774
14	115.050	20.771	20.772	-0.00	0.88325	0.74640	0.74729	-0.00089
12	115.770	20.747	20.746	0.00	0.87991	0.74816	0.74769	0.00047
13	116.483	20.717	20.721	-0.02	0.87660	0.74515	0.74809	-0.00293
13	122.039	20.521	20.519	0.01	0.85081	0.75269	0.75115	0.00154
13	127.594	20.323	20.316	0.03	0.82503	0.75847	0.75415	0.00432
13	133.150	20.126	20.112	0.07	0.79924	0.76479	0.75709	0.00770
15	184.470	18.175	18.138	0.20	0.56101	0.79083	0.78108	0.00975
15	190.000	17.944	17.910	0.19	0.53535	0.79186	0.78325	0.00861
15	200.000	17.516	17.485	0.18	0.48893	0.79408	0.78690	0.00718
15	210.000	17.068	17.042	0.15	0.44251	0.79576	0.79019	0.00557
15	220.000	16.595	16.577	0.11	0.39609	0.79668	0.79304	0.00364
15	230.000	16.093	16.085	0.05	0.34967	0.79707	0.79541	0.00167
15	240.000	15.545	15.557	-0.08	0.30325	0.79496	0.79719	-0.00222
15	250.000	14.957	14.984	-0.18	0.25683	0.79329	0.79826	-0.00497
10	253.150	14.753	14.792	-0.26	0.24221	0.79127	0.79843	-0.00716
10	263.150	14.089	14.136	-0.33	0.19579	0.78970	0.79829	-0.00858
10	273.150	13.342	13.366	-0.33	0.14937	0.78874	0.79687	-0.00813
10	283.150	12.458	12.489	-0.24	0.10296	0.78769	0.79361	-0.00592
10	293.150	11.297	11.314	-0.15	0.05654	0.78358	0.78721	-0.00362
10	298.150	10.499	10.498	0.01	0.03333	0.78193	0.78175	0.00019
10	302.150	9.544	9.543	0.01	0.01476	0.77510	0.77487	0.00022
10	303.150	9.201	9.196	0.05	0.01012	0.77416	0.77239	0.00177
10	304.150	8.737	8.730	0.08	0.00548	0.77227	0.76922	0.00305
10	305.150	7.830	7.820	0.13	0.00084	0.77224	0.76411	0.00813

NP = 29, RMSPCT = 0.142

ETHANE SATURATED LIQUID DENSITIES, E = 0.350

TCRT = 305.33C, TTRP = 89.8990

OCRT = 6.870, OTRP = 21.6800

7.6173503-001 2.9865351-001 -3.2762394-001

0.0000000+000 0.0000000+000 0.0000000+000

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						DATE	Sept. 18, 1973	

Table 7. Ethane liquid data not used for least squares.

ID	T,K	MOL/L	CALC	PCNT	X	YX	YC	YDIF
9	100.000	21.371	21.316	0.26	0.95311	0.86067	0.73872	0.12196
9	120.000	20.549	20.593	-0.21	0.86028	0.71692	0.75003	-0.03311
9	140.000	19.777	19.859	-0.41	0.76744	0.72238	0.76064	-0.03826
9	160.000	19.050	19.105	-0.29	0.67460	0.75146	0.77044	-0.01898
9	180.000	18.337	18.320	0.10	0.58176	0.78411	0.77926	0.00484
9	200.000	17.595	17.485	0.63	0.48893	0.81258	0.78690	0.02567
9	220.000	16.755	16.577	1.07	0.39609	0.82969	0.79304	0.03665
9	240.000	15.782	15.557	1.45	0.30325	0.83996	0.79719	0.04277
9	260.000	14.638	14.351	2.00	0.21042	0.85097	0.79845	0.05252
9	280.000	13.183	12.792	3.05	0.11758	0.86915	0.79489	0.07426
9	290.000	12.122	11.729	3.35	0.07116	0.87113	0.78971	0.08143
9	300.000	10.516	10.112	4.00	0.02474	0.88848	0.77899	0.10949
10	305.250	7.600	7.583	0.22	0.00037	0.78096	0.76316	0.01780
11	283.200	12.423	12.484	-0.49	0.10272	0.78179	0.79359	-0.01180
11	288.190	11.095	11.946	-0.43	0.07956	0.78051	0.79092	-0.01041
11	293.180	11.270	11.309	-0.34	0.05640	0.77867	0.78718	-0.00851
11	295.670	10.899	10.934	-0.32	0.04484	0.77672	0.78474	-0.00802
11	298.170	10.472	10.494	-0.21	0.03324	0.77610	0.78172	-0.00562
11	300.660	9.937	9.955	-0.18	0.02168	0.77281	0.77785	-0.00504
11	302.160	9.534	9.540	-0.07	0.01471	0.77282	0.77485	-0.00203
11	303.160	9.190	9.192	-0.02	0.01007	0.77159	0.77236	-0.00078
11	304.150	8.732	8.730	0.02	0.00548	0.76994	0.76922	0.00072
11	304.650	8.397	8.395	0.03	0.00316	0.76825	0.76713	0.00112
11	305.150	7.827	7.820	0.09	0.00084	0.77012	0.76411	0.00601
13	105.372	21.105	21.122	-0.08	0.92818	0.71576	0.74182	-0.02606
13	99.817	21.298	21.323	-0.11	0.95396	0.68284	0.73861	-0.05577
13	94.261	21.490	21.523	-0.15	0.97975	0.56468	0.73535	-0.17068
16	283.200	12.434	12.484	-0.39	0.10272	0.78404	0.79359	-0.00955
16	288.190	11.909	11.946	-0.31	0.07956	0.78335	0.79092	-0.00757
16	293.180	11.290	11.309	-0.17	0.05640	0.78302	0.78718	-0.00416
16	295.670	10.924	10.934	-0.08	0.04484	0.78262	0.78474	-0.00211
16	298.170	10.502	10.494	0.07	0.03324	0.78367	0.78172	0.00195
16	300.660	9.980	9.955	0.25	0.02168	0.78497	0.77785	0.00712
16	302.160	9.578	9.540	0.39	0.01471	0.78669	0.77485	0.01184

APPENDIX F. (Continued)

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Table 8. Calculated oxygen liquid densities

T, K	R, MOL/L	DR/DT	D2R/DT2
54.351	40.830	-0.1377	-0.00019
56.000	40.603	-0.1380	-0.00021
58.000	40.326	-0.1385	-0.00023
60.000	40.049	-0.1390	-0.00026
62.000	39.770	-0.1395	-0.00029
64.000	39.491	-0.1401	-0.00032
66.000	39.210	-0.1408	-0.00035
68.000	38.928	-0.1415	-0.00038
70.000	38.644	-0.1423	-0.00041
72.000	38.358	-0.1432	-0.00045
74.000	38.071	-0.1441	-0.00049
76.000	37.782	-0.1451	-0.00053
78.000	37.491	-0.1462	-0.00057
80.000	37.197	-0.1474	-0.00061
82.000	36.901	-0.1487	-0.00066
84.000	36.602	-0.1500	-0.00071
86.000	36.301	-0.1515	-0.00077
88.000	35.996	-0.1531	-0.00083
90.000	35.688	-0.1548	-0.00089
92.000	35.377	-0.1567	-0.00096
94.000	35.062	-0.1586	-0.00103
96.000	34.742	-0.1608	-0.00111
98.000	34.418	-0.1631	-0.00119
100.000	34.090	-0.1655	-0.00129
102.000	33.756	-0.1682	-0.00139
104.000	33.417	-0.1711	-0.00150
106.000	33.072	-0.1742	-0.00162
108.000	32.720	-0.1776	-0.00176
110.000	32.361	-0.1813	-0.00191
112.000	31.995	-0.1852	-0.00207
114.000	31.620	-0.1896	-0.00226
116.000	31.236	-0.1943	-0.00248
118.000	30.842	-0.1995	-0.00272
120.000	30.438	-0.2052	-0.00300
122.000	30.021	-0.2115	-0.00332
124.000	29.591	-0.2185	-0.00369
126.000	29.147	-0.2263	-0.00413
128.000	28.685	-0.2351	-0.00466
130.000	28.205	-0.2450	-0.00530
132.000	27.704	-0.2564	-0.00608
134.000	27.179	-0.2695	-0.00707
136.000	26.625	-0.2848	-0.00833
138.000	26.037	-0.3031	-0.01000
140.000	25.410	-0.3253	-0.01229
142.000	24.733	-0.3529	-0.01555
144.000	23.993	-0.3886	-0.02051
146.000	23.170	-0.4370	-0.02869
148.000	22.230	-0.5079	-0.04396
150.000	21.108	-0.6253	-0.07893
152.000	19.647	-0.8749	-0.20084
154.000	17.104	-2.1732	-2.34479
154.576	13.630	0.0000	0.00000

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			DATE	Sept. 18, 1973

Table 9. Calculated fluorine liquid densities.

T, K	R, MOL/L	DR/DT	D2R/DT2
53.481	44.862	-0.1573	-0.00054
54.000	44.781	-0.1576	-0.00055
56.000	44.464	-0.1587	-0.00058
58.000	44.146	-0.1599	-0.00061
60.000	43.825	-0.1612	-0.00065
62.000	43.501	-0.1625	-0.00068
64.000	43.174	-0.1639	-0.00072
66.000	42.845	-0.1654	-0.00076
68.000	42.513	-0.1670	-0.00081
70.000	42.177	-0.1686	-0.00085
72.000	41.838	-0.1704	-0.00090
74.000	41.496	-0.1722	-0.00095
76.000	41.149	-0.1742	-0.00101
78.000	40.799	-0.1763	-0.00107
80.000	40.444	-0.1785	-0.00114
82.000	40.085	-0.1808	-0.00121
84.000	39.720	-0.1833	-0.00129
86.000	39.351	-0.1860	-0.00137
88.000	38.976	-0.1888	-0.00146
90.000	38.596	-0.1918	-0.00156
92.000	38.209	-0.1951	-0.00167
94.000	37.815	-0.1985	-0.00179
96.000	37.415	-0.2022	-0.00192
98.000	37.006	-0.2062	-0.00207
100.000	36.590	-0.2105	-0.00223
102.000	36.164	-0.2151	-0.00242
104.000	35.729	-0.2202	-0.00262
106.000	35.283	-0.2257	-0.00286
108.000	34.826	-0.2316	-0.00313
110.000	34.356	-0.2382	-0.00344
112.000	33.873	-0.2454	-0.00380
114.000	33.374	-0.2534	-0.00422
116.000	32.856	-0.2624	-0.00472
118.000	32.324	-0.2724	-0.00533
120.000	31.768	-0.2838	-0.00606
122.000	31.188	-0.2967	-0.00696
124.000	30.579	-0.3118	-0.00811
126.000	29.939	-0.3294	-0.00959
128.000	29.260	-0.3505	-0.01156
130.000	28.534	-0.3762	-0.01428
132.000	27.751	-0.4084	-0.01821
134.000	26.894	-0.4504	-0.02426
136.000	25.939	-0.5081	-0.03440
138.000	24.843	-0.5939	-0.05377
140.000	23.524	-0.7400	-0.09999
142.000	21.770	-1.0696	-0.27704
144.000	18.328	-3.6894	-7.49794
144.310	15.150	0.0000	0.00000

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		DATE	Sept. 18, 1973	

Table 11. Calculated ethane liquid densities.

ETHANE SATURATED LIQUID DENSITIES

T, K	R, MOL/L	DR/DT	D2R/DT2
89.899	21.680	-0.0360	0.00000
90.000	21.676	-0.0360	0.00000
95.000	21.496	-0.0360	-0.00000
100.000	21.316	-0.0360	-0.00001
105.000	21.136	-0.0361	-0.00001
110.000	20.955	-0.0362	-0.00002
115.000	20.774	-0.0363	-0.00002
120.000	20.593	-0.0364	-0.00003
125.000	20.411	-0.0365	-0.00003
130.000	20.228	-0.0367	-0.00004
135.000	20.044	-0.0369	-0.00004
140.000	19.859	-0.0371	-0.00005
145.000	19.673	-0.0374	-0.00006
150.000	19.485	-0.0377	-0.00006
155.000	19.296	-0.0380	-0.00007
160.000	19.105	-0.0384	-0.00008
165.000	18.912	-0.0388	-0.00009
170.000	18.717	-0.0392	-0.00010
175.000	18.520	-0.0398	-0.00011
180.000	18.320	-0.0403	-0.00012
185.000	18.116	-0.0410	-0.00013
190.000	17.910	-0.0417	-0.00015
195.000	17.700	-0.0424	-0.00016
200.000	17.485	-0.0433	-0.00018
205.000	17.266	-0.0443	-0.00020
210.000	17.042	-0.0453	-0.00022
215.000	16.813	-0.0465	-0.00025
220.000	16.577	-0.0478	-0.00028
225.000	16.335	-0.0493	-0.00031
230.000	16.085	-0.0509	-0.00035
235.000	15.826	-0.0527	-0.00039
240.000	15.557	-0.0548	-0.00045
245.000	15.277	-0.0572	-0.00051
250.000	14.984	-0.0600	-0.00059
255.000	14.676	-0.0632	-0.00069
260.000	14.351	-0.0669	-0.00082
265.000	14.005	-0.0715	-0.00099
270.000	13.635	-0.0770	-0.00123
275.000	13.233	-0.0839	-0.00156
280.000	12.792	-0.0929	-0.00208
285.000	12.299	-0.1053	-0.00295
290.000	11.729	-0.1238	-0.00463
295.000	11.040	-0.1554	-0.00871
300.000	10.112	-0.2288	-0.02539
305.000	8.048	-1.2696	-2.44167
305.330	6.870	0.0000	0.00000

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						DATE	Sept. 18, 1973	

Table 12. Comparison of oxygen vapor densities.

E = 0.382

TCRT = 154.576, TTRP = 54.3507

DCRT. = 13.636, DTRP = 3.36122-004

2.7737066-001 -3.3866205-001 7.6907075-001 -1.5761185+000

9.3987130-001 0.0000000+000 0.0000000+000 0.0000000+000

ID	T,K	MOL/L	CALCD	PCNT	Z	YX	YC	YDIF
99	56.000	5.3300-004	5.3288-004	0.02	0.95458	0.07082	0.07159	-0.00077
99	58.000	8.9930-004	8.9941-004	-0.01	0.90296	0.07289	0.07270	0.00019
99	60.000	1.4640-003	1.4644-003	-0.03	0.85479	0.07505	0.07474	0.00031
99	62.000	2.3057-003	2.3068-003	-0.05	0.80972	0.07792	0.07752	0.00040
99	64.000	3.5233-003	3.5251-003	-0.05	0.76747	0.08123	0.08089	0.00034
99	66.000	5.2367-003	5.2388-003	-0.04	0.72778	0.08497	0.08473	0.00024
99	68.000	7.5880-003	7.5899-003	-0.02	0.69042	0.08906	0.08893	0.00013
99	70.000	1.0742-002	1.0742-002	-0.00	0.65520	0.09343	0.09341	0.00001
99	72.000	1.4885-002	1.4883-002	0.01	0.62194	0.09804	0.09811	-0.00006
99	74.000	2.0227-002	2.0220-002	0.04	0.59048	0.10281	0.10296	-0.00015
99	76.000	2.6996-002	2.6983-002	0.05	0.56067	0.10773	0.10792	-0.00019
99	78.000	3.5441-002	3.5421-002	0.06	0.53239	0.11275	0.11296	-0.00021
99	80.000	4.5831-002	4.5802-002	0.06	0.50552	0.11781	0.11804	-0.00023
99	82.000	5.8449-002	5.8412-002	0.06	0.47996	0.12292	0.12314	-0.00022
99	84.000	7.3595-002	7.3552-002	0.06	0.45562	0.12804	0.12823	-0.00013
99	86.000	9.1589-002	9.1542-002	0.05	0.43242	0.13313	0.13330	-0.00017
99	88.000	1.1276-001	1.1271-001	0.04	0.41026	0.13821	0.13833	-0.00012
99	90.000	1.3745-001	1.3741-001	0.03	0.38910	0.14323	0.14331	-0.00008
99	92.000	1.6603-001	1.6601-001	0.01	0.36885	0.14820	0.14824	-0.00004
99	94.000	1.9887-001	1.9887-001	-0.00	0.34946	0.15311	0.15310	0.00000
99	96.000	2.3637-001	2.3641-001	-0.01	0.33088	0.15794	0.15790	0.00004
99	98.000	2.7894-001	2.7902-001	-0.03	0.31306	0.16270	0.16262	0.00008
99	100.000	3.2702-001	3.2716-001	-0.04	0.29596	0.16738	0.16726	0.00012
99	102.000	3.8108-001	3.8127-001	-0.05	0.27952	0.17196	0.17182	0.00014
99	104.000	4.4162-001	4.4186-001	-0.05	0.26372	0.17645	0.17630	0.00015
99	106.000	5.0914-001	5.0943-001	-0.06	0.24851	0.18086	0.18079	0.00006
99	108.000	5.8421-001	5.8455-001	-0.06	0.23387	0.18518	0.18502	0.00016
99	110.000	6.6747-001	6.6783-001	-0.05	0.21975	0.18940	0.18925	0.00015
99	112.000	7.5953-001	7.5992-001	-0.05	0.20615	0.19355	0.19341	0.00014
99	114.000	8.6121-001	8.6155-001	-0.04	0.19302	0.19759	0.19748	0.00011
99	116.000	9.7325-001	9.7353-001	-0.03	0.18034	0.20156	0.20148	0.00008
99	118.000	1.0965+000	1.0967+000	-0.02	0.16809	0.20545	0.20540	0.00005
99	120.000	1.2321+000	1.2322+000	-0.00	0.15625	0.20926	0.20925	0.00000
99	122.000	1.3812+000	1.3810+000	0.01	0.14480	0.21299	0.21303	-0.00004
99	124.000	1.5450+000	1.5445+000	0.03	0.13372	0.21666	0.21674	-0.00008
99	126.000	1.7250+000	1.7243+000	0.04	0.12299	0.22027	0.22039	-0.00012
99	128.000	1.9230+000	1.9220+000	0.05	0.11259	0.22383	0.22398	-0.00015
99	130.000	2.1411+000	2.1399+000	0.06	0.10252	0.22735	0.22751	-0.00017
99	132.000	2.3619+000	2.3605+000	0.06	0.09275	0.23083	0.23100	-0.00017
99	134.000	2.6483+000	2.6470+000	0.05	0.08327	0.23429	0.23444	-0.00016
99	136.000	2.9444+000	2.9433+000	0.04	0.07407	0.23773	0.23786	-0.00012
99	138.000	3.2750+000	3.2745+000	0.01	0.06514	0.24119	0.24124	-0.00005
99	140.000	3.6468+000	3.6474+000	-0.02	0.05646	0.24468	0.24462	0.00006
99	142.000	4.0692+000	4.0712+000	-0.05	0.04803	0.24819	0.24801	0.00018
99	144.000	4.5552+000	4.5592+000	-0.09	0.03983	0.25176	0.25143	0.00033
99	146.000	5.1261+000	5.1316+000	-0.11	0.03185	0.25536	0.25493	0.00043
99	148.000	5.8177+000	5.8225+000	-0.08	0.02410	0.25892	0.25857	0.00035
99	150.000	6.7056+000	6.6967+000	0.13	0.01654	0.26182	0.26247	-0.00065
99	152.000	7.9239+000	7.9138+000	0.13	0.00919	0.26616	0.26692	-0.00076
99	154.000	1.0225+001	1.0230+001	-0.05	0.00203	0.27367	0.27313	0.00054

NP = 50, RMSPCT = 0.052

APPENDIX F. (Continued)

NATIONAL BUREAU OF STANDARDS, CRYOGENIC ENGINEERING LABORATORY						PROJECT NO.	FILE NO.	PAGE
LABORATORY NOTE						2750364	73-5	19
SUBJECT	The Orthobaric Densities of Ethane, Methane, Oxygen and Fluorine					NAME	R.D. Goodwin	
						DATE	Sept. 18, 1973	

Table 13. Comparison of fluorine vapor densities.

E = 0.362

TCRT = 144.310, TTRP = 53.4811
 OCRT = 15.150, DTRP = 5.67000-004

2.5715721-001 -2.2706443-001 6.0538644-001 -1.3916332+000
 7.9257188-001 0.0000000+000 0.0000000+000 0.0000000+000

ID	T,K	MOL/L	CALCD	PCNT	Z	YX	YC	YDIF
98	54.000	6.6000-004	6.6001-004	-0.00	0.98473	0.03779	0.03768	0.00010
98	56.000	1.1500-003	1.1518-003	-0.16	0.92853	0.04645	0.04297	0.00348
98	58.000	1.9300-003	1.9272-003	0.14	0.87621	0.04693	0.04877	-0.00184
98	60.000	3.1100-003	3.1038-003	0.20	0.82738	0.05309	0.05493	-0.00184
98	62.000	4.8400-003	4.8291-003	0.23	0.78169	0.05968	0.06135	-0.00167
98	64.000	7.2900-003	7.2821-003	0.11	0.73887	0.06725	0.06792	-0.00067
98	66.000	1.0680-002	1.0675-002	0.05	0.69863	0.07434	0.07459	-0.00026
98	68.000	1.5250-002	1.5253-002	-0.02	0.66077	0.08139	0.08130	0.00009
98	70.000	2.1280-002	2.1293-002	-0.06	0.62507	0.08827	0.08799	0.00028
98	72.000	2.9070-002	2.9105-002	-0.12	0.59135	0.09515	0.09464	0.00051
98	74.000	3.8970-002	3.9029-002	-0.15	0.55945	0.10181	0.10121	0.00060
98	76.000	5.1350-002	5.1434-002	-0.16	0.52923	0.10829	0.10769	0.00060
98	78.000	6.6600-002	6.6713-002	-0.17	0.50057	0.11466	0.11406	0.00060
98	80.000	8.5150-002	8.5291-002	-0.17	0.47333	0.12086	0.12030	0.00056
98	82.000	1.0745-001	1.0761-001	-0.15	0.44742	0.12691	0.12641	0.00050
98	84.000	1.3397-001	1.3416-001	-0.14	0.42275	0.13281	0.13238	0.00044
98	86.000	1.6523-001	1.6541-001	-0.11	0.39923	0.13854	0.13820	0.00034
98	88.000	2.0174-001	2.0191-001	-0.08	0.37677	0.14413	0.14388	0.00025
98	90.000	2.4407-001	2.4420-001	-0.05	0.35532	0.14956	0.14940	0.00015
98	92.000	2.9280-001	2.9286-001	-0.02	0.33479	0.15484	0.15478	0.00006
98	94.000	3.4857-001	3.4852-001	0.01	0.31514	0.15997	0.16001	-0.00004
98	96.000	4.1203-001	4.1184-001	0.05	0.29631	0.16496	0.16509	-0.00013
98	98.000	4.8389-001	4.8352-001	0.08	0.27824	0.16981	0.17003	-0.00021
98	100.000	5.6491-001	5.6432-001	0.10	0.26090	0.17453	0.17482	-0.00029
98	102.000	6.5591-001	6.5507-001	0.13	0.24424	0.17912	0.17947	-0.00035
98	104.000	7.5778-001	7.5667-001	0.15	0.22822	0.18358	0.18398	-0.00040
98	106.000	8.7151-001	8.7012-001	0.16	0.21281	0.18792	0.18836	-0.00044
98	108.000	9.9817-001	9.9651-001	0.17	0.19796	0.19215	0.19261	-0.00046
98	110.000	1.1396+000	1.1371+000	0.17	0.18366	0.19627	0.19673	-0.00046
98	112.000	1.2453+000	1.2932+000	0.16	0.16986	0.20028	0.20072	-0.00044
98	114.000	1.4687+000	1.4666+000	0.15	0.15655	0.20419	0.20460	-0.00041
98	116.000	1.6610+000	1.6596+000	0.12	0.14370	0.20801	0.20836	-0.00035
98	118.000	1.8743+000	1.8725+000	0.09	0.13129	0.21174	0.21200	-0.00027
98	120.000	2.1111+000	2.1099+000	0.06	0.11928	0.21538	0.21554	-0.00016
98	122.000	2.3744+000	2.3741+000	0.01	0.10768	0.21894	0.21898	-0.00004
98	124.000	2.6680+000	2.6690+000	-0.04	0.09644	0.22243	0.22232	0.00011
98	126.000	2.9965+000	2.9992+000	-0.09	0.08556	0.22584	0.22556	0.00027
98	128.000	3.3661+000	3.3709+000	-0.14	0.07503	0.22917	0.22873	0.00045
98	130.000	3.7848+000	3.7921+000	-0.19	0.06481	0.23243	0.23181	0.00062
98	132.000	4.2641+000	4.2739+000	-0.23	0.05491	0.23560	0.23484	0.00076
98	134.000	4.8207+000	4.8319+000	-0.23	0.04530	0.23862	0.23782	0.00081
98	136.000	5.4816+000	5.4905+000	-0.16	0.03598	0.24138	0.24077	0.00061
98	138.000	6.2910+000	6.2909+000	0.00	0.02692	0.24374	0.24375	-0.00000
98	140.000	7.3226+000	7.3133+000	0.13	0.01813	0.24625	0.24683	-0.00058
98	142.000	8.7854+000	8.7644+000	0.24	0.00958	0.24889	0.25023	-0.00133
98	144.000	1.1888+001	1.1893+001	-0.04	0.00127	0.25552	0.25509	0.00044

NP = 46, RMSPCT = 0.134

APPENDIX F. (Continued)

NATIONAL BUREAU OF STANDARDS, CRYOGENIC ENGINEERING LABORATORY					PROJECT NO.	FILE NO.	PAGE
LABORATORY NOTE					2750364	73-5	20
SUBJECT	The Orthobaric Densities of Ethane, Methane, Oxygen and Fluorine				NAME	R.D. Goodwin	
					DATE	Sept. 18, 1973	

Table 14. Comparison of methane vapor densities.

$$E = 0.382$$

$$TCRT = 190.555, TTRP = 90.6800$$

$$DCRT = 10.200, DTRP = 1.56787-002$$

$$3.7410143-001 -2.6157309-001 \quad 6.7533217-001 -1.0122063+000$$

$$4.3988336-001 \quad 0.0000000+000 \quad 0.0000000+000 \quad 0.0000000+000$$

ID	T,K	MOL/L	CALCD	PCNT	Z	YX	YC	YDIF
2	92.000	1.8280-002	1.8280-002	0.00	0.97263	0.21853	0.21874	-0.00021
2	94.000	2.2860-002	2.2858-002	0.01	0.93261	0.22329	0.22354	-0.00025
2	96.000	2.8290-002	2.8294-002	-0.01	0.89427	0.22864	0.22828	0.00036
2	98.000	3.4690-002	3.4691-002	-0.00	0.85749	0.23301	0.23295	0.00006
2	100.000	4.2160-002	4.2159-002	0.00	0.82218	0.23752	0.23755	-0.00003
2	102.000	5.0810-002	5.0813-002	-0.01	0.78826	0.24213	0.24207	0.00007
2	104.000	6.0770-002	6.0772-002	-0.00	0.75564	0.24653	0.24650	0.00003
2	106.000	7.2160-002	7.2161-002	-0.00	0.72425	0.25086	0.25084	0.00002
2	108.000	8.5110-002	8.5110-002	-0.00	0.69402	0.25510	0.25510	0.00000
2	110.000	9.9750-002	9.9753-002	-0.00	0.66490	0.25928	0.25926	0.00002
2	112.000	1.1623-001	1.1623-001	0.00	0.63681	0.26332	0.26333	-0.00000
2	114.000	1.3468-001	1.3468-001	-0.00	0.60971	0.26732	0.26730	0.00002
2	116.000	1.5527-001	1.5527-001	0.00	0.58354	0.27117	0.27119	-0.00002
2	118.000	1.7814-001	1.7813-001	0.00	0.55826	0.27495	0.27498	-0.00002
2	120.000	2.0346-001	2.0345-001	0.01	0.53383	0.27864	0.27868	-0.00004
2	122.000	2.3139-001	2.3138-001	0.00	0.51019	0.28226	0.28228	-0.00003
2	124.000	2.6212-001	2.6211-001	0.00	0.48732	0.28577	0.28580	-0.00003
2	126.000	2.9583-001	2.9582-001	0.00	0.46517	0.28921	0.28923	-0.00002
2	128.000	3.3272-001	3.3271-001	0.00	0.44372	0.29255	0.29257	-0.00002
2	130.000	3.7299-001	3.7299-001	0.00	0.42292	0.29582	0.29583	-0.00001
2	132.000	4.1686-001	4.1687-001	-0.00	0.40276	0.29902	0.29900	0.00002
2	134.000	4.6457-001	4.6461-001	-0.01	0.38320	0.30213	0.30209	0.00004
2	136.000	5.1638-001	5.1644-001	-0.01	0.36421	0.30515	0.30510	0.00006
2	138.000	5.7255-001	5.7264-001	-0.02	0.34577	0.30811	0.30803	0.00008
2	140.000	6.3337-001	6.3351-001	-0.02	0.32786	0.31099	0.31088	0.00011
2	142.000	6.9916-001	6.9937-001	-0.03	0.31046	0.31380	0.31366	0.00014
2	144.000	7.7028-001	7.7055-001	-0.04	0.29353	0.31654	0.31637	0.00016
2	146.000	8.4711-001	8.4745-001	-0.04	0.27703	0.31920	0.31901	0.00019
2	148.000	9.3007-001	9.3049-001	-0.05	0.26106	0.32179	0.32158	0.00021
2	150.000	1.0196+000	1.0201+000	-0.05	0.24548	0.32431	0.32409	0.00022
2	152.000	1.1164+000	1.1169+000	-0.05	0.23030	0.32675	0.32653	0.00022
2	154.000	1.2209+000	1.2214+000	-0.05	0.21552	0.32912	0.32891	0.00021
2	156.000	1.3338+000	1.3343+000	-0.04	0.20111	0.33140	0.33123	0.00017
2	158.000	1.4560+000	1.4563+000	-0.02	0.18707	0.33361	0.33350	0.00011
2	160.000	1.5884+000	1.5884+000	-0.00	0.17339	0.33571	0.33571	0.00000
2	162.000	1.7322+000	1.7316+000	0.03	0.16004	0.33772	0.33788	-0.00016
2	164.000	1.8886+000	1.8870+000	0.08	0.14701	0.33951	0.34000	-0.00039
2	166.000	2.0593+000	2.0561+000	0.16	0.13430	0.34135	0.34208	-0.00073
2	168.000	2.2465+000	2.2408+000	0.26	0.12190	0.34291	0.34412	-0.00121
1616	169.067	2.3408+000	2.3463+000	0.21	0.11540	0.34469	0.34520	-0.00051
1614	169.270	2.3687+000	2.3670+000	0.07	0.11417	0.34506	0.34540	-0.00035
912	169.417	2.3858+000	2.3821+000	0.16	0.11328	0.34480	0.34555	-0.00075
1612	169.468	2.3881+000	2.3873+000	0.03	0.11297	0.34545	0.34560	-0.00015
910	169.601	2.4054+000	2.4011+000	0.18	0.11217	0.34488	0.34573	-0.00085
308	169.794	2.4236+000	2.4213+000	0.10	0.11101	0.34547	0.34593	-0.00046
1716	173.088	2.7972+000	2.7954+000	0.03	0.09162	0.34905	0.34920	-0.00015
1714	173.290	2.8203+000	2.8215+000	-0.04	0.09046	0.34961	0.34940	0.00021

APPENDIX F. (Continued)

NATIONAL BUREAU OF STANDARDS, CRYOGENIC ENGINEERING LABORATORY						PROJECT NO.	FILE NO.	PAGE
LABORATORY NOTE						2750364	73-5	21
SUBJECT The Orthobaric Densities of Ethane, Methane, Oxygen and Fluorine						NAME R.D. Goodwin		
						DATE Sept. 18, 1973		
Table 14 (Continued). Methane vapor densities.								
ID	T,K	MOL/L	CALCD	PCNT	Z	YX	YC	YDIF
1712	173.489	2.8457+000	2.8465+000	-0.03	0.08931	0.34973	0.34959	0.00014
1012	173.473	2.8480+000	2.8445+000	0.12	0.08940	0.34896	0.34958	-0.00062
1010	173.675	2.8700+000	2.8701+000	-0.00	0.08824	0.34980	0.34978	0.00002
1008	173.857	2.8935+000	2.8934+000	0.00	0.08720	0.34995	0.34996	-0.00001
1816	177.094	3.3501+000	3.3513+000	-0.03	0.06901	0.35333	0.35315	0.00018
1814	177.292	3.3801+000	3.3822+000	-0.06	0.06792	0.35369	0.35335	0.00034
1114	177.328	3.3863+000	3.3879+000	-0.05	0.06772	0.35364	0.35339	0.00025
1812	177.485	3.4108+000	3.4128+000	-0.06	0.06686	0.35386	0.35354	0.00031
1112	177.509	3.4209+000	3.4166+000	0.12	0.06673	0.35290	0.35357	-0.00067
1110	177.700	3.4602+000	3.4473+000	0.37	0.06568	0.35175	0.35376	-0.00200
1916	181.105	4.0663+000	4.0686+000	-0.06	0.04738	0.35755	0.35722	0.00033
1914	181.304	4.1077+000	4.1101+000	-0.06	0.04633	0.35778	0.35743	0.00034
1213	181.389	4.1269+000	4.1281+000	-0.03	0.04588	0.35769	0.35752	0.00017
1912	181.506	4.1496+000	4.1530+000	-0.08	0.04527	0.35813	0.35765	0.00048
1211	181.589	4.1656+000	4.1708+000	-0.12	0.04483	0.35848	0.35774	0.00074
1209	181.769	4.2042+000	4.2097+000	-0.13	0.04389	0.35870	0.35793	0.00078
1516	183.117	4.5212+000	4.5240+000	-0.06	0.03688	0.35978	0.35940	0.00038
1514	183.322	4.5704+000	4.5754+000	-0.11	0.03582	0.36032	0.35963	0.00069
1512	183.514	4.6189+000	4.6246+000	-0.12	0.03484	0.36063	0.35985	0.00078
1316	184.125	4.7622+000	4.7880+000	-0.12	0.03171	0.36134	0.36055	0.00079
2108	184.387	4.7825+000	4.7775+000	0.10	0.03190	0.35982	0.36051	-0.00068
2107	184.285	4.8263+000	4.8327+000	-0.13	0.03089	0.36161	0.36074	0.00087
1314	184.370	4.8462+000	4.8567+000	-0.22	0.03046	0.36228	0.36084	0.00144
2106	184.471	4.8797+000	4.8857+000	-0.12	0.02994	0.36177	0.36096	0.00081
1312	184.513	4.8876+000	4.8969+000	-0.19	0.02975	0.36228	0.36101	0.00127
6	185.330	5.0380+000	5.0524+000	-0.28	0.02711	0.36359	0.36164	0.00195
6	185.030	5.3840+000	5.3838+000	0.00	0.02208	0.36290	0.36292	-0.00002
2208	185.103	5.4077+000	5.4098+000	-0.04	0.02172	0.36331	0.36302	0.00029
1416	186.129	5.4096+000	5.4192+000	-0.18	0.02159	0.36436	0.36305	0.00131
1414	186.319	5.4795+000	5.4891+000	-0.17	0.02064	0.36461	0.36331	0.00130
2207	186.304	5.4827+000	5.4835+000	-0.01	0.02072	0.36339	0.36329	0.00010
2206	186.501	5.5571+000	5.5581+000	-0.02	0.01974	0.36369	0.36356	0.00013
1412	186.518	5.5591+000	5.5646+000	-0.10	0.01965	0.36434	0.36359	0.00075
6	187.331	5.7360+000	5.7723+000	0.24	0.01711	0.36244	0.36433	-0.00189
6	188.031	6.2750+000	6.2474+000	0.44	0.01219	0.36201	0.36592	-0.00392
2308	188.140	6.2930+000	6.3064+000	-0.21	0.01165	0.36804	0.36612	0.00193
2307	188.343	6.4067+000	6.4218+000	-0.24	0.01066	0.36868	0.36648	0.00213
2306	188.545	6.5278+000	6.5441+000	-0.25	0.00968	0.36926	0.36686	0.00239
6	189.032	6.9180+000	6.8777+000	0.59	0.00732	0.36167	0.36787	-0.00620
5	189.765	7.5510+000	7.5576+000	-0.09	0.00378	0.37093	0.36975	0.00117
6	190.332	7.9600+000	7.9153+000	0.56	0.00250	0.36186	0.37065	-0.00879
5	190.346	7.9350+000	7.9371+000	-0.03	0.00243	0.37113	0.37070	0.00043
7	190.370	8.0000+000	7.9756+000	0.31	0.00232	0.36588	0.37079	-0.00491
7	190.170	8.1700+000	8.1508+000	0.24	0.00184	0.36709	0.37120	-0.00412
7	190.270	8.3600+000	8.3595+000	0.01	0.00136	0.37154	0.37166	-0.00013
5	190.279	8.3420+000	8.3805+000	0.14	0.00132	0.36899	0.37171	-0.00272
7	190.370	8.6200+000	8.6242+000	-0.05	0.00088	0.37333	0.37221	0.00112
7	190.470	9.0000+000	9.0116+000	-0.13	0.00041	0.37689	0.37291	0.00397
5	190.500	9.1610+000	9.1867+000	-0.28	0.00026	0.38333	0.37319	0.01014
NP = 96, RMSPCT = 0.148								

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SUBJECT

The Orthobaric Densities of Ethane, Methane, Oxygen and Fluorine

NAME

R.D. Goodwin

DATE

Sept. 18, 1973

Table 15. Comparison of ethane vapor densities.

ETHANE SATURATED VAPOR DENSITIES, E = 0.362

TCRT = 305.330, TTRP = 89.8990

DCRT = 6.870, DTRP = 1.35114-006

ID	T, K	MOL/L	CALCD	PCNT	Z	YX	YC	YDIF
1	90.000	1.3863-006	1.3863-006	0.00	0.99841	-0.07301	-0.07257	-0.00044
1	100.000	1.3347-005	1.3356-005	-0.07	0.85684	-0.05815	-0.05863	0.00048
1	110.000	8.1612-005	8.1696-005	-0.10	0.74101	-0.04219	-0.04262	0.00043
1	120.000	3.5552-004	3.5568-004	-0.04	0.64448	-0.02573	-0.02587	0.00014
1	130.000	1.1970-003	1.1963-003	0.05	0.56281	-0.00924	-0.00911	-0.00014
1	140.000	3.3033-003	3.2990-003	0.13	0.49280	0.00698	0.00728	-0.00030
1	150.000	7.8043-003	7.7918-003	0.16	0.43213	0.02275	0.02309	-0.00034
1	160.000	1.6308-002	1.6284-002	0.15	0.37904	0.03793	0.03823	-0.00029
1	170.000	3.0899-002	3.0869-002	0.10	0.33219	0.05247	0.05266	-0.00019
1	180.000	5.4111-002	5.4094-002	0.03	0.29056	0.06634	0.06639	-0.00006
1	190.000	8.8911-002	8.8944-002	-0.04	0.25330	0.07952	0.07945	0.00007
1	200.000	1.3872-001	1.3885-001	-0.09	0.21977	0.09203	0.09186	0.00017
1	210.000	2.0750-001	2.0777-001	-0.13	0.18943	0.10390	0.10367	0.00024
1	220.000	2.9992-001	3.0036-001	-0.14	0.16185	0.11517	0.11491	0.00026
1	230.000	4.2172-001	4.2230-001	-0.14	0.13667	0.12588	0.12563	0.00025
1	240.000	5.8025-001	5.8088-001	-0.11	0.11359	0.13607	0.13586	0.00021
1	245.000	6.7626-001	6.7685-001	-0.09	0.10276	0.14098	0.14081	0.00017
1	250.000	7.8551-001	7.8599-001	-0.06	0.09236	0.14578	0.14566	0.00012
10	253.150	8.6310-001	8.6237-001	0.08	0.08601	0.14848	0.14865	-0.00017
10	263.150	1.1530+000	1.1519+000	0.10	0.06689	0.15771	0.15791	-0.00020
10	273.150	1.5370+000	1.5359+000	0.07	0.04916	0.16665	0.16681	-0.00017
10	283.150	2.0670+000	2.0666+000	0.02	0.03269	0.17533	0.17538	-0.00005
10	293.150	2.8800+000	2.8727+000	0.25	0.01734	0.18285	0.18362	-0.00077
10	298.150	3.5020+000	3.5014+000	0.02	0.01005	0.18755	0.18761	-0.00006
10	302.150	4.3070+000	4.3040+000	0.07	0.00439	0.19036	0.19069	-0.00033
10	303.150	4.6040+000	4.6123+000	-0.18	0.00300	0.19241	0.19143	0.00098
10	304.150	5.0350+000	5.0389+000	-0.08	0.00162	0.19267	0.19214	0.00053
10	305.150	5.9130+000	5.9127+000	0.01	0.00025	0.19268	0.19275	-0.00007
10	305.250	6.1500+000	6.1484+000	0.03	0.00011	0.19233	0.19278	-0.00046

NP = 29, RMSPC1 = 0.104

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						DATE	Sept 18, 1973	

Table 16. Ethane vapor data not used for least squares.

ID	T,K	MOL/L	CALCD	PCNT	Z	YX	YC	YDIF
1	255.000	9.0997-001	9.1025-001	-0.03	0.08236	0.15046	0.15040	0.00006
1	260.000	1.0522+000	1.0521+000	0.01	0.07275	0.15502	0.15504	-0.00002
1	265.000	1.2154+000	1.2147+000	0.06	0.06351	0.15946	0.15959	-0.00012
1	270.000	1.4041+000	1.4023+000	0.13	0.05460	0.16377	0.16405	-0.00028
1	275.000	1.6245+000	1.6207+000	0.23	0.04602	0.16789	0.16842	-0.00053
1	280.000	1.8861+000	1.8784+000	0.41	0.03775	0.17173	0.17271	-0.00098
1	285.000	2.2047+000	2.1886+000	0.73	0.02977	0.17504	0.17693	-0.00189
1	290.000	2.6107+000	2.5736+000	1.44	0.02206	0.17701	0.18106	-0.00405
6	184.500	6.8910-002	6.8143-002	1.12	0.27329	0.07029	0.07235	-0.00206
6	226.207	3.7705-001	3.7217-001	1.31	0.14596	0.11923	0.12162	-0.00239
6	234.603	4.9353-001	4.9022-001	0.67	0.12581	0.12914	0.13040	-0.00126
6	238.921	5.6437-001	5.6173-001	0.47	0.11599	0.13390	0.13478	-0.00089
6	243.238	6.4280-001	6.4162-001	0.18	0.10652	0.13873	0.13908	-0.00035
6	248.665	7.5717-001	7.5546-001	0.23	0.09509	0.14393	0.14437	-0.00044
6	253.042	8.6348-001	8.5964-001	0.45	0.08623	0.14767	0.14855	-0.00089
6	258.809	1.0219+000	1.0166+000	0.52	0.07501	0.15288	0.15394	-0.00107
6	263.286	1.1611+000	1.1564+000	0.41	0.06664	0.15718	0.15804	-0.00086
6	268.732	1.3571+000	1.3521+000	0.37	0.05683	0.16211	0.16292	-0.00081
6	273.090	1.5403+000	1.5332+000	0.46	0.04926	0.16572	0.16676	-0.00104
6	278.638	1.8108+000	1.8037+000	0.39	0.03997	0.17061	0.17155	-0.00094
6	283.576	2.0862+000	2.0939+000	-0.36	0.03201	0.17666	0.17574	0.00092
6	288.254	2.4115+000	2.4286+000	-0.70	0.02472	0.18155	0.17963	0.00193
11	283.200	2.0685+000	2.0698+000	-0.06	0.03261	0.17558	0.17542	0.00016
11	288.190	2.4160+000	2.4235+000	-0.31	0.02482	0.18042	0.17957	0.00085
11	293.180	2.8716+000	2.8758+000	-0.15	0.01729	0.18409	0.18365	0.00045
11	295.670	3.1543+000	3.1589+000	-0.14	0.01363	0.18612	0.18565	0.00048
11	298.170	3.5002+000	3.5045+000	-0.12	0.01002	0.18807	0.18763	0.00044
11	300.660	3.9408+000	3.9499+000	-0.23	0.00648	0.19052	0.18956	0.00096
11	302.160	4.2943+000	4.3067+000	-0.29	0.00438	0.19208	0.19070	0.00138
11	303.160	4.6053+000	4.6158+000	-0.23	0.00299	0.19269	0.19144	0.00125
11	304.150	5.0203+000	5.0389+000	-0.37	0.00162	0.19464	0.19214	0.00250
11	304.650	5.3276+000	5.3544+000	-0.50	0.00093	0.19659	0.19247	0.00412
11	305.150	5.8663+000	5.9127+000	-0.78	0.00025	0.20313	0.19275	0.01038

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			DATE	Sept. 18, 1973	

Table 17. Calculated oxygen vapor densities.

T, K	R, MOL/L	DR/DT	D2R/DT2
54.351	3.3612-004	9.6727-005	2.4354-005
56.000	5.3288-004	1.4452-004	3.4007-005
58.000	8.9941-004	2.2709-004	4.9253-005
60.000	1.4644-003	3.4449-004	6.8929-005
62.000	2.3068-003	5.0609-004	9.3527-005
64.000	3.5251-003	7.2213-004	1.2342-004
66.000	5.2388-003	1.0035-003	1.5884-004
68.000	7.5899-003	1.3613-003	1.9990-004
70.000	1.0742-002	1.8068-003	2.4655-004
72.000	1.4883-002	2.3511-003	2.9868-004
74.000	2.0220-002	3.0050-003	3.5605-004
76.000	2.6983-002	3.7786-003	4.1840-004
78.000	3.5421-002	4.6817-003	4.8543-004
80.000	4.5802-002	5.7233-003	5.5684-004
82.000	5.8412-002	6.9118-003	6.3239-004
84.000	7.3552-002	8.2554-003	7.1185-004
86.000	9.1542-002	9.7617-003	7.9510-004
88.000	1.1271-001	1.1438-002	8.8208-004
90.000	1.3741-001	1.3293-002	9.7286-004
92.000	1.6601-001	1.5332-002	1.0676-003
94.000	1.9887-001	1.7566-002	1.1666-003
96.000	2.3641-001	2.0002-002	1.2703-003
98.000	2.7902-001	2.2651-002	1.3793-003
100.000	3.2716-001	2.5523-002	1.4944-003
102.000	3.8127-001	2.8633-002	1.6164-003
104.000	4.4186-001	3.1994-002	1.7466-003
106.000	5.0943-001	3.5626-002	1.8865-003
108.000	5.8455-001	3.9548-002	2.0377-003
110.000	6.6783-001	4.3785-002	2.2023-003
112.000	7.5992-001	4.8368-002	2.3830-003
114.000	8.6155-001	5.3330-002	2.5829-003
116.000	9.7353-001	5.8715-002	2.8059-003
118.000	1.0967+000	6.4572-002	3.0569-003
120.000	1.2322+000	7.0965-002	3.3422-003
122.000	1.3810+000	7.7969-002	3.6695-003
124.000	1.5445+000	8.5678-002	4.0493-003
126.000	1.7243+000	9.4210-002	4.4951-003
128.000	1.9220+000	1.0371-001	5.0254-003
130.000	2.1399+000	1.1438-001	5.6657-003
132.000	2.3805+000	1.2647-001	6.4520-003
134.000	2.6470+000	1.4032-001	7.4368-003
136.000	2.9433+000	1.5641-001	8.6997-003
138.000	3.2745+000	1.7539-001	1.0366-002
140.000	3.6474+000	1.9828-001	1.2644-002
142.000	4.0712+000	2.2661-001	1.5903-002
144.000	4.5592+000	2.6300-001	2.0854-002
146.000	5.1316+000	3.1214-001	2.9031-002
148.000	5.8225+000	3.8373-001	4.4334-002
150.000	6.6967+000	5.0204-001	7.9575-002
152.000	7.9138+000	7.5420-001	2.0346-001
154.000	1.0230+001	2.0822+000	2.4109+000
154.576	1.3630+001	0.0000+000	0.0000+000

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Table 18. Calculated fluorine vapor densities.

T, K	R, MOL/L	DR/DT	D2R/DT2
53.481	5.6700-004	1.6771-004	4.2852-005
54.000	6.6001-004	1.9119-004	4.7718-005
56.000	1.1518-003	3.0817-004	7.0323-005
58.000	1.9272-003	4.7699-004	9.9683-005
60.000	3.1038-003	7.1188-004	1.3650-004
62.000	4.8291-003	1.0283-003	1.8127-004
64.000	7.2821-003	1.4424-003	2.3426-004
66.000	1.0675-002	1.9709-003	2.9554-004
68.000	1.5253-002	2.6301-003	3.6499-004
70.000	2.1293-002	3.4361-003	4.4236-004
72.000	2.9105-002	4.4046-003	5.2731-004
74.000	3.9029-002	5.5501-003	6.1945-004
76.000	5.1434-002	6.8869-003	7.1844-004
78.000	6.6713-002	8.4282-003	8.2395-004
80.000	8.5291-002	1.0187-002	9.3580-004
82.000	1.0761-001	1.2176-002	1.0539-003
84.000	1.3416-001	1.4407-002	1.1783-003
86.000	1.6541-001	1.6893-002	1.3094-003
88.000	2.0191-001	1.9649-002	1.4475-003
90.000	2.4420-001	2.2689-002	1.5935-003
92.000	2.9286-001	2.6029-002	1.7482-003
94.000	3.4852-001	2.9688-002	1.9129-003
96.000	4.1184-001	3.3688-002	2.0893-003
98.000	4.8352-001	3.8054-002	2.2793-003
100.000	5.6432-001	4.2816-002	2.4854-003
102.000	6.5507-001	4.8009-002	2.7105-003
104.000	7.5667-001	5.3674-002	2.9585-003
106.000	8.7012-001	5.9861-002	3.2339-003
108.000	9.9651-001	6.6631-002	3.5426-003
110.000	1.1371+000	7.4058-002	3.8918-003
112.000	1.2932+000	8.2232-002	4.2910-003
114.000	1.4666+000	9.1264-002	4.7523-003
116.000	1.6590+000	1.0129-001	5.2919-003
118.000	1.8725+000	1.1250-001	5.9315-003
120.000	2.1099+000	1.2511-001	6.7013-003
122.000	2.3741+000	1.3942-001	7.6437-003
124.000	2.6690+000	1.5584-001	8.8210-003
126.000	2.9992+000	1.7492-001	1.0328-002
128.000	3.3709+000	1.9746-001	1.2313-002
130.000	3.7921+000	2.2465-001	1.5026-002
132.000	4.2739+000	2.5834-001	1.8913-002
134.000	4.8319+000	3.0165-001	2.4841-002
136.000	5.4905+000	3.6028-001	3.4720-002
138.000	6.2909+000	4.4628-001	5.3532-002
140.000	7.3133+000	5.9079-001	9.8476-002
142.000	8.7644+000	9.1469-001	2.7251-001
144.000	1.1893+001	3.5620+000	7.7289+000
144.310	1.5150+001	0.0000+000	0.0000+000

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				DATE	Sept. 18, 1973	

Table 19. Calculated methane vapor densities.

T, K	R, MOL/L	DR/DT	D2R/DT2
90.680	1.5679-002	1.8523-003	1.7385-004
92.000	1.8280-002	2.0919-003	1.8937-004
94.000	2.2858-002	2.4952-003	2.1409-004
96.000	2.8294-002	2.9492-003	2.4020-004
98.000	3.4691-002	3.4569-003	2.6763-004
100.000	4.2159-002	4.0206-003	2.9634-004
102.000	5.0813-002	4.6430-003	3.2628-004
104.000	6.0772-002	5.3265-003	3.5744-004
106.000	7.2161-002	6.0736-003	3.8980-004
108.000	8.5110-002	6.8866-003	4.2339-004
110.000	9.9753-002	7.7680-003	4.5823-004
112.000	1.1623-001	8.7204-003	4.9439-004
114.000	1.3468-001	9.7465-003	5.3195-004
116.000	1.5527-001	1.0849-002	5.7100-004
118.000	1.7813-001	1.2032-002	6.1170-004
120.000	2.0345-001	1.3297-002	6.5420-004
122.000	2.3138-001	1.4650-002	6.9870-004
124.000	2.6211-001	1.6093-002	7.4545-004
126.000	2.9582-001	1.7633-002	7.9471-004
128.000	3.3271-001	1.9274-002	8.4681-004
130.000	3.7299-001	2.1023-002	9.0214-004
132.000	4.1687-001	2.2885-002	9.6113-004
134.000	4.6461-001	2.4870-002	1.0243-003
136.000	5.1644-001	2.6986-002	1.0922-003
138.000	5.7264-001	2.9242-002	1.1657-003
140.000	6.3351-001	3.1652-002	1.2454-003
142.000	6.9937-001	3.4229-002	1.3325-003
144.000	7.7055-001	3.6988-002	1.4280-003
146.000	8.4745-001	3.9948-002	1.5335-003
148.000	9.3049-001	4.3130-002	1.6506-003
150.000	1.0201+000	4.6559-002	1.7815-003
152.000	1.1169+000	5.0267-002	1.9288-003
154.000	1.2214+000	5.4288-002	2.0957-003
156.000	1.3343+000	5.8665-002	2.2865-003
158.000	1.4563+000	6.3453-002	2.5065-003
160.000	1.5884+000	6.8715-002	2.7627-003
162.000	1.7316+000	7.4534-002	3.0643-003
164.000	1.8870+000	8.1011-002	3.4240-003
166.000	2.0561+000	8.8280-002	3.8592-003
168.000	2.2408+000	9.6514-002	4.3945-003
170.000	2.4430+000	1.0595-001	5.0661-003
172.000	2.6656+000	1.1691-001	5.9289-003
174.000	2.9119+000	1.2985-001	7.0695-003
176.000	3.1867+000	1.4546-001	8.6322-003
178.000	3.4963+000	1.6482-001	1.0873-002
180.000	3.8497+000	1.8973-001	1.4288-002
182.000	4.2610+000	2.2344-001	1.9949-002
184.000	4.7537+000	2.7274-001	3.0592-002
186.000	5.3730+000	3.5464-001	5.5251-002
188.000	6.2307+000	5.3071-001	1.4281-001
190.000	7.8668+000	1.4868+000	1.7833+000
190.555	1.0200+001	0.0000+000	0.0000+000

APPENDIX F. (Continued)

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		DATE Sept. 18, 1973		

Table 20. Calculated ethane vapor densities.

ETHANE SATURATED VAPOR DENSITIES

T, K	R, MOL/L	DR/DT	D2R/DT2
89.899	1.3511-006	3.4418-007	7.9422-008
90.000	1.3863-006	3.5229-007	8.1081-008
95.000	4.5944-006	1.0378-006	2.1037-007
100.000	1.3356-005	2.6924-006	4.8256-007
105.000	3.4683-005	6.2648-006	9.9665-007
110.000	8.1696-005	1.3276-005	1.8818-006
115.000	1.7684-004	2.5955-005	3.2903-006
120.000	3.5568-004	4.7323-005	5.3851-006
125.000	6.7091-004	8.1216-005	8.3256-006
130.000	1.1963-003	1.3223-004	1.2254-005
135.000	2.0304-003	2.0559-004	1.7283-005
140.000	3.2990-003	3.0703-004	2.3493-005
145.000	5.1575-003	4.4257-004	3.0926-005
150.000	7.7918-003	6.1835-004	3.9592-005
155.000	1.1418-002	8.4051-004	4.9474-005
160.000	1.6284-002	1.1151-003	6.0539-005
165.000	2.2666-002	1.4478-003	7.2744-005
170.000	3.0869-002	1.8443-003	8.6050-005
175.000	4.1225-002	2.3101-003	1.0043-004
180.000	5.4094-002	2.8504-003	1.1588-004
185.000	6.9862-002	3.4707-003	1.3243-004
190.000	8.8944-002	4.1767-003	1.5014-004
195.000	1.1178-001	4.9742-003	1.6912-004
200.000	1.3885-001	5.8703-003	1.8956-004
205.000	1.7066-001	6.8727-003	2.1170-004
210.000	2.0777-001	7.9907-003	2.3587-004
215.000	2.5078-001	9.2355-003	2.6252-004
220.000	3.0036-001	1.0621-002	2.9224-004
225.000	3.5725-001	1.2164-002	3.2581-004
230.000	4.2230-001	1.3887-002	3.6425-004
235.000	4.9647-001	1.5817-002	4.0894-004
240.000	5.8088-001	1.7990-002	4.6176-004
245.000	6.7685-001	2.0453-002	5.2532-004
250.000	7.8599-001	2.3267-002	6.0330-004
255.000	9.1025-001	2.6519-002	7.0116-004
260.000	1.0521+000	3.0325-002	8.2712-004
265.000	1.2147+000	3.4858-002	9.9430-004
270.000	1.4023+000	4.0373-002	1.2246-003
275.000	1.6207+000	4.7273-002	1.5572-003
280.000	1.8784+000	5.6239-002	2.0691-003
285.000	2.1886+000	6.8532-002	2.9298-003
290.000	2.5736+000	8.6820-002	4.5876-003
295.000	3.0777+000	1.1813-001	8.6241-003
300.000	3.8180+000	1.9083-001	2.5135-002
305.000	5.6889+000	1.2377+000	2.4827+000
305.330	6.8706+000	0.0000+000	0.0000+000

APPENDIX F. (Continued)

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SUBJECT	The Orthobaric Densities of Ethane, Methane, Oxygen and Fluorine	NAME	R.D. Goodwin	
		DATE	Sept. 18, 1973	
		10/10/73		
PROGRAM LICKFIT C REPRESENT ETHANE SATURATED LIQUID DENSITIES. C DEFINE X = (TC-T)/(TC-TT), Q = X**1/3, XE = X**E, AND - C DEFINE YY = (D-DC)/(DT-DC), WHEN THE EQN. IS - C (YY-X)/(XE-X) = A1 + A2*Q2 + A3*Q3 + . . . C DCRT = 6.86, 6.87 POSSIBLY VIA MY VAPORDEN EQN. C DTRP = 21.68 ESTIM. VIA REID C. MILLER. C ID, (9)TESTER, (10)DOUSLIN, (11)SLIWINSKI, (12)CANFIELD ET AL., C ID, (13)KLOSEK, (14)MILLER, (15)EUBANK, (16)TOMLINSON COMMON E,AZ,TTRP,TCRT,DTRP,DCRT,DRDT,D2RDT2,A(6) COMMON/999/NP,NF,H(15),Y(200),G(200,15) DIMENSION ID(99),T(99),DEN(99),U(99),W(99),XQ(99) 1 FORMAT(I5, 2F10.0) 2 FORMAT(1H1 13X 1HE 8X2HAZ 6X4HDCRT 8X2HSS) 3 FORMAT(5X 4F10.3) 4 FORMAT(1H1 17X *ETHANE SATURATED LIQUID DENSITIES, E =* F6.3// 1 20X 6HTCRT =F8.3, 8H, TTRP =F8.4// 2 20X 6HDCRT =F8.3, 8H, DTRP =F8.4// 2(13X 3E15.7//) / 3 8X2HID 7X3HT,K 5X5HMOL/L 6X4HCA LC 4X4HPCNT 4 14X 1HX 8X2HYX 8X2HYC 6X4HYDIF) 5 FOR1AT(5X I5, 3F10.3, F8.2, F15.5, 3F10.5) 6 FORMAT(1H1 16X *ETHANE SATURATED LIQUID DENSITIES* // 1 17X 3HT,K 3X7HR,MOL/L 5X5HDT/DT 3X7HD2R/DT2) 7 FORMAT(10X 2F10.3, F10.4, F10.5) 9 FORMAT(18X 4HNP =I3, 10H, RMSPCT =F7.3//) C C DO ALL FOUR, OXYGEN, FLUORINE, METHANE, AND ETHANE. 10 DO 99 IG=1,4 \$ GOTO(11,13,15,17),IG C C CONSTANTS FOR OXYGEN. 11 TTRP=54.3507 \$ TCRT=154.576 \$ TZ=52 \$ DT=2 \$ NZ=52 12 DTRP=40.63 \$ DCRT=13.63 \$ DZ=13.58 \$ EZ=0.340 \$ GOTO 19 C C CONSTANTS FOR FLUORINE. 13 TTRP=53.4811 \$ TCRT=144.31 \$ TZ=50 \$ DT=2 \$ NZ=48 14 DTRP=44.6623 \$ DCRT=15.15 \$ DZ=15.10 \$ EZ=0.342 \$ GOTO 19 C C CONSTANTS FOR METHANE. 15 TTRP=90.680 \$ TCRT=190.555 \$ TZ=88 \$ DT=2 \$ NZ=52 16 DTRP=28.147 \$ DCRT=10.20 \$ DZ=10.05 \$ EZ=0.350 \$ GOTO 19 C C CONSTANTS FOR ETHANE. 17 TTRP=89.699 \$ TCRT=305.33 \$ TZ=80 \$ DT=5 \$ NZ=46 18 DTRP=21.68 \$ DCRT= 6.87 \$ DZ= 6.82 \$ EZ=0.349 19 XN = TCRT-TTRP \$ YN = DTRP-DCRT C C READ NP DATA FOR LEAST SQUARES. C C READ L.A.WEBER S OXYGEN VOLUMES, GC/MOL. 20 DO 27 J=1,99 \$ READ 1, ID(J),T(J),DEN(J) \$ IF(ID(J)) 21,28 21 IF(ID(J)-15) 23,22 22 CONTINUE 23 IF(ID(J)-99) 25,24 24 DEN(J) = 1000/DEN(J) 25 U(J) = X = (TCRT-T(J))/XN \$ Q = CUBERTF(X) \$ DO 26 K=2,6 26 G(J,K) = Q**K \$ G(J,1) = 1 27 W(J) = (DEN(J)-DCRT)/YN 28 NPP = NP = J-1 \$ NF = 3 \$ E = 0.36 C C EXPLORE E, AZ, AND DCRT. 29 AZ = NF \$ SSK = 1.2E+010 30 DO 49 IE=1,21 \$ E = EZ + 0.001*IE				

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LICKFIT

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C   SET UP THE LEAST SQUARES ARRAYS.
36 DO 40 J=1,NP $ X = U(J) $ XQ(J) = XE = X**E
37 Y(J) = (W(J)-X)/(XE-X)
40 CONTINUE $ CALL EGENFT $ SS=0 $ DO 43 J=1,NP $ YC=0 $ DO 41 K=1,NF
41 YC = YC + H(K)*G(J,K) $ X = U(J) $ XE = XQ(J)
42 DC = DCRT + (X + (XE-X)*YC)*YN
43 SS = SS + (DEN(J)/DC-1)**2 $ SS = 100*SQRTE(SS/NP)
44 IF(SS.LT.SSK) 45,48
45 SSK=SS $ EK=E $ AZK=AZ $ DK=DCRT
46 DO 47 K=1,6
47 A(K) = H(K)
48 CONTINUE
49 CONTINUE
50 E=EK $ AZ=AZK $ DCRT=DK $ YN = DTRP - DCRT
C   USE SAVED CONSTANTS FOR DEVIATIONS.
60 PRINT 4, E,TCRT,TTRP,DCRT,DTRP,(A(K),K=1,6) $ SS = 0
61 DO 70 J=1,NPP $ X = U(J) $ XE = X**E $ XEX = XE-X
62 YC = 0 $ DO 63 K=1,NF
63 YC = YC + A(K)*G(J,K)
64 YS = X + XEX*YC $ DC = DCRT + YN*YS
65 YX = (W(J)-X)/XEX $ YD = YX-YC
66 PCT = 100*(DEN(J)/DC-1) $ SS = SS + PCT**2
67 PRINT 5, ID(J),T(J),DEN(J), DC,PCT, X,YX,YC,YD
68 IF(J-NP) 70,69
69 SS = SQRTE(SS/NP) $ PRINT 9, NP, SS
70 CONTINUE
C   PRINT UNIFORM TABLE FOR PUBLICATION.
71 PRINT 6 $ DO 80 J=1,NZ $ IF(J-1) 73,72
72 TT = TTRP $ GO TO 76
73 IF(J-NZ) 75,74
74 TT = TCRT $ GO TO 76
75 TT = TZ + DT*J
76 R = DENLIQF(TT)
80 PRINT 7, TT,R,DRDT,D2RDT2
99 CONTINUE
C   DO OTHER ETHANE DATA WITH EXISTING COEFFICIENTS.
100 PRINT 4, E,TCRT,TTRP,DCRT,DTRP,(A(K),K=1,6) $ SS = 0
101 DO 110 J=1,99 $ READ 1, IDD,TT,DN $ IF(IDD) 102,999
102 X=(TCRT-TT)/XN $ Q=CUBERTF(X) $ XE=X**E $ XEX=XE-X
103 YC = A(1) $ DO 104 K=2,NF
104 YC = YC + A(K)*Q**K
105 DC = DCRT + YN*(X+XEX*YC) $ PCT = 100*(DN/DC-1)
106 YY = (DN-DCRT)/YN $ YX = (YY-X)/XEX $ YD = YX-YC
110 PRINT 5, IDD,TT,DN, DC,PCT, X,YX,YC,YD
999 STOP $ END

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SUBJECT	The Orthobaric Densities of Ethane, Methane, Oxygen and Fluorine		NAME	R.D. Goodwin
			DATE	Sept. 18, 1973
10/10/73				
PROGRAM VAPORFIT C REPRESENT ETHANE SATURATED VAPOR DENSITIES. C THIS FORM IS CONSTRAINED AT THE TRIPLE POINT, AND C DEFINE X(T) AS FOR THE VAPOR PRESSURE EQUATION - C $Z = (1-X) = (TC/T-1)/(TC/TT-1)$, $ZE = Z**E$, $Q = Z**1/3$, AND - C DEFINE $YY = LN(DC/D)/LN(DC/DT)$, AND THE DEPENDENT VARIABLE - C $Y(Z,YY) = (YY-Z)/(ZE-Z)$, WHEN THE L.S. EQN. IS - C $Y(Z,YY) = A1 + A2*Q2 + A3*Q3 + A4*Q4 + . . .$ C ID., (1)VIRIAL/V.P., (6)PORTER, (10)DOUSLIN, (11)SLIWINSKI. C COMMON E,AL, TTRP,TCRT, DTRP,DCRT, DROT,D2ROT2, A(9) C COMMON/999/NP,NF,H(15),Y(200),G(200,15) C DIMENSION ID(99),T(99),DEN(99), U(99),W(99), ZQ(99) 1 FORMAT(I5, F10.0, E15.5) 2 FORMAT(1H1 18X 1HE 8X2HAL 6X4HDCRT 8X2HSS) 3 FORMAT(10X 4F10.3) 4 FORMAT(1H1 17X *ETHANE SATURATED VAPOR DENSITIES, E =* F6.3// 1 20X 6HTCRT =F8.3, 8H, TTRP =F8.4/ 2 20X 6HDCRT =F8.3, 8H, DTRP =E12.5// 2(13X 4E15.7//) / 2 3X2HID 7X3HT,K 8X5HMOL/L 8X5HCALCD 4X4HPCNT 3 12X 1HZ 8X2HYX 3X2HYC 6X4HYDIF) 5 FORMAT(5X I5, F10.3, 2E13.4, F8.2, F13.5, 3F10.5) 6 FORMAT(I5, 2F10.0) 7 FORMAT(1H1 16X *ETHANE SATURATED VAPOR DENSITIES* // 1 17X 3HT,K 6X7HR,MOL/L 8X5HDR/DT 6X7HD2R/DT2) 8 FORMAT(10X F10.3, 3E13.4) 9 FORMAT(18X 4HNP =I3, 10H, RMSPT =F7.3// 61 FORMAT(1H1 7X2HID 7X3HT,K 8X5HMOL/L 8X5HCALCD 4X4HPCNT 1 12X 1HZ 8X2HYX 8X2HYC 6X4HYDIF) C C DO ALL FOUR, OXYGEN, FLUORINE, METHANE, ETHANE. 10 DO 31 IG=1,4 \$ GOTO(11,13,15,17),IG C C CONSTANTS FOR OXYGEN. 11 TTRP=54.3507 \$ TCRT=154.576 \$ TZ=52 \$ DT=2 \$ NZ=52 12 DTRP=3.36122E-4 \$ DCRT=13.63 \$ DZ=13.58 \$ EZ=0.360 \$ GOTO 19 C C CONSTANTS FOR FLUORINE. 13 TTRP=53.4811 \$ TCRT=144.31 \$ TZ=50 \$ DT=2 \$ NZ=48 14 DTRP=5.670E-4 \$ DCRT=15.15 \$ DZ=15.10 \$ EZ=0.340 \$ GOTO 19 C C CONSTANTS FOR METHANE. 15 TTRP=90.680 \$ TCRT=190.555 \$ TZ=88 \$ DT=2 \$ NZ=52 16 DTRP=0.01567865 \$ DCRT=10.20 \$ DZ=10.05 \$ EZ=0.360 \$ GOTO 19 C C CONSTANTS FOR ETHANE. C OMIT 24, AND FIX DTRP. 17 TTRP=89.899 \$ TCRT=305.33 \$ TZ=80 \$ DT=5 \$ NZ=46 18 DTRP= 1.35114E-6 \$ DCRT=6.87 \$ DZ=6.84 \$ EZ=0.340 19 ZN = TCRT/TTRP-1 \$ YN = LOGF(DCRT/DTRP) C C READ OUR ID(1) DATA MIXED WITH DOUSLIN. C INCREASE OUR DEN BY 0.15 PCT TO AGREE WITH DOUSLIN. 20 DO 27 J=1,200 \$ IF(IG-4) 22,21 21 READ 1, ID(J),T(J),DEN(J) \$ IF(ID(J)) 23,28 22 READ 6, ID(J),T(J),DEN(J) \$ IF(ID(J)) 25,28 23 IF(ID(J)-1) 25,24 24 CONTINUE 25 U(J) = Z = (TCRT/T(J)-1)/ZN \$ Q = CUBERTF(Z) \$ DO 26 K=2,7 26 G(J,K) = Q**K \$ G(J,1) = 1 27 W(J) = LOGF(DCRT/DEN(J))/YN				

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			DATE	Sept. 18, 1973

VAPORFIT

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28 NP = J-1 $ AL = NF = 5 $ E = 0.360
C EXPLORE DCRT, AND EXPONENT E.
33 SSK = 1.0E+010
34 DO 48 IE=1,21 $ E = EZ + 0.002*IE
C SET UP THE ARRAYS FOR LEAST SQUARES.
36 DO 39 J=1,NP $ Z = U(J) $ ZQ(J) = ZE = Z**E
37 Y(J) = (W(J)-Z)/(ZE-Z)
39 CONTINUE $ CALL EGENFT $ SS = 0
C NOW GET THE RMS DEVIATION.
40 DO 44 J=1,NP $ YC = 0 $ DO 41 K=1,NF
41 YC = YC + H(K)*G(J,K)
42 Z = U(J) $ YS = Z + (ZQ(J)-Z)*YC
43 DC = DCRT*EXPF(-YN*YS)
44 SS = SS + (DC/DEN(J)-1)**2 $ SS = 100*SQRTF(SS/NP)
45 IF(SS.LT.SSK) 46,48
46 SSK=SS $ EK=E $ ALK=AL $ DK=DCRT $ DO 47 K=1,9
47 A(K) = H(K)
48 CONTINUE
49 E=EK $ AL=ALK $ DCRT=DK $ YN = LOGF(DK/DTRP)
C USE SAVED CONSTANTS FOR DEVIATIONS.
50 PRINT 4, E,TCRT,TTRP,DCRT,DTRP,(A(K),K=1,8) $ SS = 0
51 DO 59 J=1,NP $ Z = U(J) $ ZE = Z**E $ ZEZ = ZE - Z
52 YC = 0 $ DO 53 K=1,NF
53 YC = YC + A(K)*G(J,K)
54 YS = Z + ZEZ*YC $ DC = DCRT*EXPF(-YN*YS)
55 YX = (W(J)-Z)/ZEZ $ YD = YX - YC
56 PCT = 100*(DEN(J)/DC-1) $ SS = SS + PCT**2
57 IF(IG.EQ.3.AND.J.EQ.48) 58,59
58 PRINT 61
59 PRINT 5, ID(J),T(J),DEN(J), DC,PCT, Z,YX,YC,YD
60 SS = SQRTF(SS/NP) $ PRINT 9, NP, SS
C PRINT UNIFORM TABLE FOR PUBLICATION.
71 PRINT 7 $ DO 80 J=1,NZ $ IF(J-1) 73,72
72 TT = TTRP $ GO TO 76
73 IF(J-NZ) 75,74
74 TT = TCRT $ GO TO 76
75 TT = TZ + DT*J
76 R = DENGASF(TT)
80 PRINT 8, TT,R, DRDT, D2ROT2
81 CONTINUE $ PRINT 61
C DO OTHER ETHANE DATA WITH EXISTING COEFFICIENTS.
82 DO 88 J=1,99 $ READ 6, IDD,TT,DN $ IF(IDD) 83,99
83 Z = (TCRT/TT-1)/ZN $ ZE = Z**E $ ZEZ = ZE - Z
84 Q = CUBERTF(Z) $ YC = A(1) $ DO 85 K=2,NF
85 YC = YC + A(K)*Q**K
86 YY = LOGF(DCRT/DN)/YN $ YX = (YY-Z)/ZEZ $ YD = YX-YC
87 DC = DCRT*EXPF(-YN*(Z+ZEZ*YC)) $ PCT = 100*(DN/DC-1)
88 PRINT 5, IDD,TT,DN, DC,PCT, Z,YX,YC,YD
99 STOP $ END

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		DATE Sept. 18, 1973		

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FUNCTION DENLIQF(T)
C   ETHANE SATURATED LIQUID DENSITIES, MOL/L.
C   Y = A1 + A2*Q2 + A3*Q3 + . . . , YN = DTRP-DCRT,
C   DEN = DCRT + YN*(X + (XE-X)*Y).
COMMON E,AZ,ITRP,TCRT,DTRP,DCRT,DRDT,D2RDT2,A(E)
1  FORMAT(1H0 9X *DENLIQF = 0, T EXCEEDS TCRT. * / )
2  IF(TCRT-T) 3,4,5
3  PRINT 1 $ STOP
4  DENLIQF=DCRT $ DRDT=D2RDT2=0 $ RETURN
5  XN=TCRT-ITRP $ YN=DTRP-DCRT $ X=(TCRT-T)/XN $ DXDT=-1/XN
6  XE = X**E $ XE1 = E*XE/X $ XE2 = (E-1)*XE1/X
7  W = CUBERTF(X) $ W1 = W/3/X $ W2 = -2*W1/3/X
8  Q = XE-X $ Q1 = XE1 - 1 $ Q2 = XE2
9  NF = AZ $ Y = A(1) $ Y1 = Y2 = 0 $ DO 11 K=2,NF
10 Y = Y + A(K)*W**K $ Y1 = Y1 + K*A(K)*W**(K-1)
11 Y2 = Y2 + K*(K-1)*A(K)*W**(K-2)
12 Y2 = Y1*W2 + Y2*W1**2 $ Y1 = Y1*W1
13 DENLIQF = DCRT + (X + Q*Y)*YN
14 DRDT = (1 + Q*Y1 + Q1*Y)*YN*DXDT
15 D2RDT2 = (Q*Y2 + 2*Q1*Y1 + Q2*Y)*YN*DXDT**2 $ RETURN $ END

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FUNCTION DENGASF(T)
C   ETHANE SATURATED VAPOR DENSITIES, MOL/L.
C   Y = A1 + A2*Q2 + A3*Q3 + . . . , NF = AL, YN = LN(DCRT/DTRP),
C   U = Z + (ZE-Z)*Y, DEN = DCRT*EXP(-YN*U).
C   NOTE THAT Z = 0 ONLY AT T = TCRT, WHICH IS EXCLUDED.
COMMON I,AL,ITRP,TCRT,DTRP,DCRT,DRDT,D2RDT2,A(9)
1  FORMAT(1H0 9X *DENGASF = 0, T EXCEEDS TCRT. * / )
2  IF(TCRT-T) 3,4,5
3  PRINT 1 $ STOP
4  DENGASF = DCRT $ DRDT = D2RDT2 = 0 $ RETURN
5  ZN=TCRT/ITRP-1 $ YN=LOGF(DCRT/DTRP) $ Z=(TCRT/T-1)/ZN
6  DZDT = -TCRT/ZN/T**2 $ D2ZDT2 = -2*DZDT/T
7  ZE = Z**E $ ZE1 = E*ZE/Z $ ZE2 = (E-1)*ZE1/Z
8  X = ZE-Z $ X1 = ZE1 - 1 $ X2 = ZE2
9  Q = CUBERTF(Z) $ Q1 = Q/3/Z $ Q2 = -2*Q1/3/Z
10 NF = AL $ Y = A(1) $ Y1 = Y2 = 0 $ DO 13 K=2,NF
11 Y = Y + A(K)*Q**K
12 Y1 = Y1 + K*A(K)*Q**(K-1)
13 Y2 = Y2 + K*(K-1)*A(K)*Q**(K-2)
14 Y2 = Y1*Q2 + Y2*Q1**2 $ Y1 = Y1*Q1
15 U = Z + X*Y $ UA = 1 + X*Y1 + X1*Y $ U1 = UA*DZDT
16 U2 = UA*D2ZDT2 + (X*Y2 + 2*X1*Y1 + X2*Y)*DZDT**2
17 XP = EXPF(-YN*U) $ DENGASF = F = DCRT*XP $ YU = -YN*U1
18 DRDT = YU*F $ D2RDT2 = (YU*YU-YN*U2)*F $ RETURN $ END

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CGM 181

APPENDIX G.

Cryogenics Division—NBS Institute for Basic Standards

LABORATORY NOTE

COST CENTER

2750364

FILE NO

73-6

PAGE

SUBJECT

Liquid-Vapor Saturation (Orthobaric) Temperatures of
Ethane and Methane

NAME

R. D. Goodwin

DATE

Nov. 28, 1973

1. Introduction.

The present, new investigation has been necessary to accommodate the extreme range of ethane saturated vapor densities (a factor of 10^7). Our previous work on ethane appears in Lab. Notes 73-2, 3, 4, 5.

Analytical description of the two-phase, liquid-vapor equilibrium (temperature-density relationship) is needed for our new equation of state which originates on this locus (NBS IR 73-342). In particular, the forms used below give the important property that all derivatives are zero at the critical point.

In the following we split the range, using different functions according to $\rho \leq \rho_c$. In each case the dependent variable is

$$Y(T) \equiv (T_c / T - 1) / (T_c / T_t - 1) \quad (1)$$

The symbols used here appear in a LIST.

2. The Saturated Vapor Temperatures.

The analytical formulation is

$$Y(T) = U(\sigma) \cdot [1 + A_0 \cdot \ln(\sigma / \sigma_g) + W(\sigma)] \quad (2)$$

where

$$U(\sigma) \equiv \exp[\alpha \cdot (u_g - u)], \quad (2-a)$$

and

$$W(\sigma) = \sum_{i=1}^n A_i \cdot (q^i - q_g^i). \quad (2-b)$$

The notation is $q = \sigma^{1/3}$, $q_g = \sigma_g^{1/3}$, and $u_g = 1/|\sigma_g - 1|$.

This equation is constrained at the vapor triple point.

Fixed-point constants are given by table 1, and coefficients by table 2. The comparisons of results for ethane and for methane are in tables 3, 5. Deviations necessarily are systematic because the "data" are smoothed analytically (Lab. Note 73-5). We believe all deviations to be well within the real accuracy of the data.

3. The Saturated Liquid Temperatures.

The analytical formulation is

$$\ln(Y) = \beta \cdot (u_t - u) + W(\sigma) \quad (3)$$

where

$$W(\sigma) = \sum_{i=1}^n B_i \cdot (x^i - x_t^i). \quad (3-a)$$

LABORATORY NOTE

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SUBJECT

Liquid-Vapor Saturation (Orthobaric) Temperatures of
Ethane and Methane

NAME

R. D. Goodwin

DATE

Nov. 28, 1973

The notation is $x_t \equiv |\sigma_t - 1|$, $u_t \equiv 1/x_t$.

This equation is constrained at the liquid triple point.

The comparisons of results for ethane and for methane are in tables 4, 6. Computer programs are attached.

LIST OF SYMBOLS

d ,	density, mol/l,	DEN
d_c ,	critical-point density,	DCRT
d_g ,	vapor triple-point density,	DGAT
d_t ,	liquid triple-point density,	DTRP
q ,	$\sigma^{1/3}$, $q_g \equiv \sigma_g^{1/3}$	
ρ ,	d/d_t , density reduced at liquid triple point	
σ ,	d/d_c , density reduced at the critical point	
σ_g ,	d_g/d_c , reduced triple-point vapor density	
σ_t ,	d_t/d_c , reduced triple-point liquid density	
T ,	$T_s(\rho)$, the saturation temperature	
T_c ,	critical-point temperature,	TCRT
T_t ,	triple-point temperature,	TTRP
u ,	$1/x$, $u_g \equiv 1/x_g$, $u_t \equiv 1/x_t$	
x ,	$ \sigma - 1 $, $x_g \equiv \sigma_g - 1 $, $x_t \equiv \sigma_t - 1 $	

Table 1. The fixed-point constants

	<u>Ethane</u>	<u>Methane</u>
T_t , K	89.899	90.680
T_c , K	305.330	190.555
d_c , mol/l	6.87	10.20
d_t , liquid	21.68	28.147
d_g , vapor	$1.35114 \cdot 10^{-6}$	$1.567865 \cdot 10^{-2}$

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Table 2. Coefficients for the equations					
		Ethane	Methane		
<u>Vapor</u>	α	3/2	1/2		
	A ₀	-0.0610 6983	-0.1596 5159		
	A ₁	-0.5510 7806	-0.6669 5380		
	A ₂	1.8906 0757	1.0242 2995		
	A ₃	-4.8476 0684	-0.5885 7993		
	A ₄	8.5887 8625	0.2042 8358		
	A ₅	-8.3103 1296	-		
	A ₆	3.3001 3887	-		

rms, %	d	0.111	0.043		
	T	0.009	0.004		
<u>Liquid</u>	β	1/3	1/3		
	B ₁	9.1071 7170	8.5837 7917		
	B ₂	-7.9603 9387	-7.0525 4699		
	B ₃	4.8472 6284	4.1610 2443		
	B ₄	-1.5919 0104	-1.3691 9291		
	B ₅	0.2253 7899	0.2067 1342		

rms, %	d	0.004	0.006		
	T	0.016	0.006		

Liquid-Vapor Saturation (Orthobaric) Temperatures of Ethane and Methane				COST CENTER	FILE NO	PAGE
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Table 3. Ethane Saturated Vapor Temperatures				NAME	R. D. Goodwin	
				DATE	Nov. 28. 1973	

NF = 7, AL = 1.500, PE = 0.000, DGAT = 1.35114-006

TTRP = 89.899, TCRT = 305.330, DTRP = 21.680, DCRT = 6.870

-0.06106983	-0.55107806	1.89060757	-4.84760684
8.58878625	-8.31031296	3.30013887	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000

MOL/L	CALC	PCNT	T,K	CALC	PCNT	DTS/DD
1.35114-006	1.35114-006	0.00	89.899	89.899	0.00	2.915+006
1.38631-006	1.38619-006	-0.01	90.000	90.000	0.00	2.848+006
4.59443-006	4.58134-006	-0.28	95.000	95.013	0.01	9.651+005
1.33561-005	1.33129-005	-0.32	100.000	100.016	0.02	3.714+005
3.46326-005	3.46067-005	-0.22	105.000	105.012	0.01	1.594+005
8.16960-005	8.16454-005	-0.06	110.000	110.004	0.00	7.518+004
1.76844-004	1.76987-004	0.08	115.000	114.995	-0.00	3.846+004
3.55631-004	3.56292-004	0.17	120.000	119.987	-0.01	2.111+004
6.70303-004	6.72259-004	0.20	125.000	124.983	-0.01	1.231+004
1.19634-003	1.19845-003	0.18	130.000	129.984	-0.01	7.567+003
2.03041-003	2.03275-003	0.12	135.000	134.989	-0.01	4.870+003
3.29903-003	3.30029-003	0.04	140.000	139.996	-0.00	3.262+003
5.15754-003	5.15568-003	-0.04	145.000	145.004	0.00	2.263+003
7.79177-003	7.78449-003	-0.09	150.000	150.012	0.01	1.619+003
1.14183-002	1.14040-002	-0.13	155.000	155.017	0.01	1.191+003
1.62342-002	1.62628-002	-0.13	160.000	160.019	0.01	8.969+002
2.26660-002	2.26402-002	-0.11	165.000	165.018	0.01	6.903+002
3.08696-002	3.08446-002	-0.08	170.000	170.013	0.01	5.415+002
4.12247-002	4.12114-002	-0.03	175.000	175.006	0.00	4.322+002
5.40333-002	5.41016-002	0.01	180.000	179.997	-0.00	3.502+002
6.38623-002	6.99003-002	0.05	185.000	184.989	-0.01	2.877+002
8.89439-002	8.90172-002	0.08	190.000	189.982	-0.01	2.392+002
1.11782-001	1.11888-001	0.10	195.000	194.979	-0.01	2.009+002
1.38350-001	1.38978-001	0.09	200.000	199.978	-0.01	1.704+002
1.70662-001	1.70787-001	0.07	205.000	204.982	-0.01	1.457+002
2.07770-001	2.07862-001	0.04	210.000	209.988	-0.01	1.253+002
2.50780-001	2.50803-001	0.01	215.000	214.997	-0.00	1.085+002
3.00359-001	3.00280-001	-0.03	220.000	220.007	0.00	9.434+001
3.57253-001	3.57050-001	-0.06	225.000	225.017	0.01	8.234+001
4.22301-001	4.21977-001	-0.08	230.000	230.023	0.01	7.208+001
4.96469-001	4.96061-001	-0.08	235.000	235.026	0.01	6.322+001
5.80877-001	5.80460-001	-0.07	240.000	240.023	0.01	5.553+001
6.76852-001	6.76541-001	-0.05	245.000	245.015	0.01	4.879+001
7.85330-001	7.85922-001	-0.01	250.000	250.003	0.00	4.286+001
9.10251-001	9.10553-001	0.03	255.000	254.989	-0.00	3.760+001
1.05210+000	1.05283+000	0.07	260.000	259.976	-0.01	3.291+001
1.21471+000	1.21579+000	0.09	265.000	264.969	-0.01	2.867+001
1.40231+000	1.40343+000	0.08	270.000	269.972	-0.01	2.482+001
1.62073+000	1.62131+000	0.04	275.000	274.988	-0.00	2.124+001
1.87345+000	1.87773+000	-0.04	280.000	280.013	0.00	1.788+001
2.18360+000	2.18618+000	-0.11	285.000	285.035	0.01	1.463+001
2.57357+000	2.57061+000	-0.11	290.000	290.032	0.01	1.146+001
3.07773+000	3.03011+000	-0.08	295.000	294.980	-0.01	8.351+000
3.81303+000	3.82168+000	0.10	300.000	299.980	-0.01	5.426+000

NP = 44, DNRMSPT = 0.111, TSRMSPT = 0.009

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Table 4. Ethane Saturated Liquid Temperatures

NF = 5, AL = 0.000, BE = 0.333, NGAT = 1.35114-006

TTRP = 89.899, TCRT = 305.330, DTRP = 21.680, DCRT = 6.870

9.10717170	-7.96039387	4.84726284	-1.59190104
0.22537899	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000

MOL/L	CALC	PCNT	T, K	CALC	PCNT	DTS/00
2.16800+001	2.16800+001	0.00	89.899	89.899	0.00	-2.753+001
2.16764+001	2.16763+001	-0.00	90.000	89.999	-0.00	-2.753+001
2.14963+001	2.14951+001	-0.01	95.000	94.967	-0.04	-2.764+001
2.13162+001	2.13145+001	-0.01	100.000	99.952	-0.05	-2.771+001
2.11359+001	2.11341+001	-0.01	105.000	104.951	-0.05	-2.773+001
2.09553+001	2.09538+001	-0.01	110.000	109.958	-0.04	-2.771+001
2.07743+001	2.07732+001	-0.01	115.000	114.969	-0.03	-2.766+001
2.05928+001	2.05921+001	-0.00	120.000	119.983	-0.01	-2.758+001
2.04106+001	2.04105+001	-0.00	125.000	124.997	-0.00	-2.746+001
2.02276+001	2.02260+001	0.00	130.000	130.010	0.01	-2.733+001
2.00438+001	2.00445+001	0.00	135.000	135.020	0.01	-2.717+001
1.98598+001	1.98598+001	0.01	140.000	140.027	0.02	-2.698+001
1.96727+001	1.96739+001	0.01	145.000	145.031	0.02	-2.679+001
1.94852+001	1.94864+001	0.01	150.000	150.032	0.02	-2.655+001
1.92961+001	1.92972+001	0.01	155.000	155.031	0.02	-2.631+001
1.91052+001	1.91062+001	0.01	160.000	160.027	0.02	-2.604+001
1.89123+001	1.89132+001	0.00	165.000	165.021	0.01	-2.575+001
1.87173+001	1.87178+001	0.00	170.000	170.014	0.01	-2.544+001
1.85198+001	1.85201+001	0.00	175.000	175.006	0.00	-2.511+001
1.83196+001	1.83195+001	-0.00	180.000	179.999	-0.00	-2.476+001
1.81164+001	1.81160+001	-0.00	185.000	184.992	-0.00	-2.438+001
1.79098+001	1.79092+001	-0.00	190.000	189.986	-0.01	-2.397+001
1.76996+001	1.76987+001	-0.00	195.000	194.981	-0.01	-2.354+001
1.74852+001	1.74843+001	-0.01	200.000	199.978	-0.01	-2.308+001
1.72664+001	1.72653+001	-0.01	205.000	204.977	-0.01	-2.260+001
1.70425+001	1.70415+001	-0.01	210.000	209.979	-0.01	-2.208+001
1.68130+001	1.68121+001	-0.01	215.000	214.981	-0.01	-2.153+001
1.65774+001	1.65767+001	-0.00	220.000	219.985	-0.01	-2.094+001
1.63348+001	1.63344+001	-0.00	225.000	224.990	-0.00	-2.033+001
1.60845+001	1.60843+001	-0.00	230.000	229.996	-0.00	-1.967+001
1.58255+001	1.58256+001	0.00	235.000	235.002	0.00	-1.898+001
1.55567+001	1.55571+001	0.00	240.000	240.007	0.00	-1.825+001
1.52767+001	1.52773+001	0.00	245.000	245.011	0.00	-1.749+001
1.49838+001	1.49846+001	0.01	250.000	250.013	0.01	-1.668+001
1.46761+001	1.46770+001	0.01	255.000	255.014	0.01	-1.582+001
1.43511+001	1.43518+001	0.01	260.000	260.012	0.00	-1.493+001
1.40054+001	1.40059+001	0.00	265.000	265.008	0.00	-1.398+001
1.36348+001	1.36350+001	0.00	270.000	270.002	0.00	-1.298+001
1.32333+001	1.32331+001	-0.00	275.000	274.997	-0.00	-1.191+001
1.27923+001	1.27917+001	-0.00	280.000	279.994	-0.00	-1.076+001
1.22965+001	1.22978+001	-0.01	285.000	284.993	-0.00	-9.500+000
1.17293+001	1.17290+001	-0.00	290.000	289.997	-0.00	-8.090+000
1.10398+001	1.10403+001	0.00	295.000	295.003	0.00	-6.441+000
1.01117+001	1.01117+001	0.00	300.000	300.000	-0.00	-4.358+000

Liquid-Vapor Saturation (Orthobaric) Temperatures of
Ethane and Methane

Table 5. Methane Saturated Vapor Temperatures

6

NF = 5, AL = 0.500, BE = 0.000, DGAT = 1.56787-002

TTRP = 90.680, TCRT = 190.555, DTRP = 28.147, DCRT = 10.200

-0.15965159	-0.66695380	1.02422995	-0.58857993
0.20428358	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000

MOL/L	CALC	PCNT	T,K	CALC	PCNT	DTS/DO
1.56786-002	1.56786-002	0.00	90.680	90.680	0.00	5.391+002
1.82791-002	1.82830-002	0.02	92.000	91.938	-0.00	4.775+002
2.28579-002	2.28668-002	0.04	94.000	93.936	-0.00	4.005+002
2.82943-002	2.83066-002	0.04	96.000	95.936	-0.00	3.390+002
3.46926-002	3.47064-002	0.04	98.000	97.936	-0.00	2.893+002
4.21625-002	4.21756-002	0.03	100.000	99.937	-0.00	2.488+002
5.08186-002	5.08288-002	0.02	102.000	101.938	-0.00	2.154+002
6.07803-002	6.07855-002	0.01	104.000	103.939	-0.00	1.878+002
7.21719-002	7.21702-002	-0.00	106.000	106.000	0.00	1.647+002
8.51224-002	8.51123-002	-0.01	108.000	108.001	0.00	1.453+002
9.97658-002	9.97466-002	-0.02	110.000	110.002	0.00	1.288+002
1.16241-001	1.16213-001	-0.02	112.000	112.003	0.00	1.147+002
1.34692-001	1.34655-001	-0.03	114.000	114.004	0.00	1.026+002
1.55269-001	1.55226-001	-0.03	116.000	116.004	0.00	9.221+001
1.78128-001	1.78080-001	-0.03	118.000	118.004	0.00	8.314+001
2.03431-001	2.03383-001	-0.02	120.000	120.004	0.00	7.522+001
2.31348-001	2.31304-001	-0.02	122.000	122.003	0.00	6.827+001
2.62058-001	2.62022-001	-0.01	124.000	124.002	0.00	6.215+001
2.95748-001	2.95725-001	-0.01	126.000	126.001	0.00	5.672+001
3.32616-001	3.32611-001	-0.00	128.000	128.000	0.00	5.189+001
3.72870-001	3.72889-001	0.01	130.000	129.939	-0.00	4.757+001
4.16733-001	4.16780-001	0.01	132.000	131.938	-0.00	4.370+001
4.64444-001	4.64526-001	0.02	134.000	133.937	-0.00	4.021+001
5.16255-001	5.16367-001	0.02	136.000	135.936	-0.00	3.706+001
5.72441-001	5.72579-001	0.02	138.000	137.935	-0.00	3.420+001
6.33297-001	6.33462-001	0.03	140.000	139.935	-0.00	3.159+001
6.99144-001	6.99331-001	0.03	142.000	141.935	-0.00	2.921+001
7.70334-001	7.70534-001	0.03	144.000	143.935	-0.00	2.704+001
8.47251-001	8.47451-001	0.02	146.000	145.935	-0.00	2.503+001
9.30320-001	9.30504-001	0.02	148.000	147.936	-0.00	2.319+001
1.02001+000	1.02016+000	0.01	150.000	149.937	-0.00	2.148+001
1.11685+000	1.11694+000	0.01	152.000	151.938	-0.00	1.989+001
1.22143+000	1.22144+000	0.00	154.000	154.000	-0.00	1.842+001
1.33441+000	1.33433+000	-0.01	156.000	156.001	0.00	1.705+001
1.45656+000	1.45636+000	-0.01	158.000	158.003	0.00	1.576+001
1.58877+000	1.58843+000	-0.02	160.000	160.005	0.00	1.455+001
1.73204+000	1.73156+000	-0.03	162.000	162.007	0.00	1.341+001
1.88759+000	1.88697+000	-0.03	164.000	164.008	0.00	1.234+001
2.05685+000	2.05610+000	-0.04	166.000	166.008	0.01	1.132+001
2.24155+000	2.24073+000	-0.04	168.000	168.008	0.01	1.036+001
2.44331+000	2.44300+000	-0.03	170.000	170.008	0.00	9.433+000
2.66631+000	2.66564+000	-0.03	172.000	172.006	0.00	8.548+000
2.91249+000	2.91214+000	-0.01	174.000	174.003	0.00	7.696+000
3.18691+000	3.18711+000	0.01	176.000	175.939	-0.00	6.871+000
3.49581+000	3.49685+000	0.03	178.000	177.934	-0.00	6.066+000
3.84823+000	3.85039+000	0.06	180.000	179.939	-0.01	5.275+000
4.25806+000	4.26143+000	0.08	182.000	181.935	-0.01	4.488+000
4.74367+000	4.75265+000	0.08	184.000	183.935	-0.01	3.690+000
5.36526+000	5.36679+000	0.03	186.000	185.936	-0.00	2.858+000
6.20000+000	6.20573+000	-0.23	188.000	188.028	0.01	1.935+000

Liquid-Vapor Saturation (Orthobaric) Temperatures of
Ethane and Methane

Table 6. Methane Saturated Liquid Temperatures

7

NF = 5, AL = 0.000, BE = 0.333, DGAT = 1.56787-002

TTRP = 90.680, TCRT = 190.555, DTRP = 28.147, DCRT = 10.200

	8.53377917 0.20671342	-7.05254599 0.00000000	4.16102443 0.00000000	-1.36919291 0.00000000			
I	MOL/L	CALC	PCNT	T,K	CALC	PCNT	DTS/DO
2.81470+001	2.81470+001	0.00	90.680	90.630	0.00	-1.208+001	
2.80378+001	2.80375+001	-0.00	92.000	91.936	-0.00	-1.203+001	
2.78714+001	2.78706+001	-0.00	94.000	93.931	-0.01	-1.194+001	
2.77036+001	2.77026+001	-0.00	96.000	95.938	-0.01	-1.186+001	
2.75344+001	2.75332+001	-0.00	98.000	97.936	-0.01	-1.176+001	
2.73638+001	2.73625+001	-0.00	100.000	99.935	-0.01	-1.167+001	
2.71916+001	2.71904+001	-0.00	102.000	101.936	-0.01	-1.157+001	
2.70179+001	2.70167+001	-0.00	104.000	103.937	-0.01	-1.147+001	
2.68425+001	2.68415+001	-0.00	106.000	105.938	-0.01	-1.136+001	
2.66654+001	2.66645+001	-0.00	108.000	107.930	-0.01	-1.125+001	
2.64865+001	2.64857+001	-0.00	110.000	109.932	-0.01	-1.113+001	
2.63056+001	2.63051+001	-0.00	112.000	111.934	-0.01	-1.101+001	
2.61228+001	2.61224+001	-0.00	114.000	113.936	-0.00	-1.089+001	
2.59379+001	2.59377+001	-0.00	116.000	115.938	-0.00	-1.076+001	
2.57507+001	2.57507+001	0.00	118.000	118.000	0.00	-1.063+001	
2.55612+001	2.55615+001	0.00	120.000	120.012	0.00	-1.050+001	
2.53693+001	2.53697+001	0.00	122.000	122.014	0.00	-1.036+001	
2.51749+001	2.51754+001	0.00	124.000	124.016	0.00	-1.022+001	
2.49777+001	2.49784+001	0.00	126.000	126.017	0.01	-1.008+001	
2.47776+001	2.47784+001	0.00	128.000	128.018	0.01	-9.928+000	
2.45745+001	2.45754+001	0.00	130.000	130.019	0.01	-9.775+000	
2.43632+001	2.43692+001	0.00	132.000	132.019	0.01	-9.618+000	
2.41535+001	2.41595+001	0.00	134.000	134.019	0.01	-9.457+000	
2.39452+001	2.39462+001	0.00	136.000	136.019	0.01	-9.292+000	
2.37230+001	2.37290+001	0.00	138.000	138.019	0.01	-9.122+000	
2.35067+001	2.35076+001	0.00	140.000	140.018	0.01	-8.948+000	
2.32810+001	2.32813+001	0.00	142.000	142.017	0.01	-8.768+000	
2.30506+001	2.30513+001	0.00	144.000	144.016	0.00	-8.584+000	
2.28152+001	2.28158+001	0.00	146.000	146.015	0.00	-8.395+000	
2.25744+001	2.25748+001	0.00	148.000	148.013	0.00	-8.200+000	
2.23276+001	2.23278+001	0.00	150.000	150.012	0.00	-7.999+000	
2.20746+001	2.20745+001	-0.00	152.000	152.010	-0.00	-7.793+000	
2.18146+001	2.18143+001	-0.00	154.000	153.938	-0.00	-7.579+000	
2.15471+001	2.15466+001	-0.00	156.000	155.936	-0.00	-7.359+000	
2.12713+001	2.12705+001	-0.00	158.000	157.935	-0.00	-7.132+000	
2.09863+001	2.09853+001	-0.00	160.000	159.933	-0.00	-6.896+000	
2.06912+001	2.06901+001	-0.01	162.000	161.932	-0.00	-6.652+000	
2.03849+001	2.03835+001	-0.01	164.000	163.931	-0.01	-6.399+000	
2.00658+001	2.00643+001	-0.01	166.000	165.931	-0.01	-6.135+000	
1.97322+001	1.97307+001	-0.01	168.000	167.932	-0.00	-5.859+000	
1.93820+001	1.93807+001	-0.01	170.000	169.933	-0.00	-5.570+000	
1.90125+001	1.90114+001	-0.01	172.000	171.934	-0.00	-5.265+000	
1.86201+001	1.86195+001	-0.00	174.000	173.937	-0.00	-4.943+000	
1.82004+001	1.82004+001	0.00	176.000	176.010	-0.00	-4.600+000	
1.77457+001	1.77475+001	0.00	178.000	178.013	0.00	-4.232+000	
1.72499+001	1.72516+001	0.01	180.000	180.016	0.00	-3.833+000	
1.66958+001	1.66983+001	0.01	182.000	182.018	0.00	-3.394+000	
1.60606+001	1.60632+001	0.02	184.000	184.018	0.00	-2.903+000	
1.52986+001	1.52997+001	0.01	186.000	186.013	0.00	-2.338+000	
1.42978+001	1.42937+001	-0.03	188.000	187.933	-0.00	-1.652+000	
1.25270+001	1.25276+001	0.00	190.000	190.000	0.00	-6.700-001	

APPENDIX G. (Continued)

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Appendix I. The Computer Programs

```

PROGRAM TSATFIT
C  DESCRIBE ETHANE SATN. TEMPS., TSAT(DEN).
C  DEFINE R=D/DTRP, S=D/DCRT, ST=DTRP/DCRT, AND -
C  YY(TSAT) = (TCRT/T-1)/(TCRT/ITRP-1), AND -
C
COMMON NG,AL,BE,TTRP,TCRT,DGAT,DTRP,DCRT,DTSDR,A(15),B(15)
COMMON/999/NP,NF,H(15),Y(200),G(200,15)
DIMENSION T(99),DEN(99),YY(99),F(15)
DIMENSION UL(99)
2  FORMAT(1H1 30X *ETHANE SATURATION TEMPERATURES* //
1  16X4HNF =I3, 6H, AL =F7.3, 6H, BE =F7.3, 8H, DGAT =E13.5//
1  16X 6HTTRP =F7.3, 8H, TCRT =F8.3, 8H, DTRP =F7.3,
2  8H, DCRT =F6.3// 3(12X 4F16.8/ ) /
315X5HMOL/L 11X4HCALC 5X4HPCNT 8X3HT,K 6X4HCALC 5X4HPCNT6X6HDTS/DD)
3  FORMAT(1H1 14X 5HMOL/L 11X4HCALC 5X4HPCNT
3  8X3HT,K 6X4HCALC 5X4HPCNT 6X6HDTS/DD )
4  FORMAT(5X 2E15.5, F9.2, F11.3, F10.3, F9.2, E12.3)
5  FORMAT(13X 2HNF 13X2HAL 13X2HBE 8X2HSS)
6  FORMAT(10X I5, 2E15.5, F10.3)
9  FORMAT(1H0 6X 4HNP =I3, 12H, DNRMSPT =F6.3, 12H, TSRMSPT =F6.3)
11 TTRP=89.899 $ TCRT=305.33 $ YN = TCRT/TTRP-1
12 DTRP=21.68 $ DCRT=6.87 $ DGAT=1.35114E-6
13 ST=DGAT/DCRT $ VT=1/(1-ST) $ QT=CUBERTF(ST)
C
C  SATD. VAPOR TEMPS. CONSTRAINED AT T.P. BY SUBTRACTION -
C  EQUATION, YY = U(S)*(1+W(S)), U = EXP(AL*(VT-V)),
C  V = 1/ABS(S-1), Q = S*(1/3), AND -
C  W = A1*LN(S/ST) + A2*(Q-QT) + A3*(Q2-QT2) + . . .
C  GENERATE THE SATD. VAPOR DATA.
25 DO 29 J=1,44 $ IF(J-1) 27,26
26 T(J) = TTRP $ GO TO 28
27 T(J) = 80 + 5*J
28 DEN(J) = DENGASF(T(J))
29 YY(J) = (TCRT/T(J)-1)/YN $ NP = 44
C  PRINT FOR NF, GET AL BY TRIAL.
30 AL = 1.50
31 DO 69 NF=4,10 $ NG = NF $ SSK = 1.0E+100
32 DO 40 J=1,NP $ S=DEN(J)/DCRT $ Q=CUBERTF(S) $ V=1/(1-S)
33 U = EXPF(AL*(VT-V)) $ G(J,1) = U*LOGF(S/ST)
35 DO 36 K=2,NF $ N = K-1
36 G(J,K) = U*(Q**N - QT**N)
40 Y(J) = YY(J) - U
49 CALL EGENFT $ DO 50 K=1,NF
50 A(K) = H(K) $ SD = SS = 0
51 DO 52 J=1,NP $ TC = TSATF(DEN(J))
52 SS = SS + (TC/T(J)-1)**2 $ SS = 100*SQRTF(SS/NP)
53 IF(SS.LT.SSK) 54,56
54 SSK=SS $ NGK=NG $ ALK=AL $ BEK=BE $ DO 55 K=1,NF
55 F(K) = A(K)
56 CONTINUE
57 CONTINUE $ NG=NGK $ AL=ALK $ BE=BEK $ DO 58 K=1,NF
58 A(K) = F(K) $ SS = SD = 0

```

APPENDIX G. (Continued)

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Appendix I. (continued)

C PRINT CONSTANTS AND DEVIATIONS.

60 PRINT 2, NG, AL, BE, DGAT, TTRP, TCRT, DTRP, DCRT, (A(K), K=1, 12)

61 DO 67 J=1, NP \$ D=DEN(J) \$ X=T(J) \$ DC=FINDSATF(0, X)

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62 DPCT = 100*(DC/D-1) \$ SD = SD + DPCT*DPCT

64 IC = TSATF(0) \$ DTSDD = DTSOR/DTRP

65 TPCT = 100*(TC/X-1) \$ SS = SS + TPCT*TPCT

67 PRINT 4, D, DC, DPCT, X, TC, TPCT, DTSDD

68 SD=SQRTF(SD/NP) \$ SS=SQRTF(SS/NP) \$ PRINT 9, NP, SD, SS

69 CONTINUE \$ AL = 0

C
C SATD. LIQUID TEMPS. CONSTRAINED AT THE T.P. BY SUBTRACTION, -
C EQN., $\ln(YY) = W(S)$, WHERE $X=ABS(S-1)$, $XT=ABS(ST-1)$, AND -
C $W(S) = BE*(1/XT-1/X) + B1*(X-XT) + B2*(X2-XT2) + \dots$
C GENERATE LIQUID DATA.

70 DO 74 J=1, 44 \$ IF(J-1) 72, 71

71 T(J) = TTRP \$ GO TO 73

72 T(J) = 80 + 5*J

73 DEN(J) = DENLIQF(T(J))

74 YY(J) = LOGF((TCRT/T(J)-1)/YN)

75 NP = 44 \$ NG = NF = 5 \$ XT = DTRP/DCRT - 1

C SET UP FIXED LEAST SQUARES FUNCTIONS.

80 DO 85 J=1, NP \$ S = DEN(J)/DCRT \$ X = ABSF(S-1)

81 UL(J) = 1/XT - 1/X \$ DO 82 K=1, NF \$ N = K

82 G(J, K) = X**N - XT**N

85 CONTINUE

C FIND NF, BE BY TRIAL.

90 BE = 1.0/3.0 \$ DO 91 J=1, NP

91 Y(J) = YY(J) - BE*UL(J) \$ CALL EGENFT \$ DO 92 K=1, NF

92 B(K) = H(K) \$ SD = SS = 0

C PRINT LIQUID DEVIATIONS.

100 PRINT 2, NG, AL, BE, DGAT, TTRP, TCRT, DTRP, DCRT, (B(K), K=1, 12)

101 DO 105 J=1, NP \$ D=DEN(J) \$ X=T(J) \$ DC = FINDSATF(1, X)

102 DPCT = 100*(DC/D-1) \$ SD = SD + DPCT**2

103 TC = TSATF(0) \$ DTSDD = DTSOR/DTRP

104 TPCT = 100*(TC/X-1) \$ SS = SS + TPCT**2

105 PRINT 4, D, DC, DPCT, X, TC, TPCT, DTSDD

106 SD = SQRTF(SD/NP) \$ SS = SQRTF(SS/NP)

107 PRINT 9, NP, SD, SS

110 CONTINUE

999 STOP \$ END

APPENDIX G. (Continued)

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SUBJECT Liquid-Vapor Saturation (Orthobaric) Temperatures
of Ethane and Methane

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Appendix I. (continued)

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FUNCTION TSATF(DEN)

COMMON NG,AL,BE,ITRP,ICRT,DGAT,DTRP,DCRT,DTSDR,A(15),B(15)

1 R=DEN/DTRP \$ S=DEN/DCRT \$ QS = S-1 \$ DSDR=DTRP/DCRT \$ IF(QS) 2,30

2 X = ABSE(QS) \$ X1 = DSDR*QS/X \$ YN = TCRT/ITRP - 1

3 V = 1/X \$ V1 = -DSDR/QS/X \$ IF(QS) 4,30,15

C SATD. VAPOR TEMPS. CONSTRAINED AT T.P. BY SUBTRACTION -

C EQUATION, YY = U(S)*(1+W(S)), U = EXP(AL*(VT-V)),

C V = 1/ABS(S-1), Q = S**(1/3), AND -

C W = A1*LN(S/ST) + A2*(Q-QT) + A3*(Q2-QT2) + . . .

4 ST=DGAT/DCRT \$ V1=1/(1-ST) \$ QT=CUBERTF(ST)

5 U = EXPF(AL*(VT-V)) \$ U1 = -AL*V1*U

6 Q = CUBERTF(S) \$ Q1 = C*DSDR/3/S

7 W = 1 + A(1)*LOGF(S/ST) \$ W1 = A(1)*DSDR/S

8 DO 10 K=2,NG \$ N = K-1

9 W = W + A(K)*(Q**N - QT**N)

10 W1 = W1 + N*A(K)*Q1*Q**(N-1)

12 F = U*W \$ F1 = U*W1 + U1*W \$ Q = 1 + YN*F

14 TSATF = TCRT/Q \$ DTSDR = -YN*F1*TSATF/Q \$ RETURN

C SATD. LIQUID TEMPS. CONSTRAINED AT THE T.P. BY SUBTRACTION, -

C EQN., LN(YY) = W(S), WHERE X=ABS(S-1), XT=ABS(ST-1), AND -

C W(S) = BE*(1/XT-1/X) + B1*(X-XT) + B2*(X2-XT2) + . . .

15 XT = DSDR-1 \$ W = BE*(1/XT-V) \$ W1 = -BE*V1

17 DO 19 K=1,NG \$ N = K

18 W = W + B(K)*(X**N - XT**N)

19 W1 = W1 + B(K)*N*X1*X**(N-1)

20 F = EXPF(W) \$ F1 = W1*F \$ Q = 1 + YN*F

22 TSATF = TCRT/Q \$ DTSDR = -YN*F1*TSATF/Q \$ RETURN

30 TSATF = TCRT \$ DTSDR = 0 \$ RETURN \$ END

FUNCTION DENGASF(T)

C ETHANE SATURATED VAPOR DENSITIES, MOL/L.

C Y = A1 + A2*Q2 + A3*Q3 + . . . , NF = AL, YN = LN(DCRT/DTRP),

C U = Z + (ZE-Z)*Y, DEN = DCRT*EXP(-YN*U).

DIMENSION A(5)

DATA (ITRP=89.899),(TCRT=305.33),(E=0.362)

DATA (DCRT=6.87),(DTRP=1.35114E-6)

DATA(A = 0.19277431, 0.04155009, -0.78922629,

1 0.35766750, 0.12454376)

1 FORMAT(1H0 9X *DENGASF = 0, T EXCEEDS TCRT. * /)

2 IF(TCRT-T) 3,4,5

3 PRINT 1 \$ STOP

4 DENGASF = DCRT \$ DRDT = D2RDT2 = 0 \$ RETURN

5 ZN=TCRT/ITRP-1 \$ YN=LOGF(DCRT/DTRP) \$ Z=(TCRT/T-1)/ZN

6 DZDT = -TCRT/ZN/T/T \$ ZE = Z**E \$ ZE1 = E*ZE/Z

8 X = ZE-Z \$ X1 = ZE1-1 \$ Q = CUBERTF(Z) \$ Q1 = Q/3/Z

10 Y = A(1) \$ Y1 = 0 \$ DO 13 K=2,5

11 Y = Y + A(K)*Q**K

12 Y1 = Y1 + K*A(K)*Q**(K-1)

13 CONTINUE \$ Y1 = Y1*Q1

15 U = Z + X*Y \$ UA = 1 + X*Y1 + X1*Y \$ U1 = UA*DZDT

16 XP = EXPF(-YN*U) \$ DENGASF = F = DCRT*XP

17 DRDT = -YN*U1*F \$ RETURN \$ END

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SUBJECT Liquid-Vapor Saturation (Orthobaric) Temperatures
of Ethane and Methane

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Appendix I. (continued)

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FUNCTION FINDSATF(M,T)

```

C THIS FINDSATF ADJUSTED FOR ETHANE.
C ITERATE DEN TO MINIMIZE (T-TS) VIA TSATF(DEN).
C 1 = 0 FOR VAPOR, M = 1 FOR LIQUID.
COMMON NG,AL,BE,TTRP,TCRT, DGAT,DTRP,DCRT, DTSOR, A(15),B(15)
DATA (DGT=1.0E-6),(DLT=23.0)
1 FORMAT(1H0 9X *FINDSATF = 0, FAILS TO CONVERGE.* / )
2 FORMAT(1H0 9X *FINDSATF = 0, T EXCEEDS TCRT.* / )
3 IF(T-TCRT) 4,22,23
4 IF(M.EQ.0) 5,6
5 D = DENGASF(T) $ GO TO 7
6 D = DENLIQF(T)
7 DO 20 J=1,50 $ DT=T-TSATF(D) $ IF(ABS(DT/T)-1.0E-6) 21,21,8
8 DTDD = DTSOR/DTRP $ IF(DTDD.EQ.0.0) 22,9
9 DD = DT/DTDD $ IF(ABS(DD/D)-1.0E-6) 21,21,10
10 D = D + DD $ IF(M.EQ.0) 11,15
11 IF(D.GT.DGT) 13,12
12 D = DGT $ GO TO 20
13 IF(D.LT.DCRT) 20,14
14 D = DCRT - 0.02 $ GO TO 20
15 IF(D.GT.DLT) 16,17
16 D = DLT $ GO TO 20
17 IF(D.GT.DCRT) 20,18
18 D = DCRT + 0.02
20 CONTINUE $ FINDSATF = 1 $ PRINT 1 $ RETURN
21 FINDSATF = 0 $ RETURN
22 FINDSATF = DCRT $ RETURN
23 FINDSATF = 0 $ PRINT 2 $ RETURN $ END

```

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FUNCTION DENLIQF(T)

```

C ETHANE SATURATED LIQUID DENSITIES, MOL/L.
C Y = A1 + A2*Q2 + A3*Q3 + . . . , YN = DTRP-DCRT,
C DEN = DCRT + YN*(X + (XE-X)*Y1).
DATA (TCRT=305.33),(TTRP=89.899),(DCRT=6.87),(DTRP=21.68),(E=0.35)
DATA (A=0.76173503),(B=0.29865351),(C=-0.32762394)
1 FORMAT(1H0 9X *DENLIQF = 0, T EXCEEDS TCRT.* / )
2 IF(TCRT-T) 3,4,5
3 PRINT 1 $ STOP
4 DENLIQF=DCRT $ DRDT=D2FDT2=0 $ RETURN
5 XN=TCRT-TTRP $ YN=DTRP-DCRT $ X=(TCRT-T)/XN $ DXDT=-1/XN
6 XE = X**E $ XE1 = E*XE/X $ W = CUBERTF(X) $ W1 = W/3/X
8 Q = XE-X $ Q1 = XE1-1
9 WW = W*W $ Y = A + B*W + C*X
10 Y1 = 2*B*W + 3*C*WW
11 Y1 = Y1*W1
13 DENLIQF = DCRT + (X + Q*Y)*YN
14 DRDT = (1 + Q*Y1 + Q1*Y)*YN*DXDT $ RETURN $ END

```

APPENDIX G. (Continued)

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Appendix I. (continued)

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FUNCTION DENGASF(T)

```

C METHANE SAT. VAPOR DEN, MOL/L, VIA VAPORFIT, 11/19/73.
C  $Y = A1 + A2*Q2 + A3*Q3 + \dots$ ,  $NF = AL$ ,  $YN = LN(DCRT/DTRP)$ ,
C  $U = Z + (ZE-Z)*Y$ ,  $DEN = DCRT*EXP(-YN*U)$ .
  DIMENSION A(5)
  DATA (TTRP=90.68), (TCRT=190.555), (E=0.388)
  DATA (DCRT=10.2), (DTRP=0.01567865)
  DATA (A = 0.3925579, -0.4976888, 1.3200516,
1 -1.6817790, 0.6848609)
1 FORMAT(1H0 9X *DENGASF = 0, T EXCEEDS TCRT. * / )
2 IF(TCRT-T) 3,4,5
3 PRINT 1 $ STOP
4 DENGASF = DCRT $ DRDT = D2RDT2 = 0 $ RETURN
5 ZN=TCRT/TTRP-1 $ YN=LOGF(DCRT/DTRP) $ Z=(TCRT/T-1)/ZN
6 DZDT = -TCRT/ZN/T/T $ ZE = Z**E $ ZE1 = E*ZE/Z
8 X = ZE-Z $ X1 = ZE1-1 $ Q = CUBERTF(Z) $ Q1 = Q/3/Z
10 Y = A(1) $ Y1 = 0 $ DO 13 K=2,5
11 Y = Y + A(K)*Q**K
12 Y1 = Y1 + K*A(K)*Q**(K-1)
13 CONTINUE $ Y1 = Y1*Q1
15 U = Z + X*Y $ UA = 1 + X*Y1 + X1*Y $ U1 = UA*DZDT
16 XP = EXPF(-YN*U) $ DENGASF = F = DCRT*XP
17 DRDT = -YN*U1*F $ RETURN $ END

```

FUNCTION DENLIQF(T)

```

C METHANE SATD. LIQUID DEN, MOL/L, VIA LAB. NOTE 73-5.
C  $Y = A1 + A2*Q2 + A3*Q3 + \dots$ ,  $YN = DTRP-DCRT$ ,
C  $DEN = DCRT + YN*(X + (XE-X)*Y)$ .
  DATA (TTRP=90.68), (TCRT=190.555), (E=0.361)
  DATA (DCRT=10.2), (DTRP=28.147)
  DATA (A=0.83709103), (B=0.08416127), (C=-0.07478575)
1 FORMAT(1H0 9X *DENLIQF = 0, T EXCEEDS TCRT. * / )
2 IF(TCRT-T) 3,4,5
3 PRINT 1 $ STOP
4 DENLIQF=DCRT $ DRDT=D2RDT2=0 $ RETURN
5 XN=TCRT-TTRP $ YN=DTRP-DCRT $ X=(TCRT-T)/XN $ DXDT=-1/XN
6 XE = X**E $ XE1 = E*XE/X $ W = CUBERTF(X) $ W1 = W/3/X
8 Q = XE-X $ Q1 = XE1-1
9 WW = W*W $ Y = A + B*WW + C*X
10 Y1 = 2*B*W + 3*C*WW
11 Y1 = Y1*W1
13 DENLIQF = DCRT + (X + Q*Y)*YN
14 DRDT = (1 + Q*Y1 + Q1*Y)*YN*DXDT $ RETURN $ END

```

APPENDIX H.

Computer Programs for Equation of State

06/05/74

PROGRAM ETHANE

```

C GOODWIN EQUATION OF STATE APPLIED TO ETHANE.
C EQN.  $(Y-YSAT) = F(R,T)$ , WHERE  $Y = (Z-1)*X/R$ , AND -
C  $F(R,T) = B*XBF + E*XEF$ , NOTE ONLY TWO TERMS.
C  $XBF = \sqrt{T/TC} * \ln(T/TS)$ .
C  $XEF = \Psi - \Psi_{SAT}$ ,  $\Psi = (1-W*\ln(1+1/W))/X$ ,  $W = EP*(T/TH-1)$ .
C  $B = B1 + B2*R + B3*R^2/(1+BE*R^2)$ ,  $BE = 1$ , APPROX.,
C  $E = (S-1)*(S-ER)*(E1 + E2*R)$ ,  $ER = 1.9$ ,  $NF = 5$ .
C NOTE, PRESSURE IN BARS, 1.01325 BAR/ATM.
C LET GAS CONSTANT GK = 0.0831434*DTRP,  $PN = R*GK*T$ .
C AUTHOR ID. VIRIAL(2), PAL(4), REAMER(8), MICHELS(9), DOUSLIN(10).
COMMON B1,B2,B3,B4, ER, E1,E2,E3
COMMON/1/AL,BE,EP,GK, DCRT,TCRT,PCRT, DTRP,TTRP,PTRP
COMMON/2/NP,NF, ID(999),T(999),P(999),DEN(999)
COMMON/3/D PDT,D2PDT2,DPSDT,DPHCT,DPDO,DPCR,DTSDR,DTHDR
COMMON/4/XB1,XB2, XC1,XC2, XE1,XE2, OXBDR,DXCDR,DXEDR
COMMON/6/ TSAT, THETA, PSAT
COMMON/7/ XB,XC,XD,XE
COMMON/8/IP,NPP,P1,P2,P3,P4,P5, IDP(99),TPS(99),PPS(99)
COMMON/9/IS,NPS,EG,EL,ALS,BES,AL1,AL2,AL3,CG(5),AV(8),AW(5)
COMMON/10/ IDS(99), TSS(99), DNS(99)
COMMON/11/ NP4, NP5
COMMON/999/ NFUN,Y,F(30)
DIMENSION G(30), DND(30),TD(16), PPD(30,16)
1 FORMAT(I5, 3F10.0)
2 FORMAT(I5, F10.3, E15.5)
3 FORMAT(1H09X *EQN. OF STATE, DTRP=*F7.3, 8H, DCRT =F7.3,
1 8H, TCRT =F8.3//10X4HAL =F5.2, 6H, BE =F5.2, 6H, EP =F5.2//
2 10X 4HNP =I4, 10H, PAVPCT =F6.3)
6 FORMAT(1H1 16X *THE ISOCHORE AT* F6.2, * MOL/L* //
1 17X 3HT,K 5X5HP,BAR 5X5HDP/DD 5X5HDP/DT 4X7HD2P/DT2)
7 FORMAT(10X F10.1, 2F10.3, F10.4, F11.5)
8 FORMAT(1H1 14X *THE ISOTHERM AT* F7.2, * DEG. K* //
1 10X 5HMOL/L 5X5HP,BAR 5X5HDP/CD 5X5HDP/DT 5X7HD2P/DT2 )
9 FORMAT(5X F10.2, 2F10.3, F10.4, F12.6)
11 FORMAT(1H1 7X *EQUATION OF STATE VS. PVT DATA* //
1 8X 2HID 7X3HT,K 5X5HMOL/L 5X5HCALCD 4X5HD,PCT
2 6X5HP,BAR 5X5HCALCD 4X5HP,PCT)
12 FORMAT(5X I5, F10.3, 2F10.4, F9.2, F11.3, F10.3, F9.2)
13 FORMAT(1H0 8X 4HNP =I4, 12H, DNRMSPT =F6.3, 12H, PMPANPCT =F6.3)
14 FORMAT(8F10.0)
15 FORMAT(16X 8F8.0)
16 FORMAT(10X 7F10.0)
22 TTRP=89.899 $ DTRP=21.68 $ Q=1.01325 $ PTRP=Q*9.967E-6
23 TCRT = 305.37 $ DCRT = 6.74
24 WM=30.07 $ QP=Q/14.69595 $ GK=0.0831434 $ GK=DTRP*GKK
25 AL=2.0 $ BE=1.0 $ EP=0.5 $ ER=1.9

C
C READ MIXED VAPOR PRESSURE DATA, ALL IN T-68, BAR.
26 DO 27 J=1,99 $ READ 2, IDP(J),TPS(J),PPS(J) $ IF(IDP(J))27,28
27 CONTINUE
C READ TSAT(DEN) DATA (ORTHOBARIC DENSITIES).
28 NPP = J-1 $ DO 29 J=1,28
29 READ 2, IDS(J),TSS(J),DNS(J) $ DO 31 J=29,99
30 READ 1, IDO,TSS(J),DNS(J) $ IF(IDO) 31,32

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31 IDS(J) = IDD
32 NPS = J - 1

C
C   GENERATE VIRIAL PVT DATA BELOW 1 MOL/L.
34 NP1 = 38 $ DN = 0.4 $ DO 37 J=1,NP1 $ N = J
35 TT = 220 + 10*N $ ID(N) = 2 $ T(N) = TT $ DEN(N) = DN
37 P(N) = DN*GKK*TT*ZIPF(TT,DN)
C   READ DOUSLIN ETHANE PVT DATA.
39 N=N+1 $ DEN(N)=0.70 $ T(N)=248.15 $ P(N)=Q*11.6087 $ ID(N)=10
C   SET UP HIS DENSITIES, AND READ HIS TEMPERATURES.
40 DND(1) = 0.75 $ DO 41 I=2,30
41 DND(I) = 0.5*I $ READ 14, (TD(J),J=1,16)
C   READ PRESSURES(ATM) ALONG ISOCHORES (MANY BLANKS).
42 DO 43 I=1,30 $ READ 15, (PPD(I,J),J=1,16)
C   CONVERT TO ONE PVT POINT PER INDEX, N.
43 CONTINUE $ DO 46 I=1,30 $ DO 46 J=1,16 $ IF(PPD(I,J)) 44,46
44 N = N+1 $ ID(N) = 10 $ T(N) = 273.15 + TD(J)
45 DEN(N) = DND(I) $ P(N) = Q*PPD(I,J)
46 CONTINUE $ DO 48 J=1,5 $ READ 1, IDD,DN,TT,PP
47 N=N+1 $ ID(N)=IDD $ DEN(N)=DN $ T(N)=TT $ P(N) = Q*PP
C   READ MICHELS, DEG. C, AMAGAT DEN, AMAGAT (PV).
48 CONTINUE $ NP2 = N $ READ 16, (TD(J),J=1,7) $ DO 49 I=1,17
49 READ 14, DND(I), (PPD(I,J),J=1,7)
50 DO 53 I=1,17 $ DO 53 J=1,7 $ IF(PPD(I,J)) 51,53
51 N = N+1 $ ID(N) = 9 $ T(N) = 273.15 + TD(J)
52 DEN(N) = 0.045064*DND(I) $ P(N) = Q*DND(I)*PPD(I,J)
53 CONTINUE $ NP3 = N
C   READ 8 PAL/POPE ISOCHORES NO. 17 THRU 24, GRAM/CC, PSIA.
C   THESE DATA ADJUSTED BY RICE UNIV., APRIL, 1974.
57 DO 62 I=1,12 $ DO 61 J=1,99
58 READ 14, DN,TT,PP $ IF(DN) 59,62
59 N = N+1 $ ID(N) = 1200 + 100*I + J
60 T(N) = TT $ P(N) = QP*PP $ DEN(N) = 1000*DN/WM
61 CONTINUE
C   READ REAHER ET AL UP TO NP5.
62 CONTINUE $ NP4 = N $ CALL READIT
C   USE ONLY DATA THRU PAL/POPE FOR LEAST SQUARES.
63 NP = NP4 $ NF = 5 $ SSK = 1.0E+100 $ IP = IS = 1
C
C   EXPLORE NONLINEAR PARAMETERS DTRP,DCRT,TCRT,AL,BE,EP.
64 CALL PSATFIT $ PCRT = PSATF(TCRT)
65 CALL DSATFIT $ CALL TSATFIT
C 66 DO 74 MA=1,3 $ AL = 0.5*(MA+2)
C 67 DO 74 ME=1,3 $ EP = 1.0/(6-ME)
68 CALL SETUP $ SS = 0 $ DO 69 J=1,NP
69 SS = SS + ABSF(1-PVTF(T(J),DEN(J))/P(J)) $ SS = 100*SS/NP
70 IF(SS-SSK) 71,74,74
71 SSK=SS $ DCR=DCRT $ TCR=TCRT $ ALK=AL $ BEK=BE $ EPK=EP
72 DO 73 K=1,NF
73 G(K) = F(K)
74 PRINT 3, DTRP,DCRT,TCRT, AL,BE,EP, NP,SS
76 DCR=DCR $ TCR=TCR $ AL=ALK $ BE=BEK $ EP=EPK
77 B1=G(1) $ B2=G(2) $ B3=G(3)
78 E1=G(4) $ E2=G(5)
80 CALL PEEK $ CALL ISOTHERM

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C
C   GET DEVIATIONS FOR INDIVIDUAL AUTHORS.
83 DO 100 IG=1,5 $ GOTO(84,85,86,87,88),IG
84 M=1 $ N=NP1 $ GO TO 90
85 M=N+1 $ N=NP2 $ GO TO 90
86 M=N+1 $ N=NP3 $ GO TO 90
87 M=N+1 $ N=NP4 $ GO TO 90
88 M=N+1 $ N=NP5 $ GO TO 90
90 PRINT 11 $ SD = SS = K = L = 0
91 DO 98 J=M,N $ K=K+1 $ L=L+1 $ IF(L-53) 93,92
92 L = 0 $ PRINT 11
93 FC = PVTf(T(J),DEN(J)) $ DC = FINDENF(T(J),P(J),DEN(J))
94 PPCT=100*(1-PC/P(J)) $ SS=SS+ABSf(PPCT) $ IF(DC) 95,96
95 DPCT = 100*(1-DC/DEN(J)) $ GO TO 97
96 DPCT = 0.0
97 SD = SD + DPCT**2
98 PRINT 12, ID(J),T(J), DEN(J),DC,DPCT, P(J),PC,PPCT
99 SS = SS/K $ SD = SQRTf(SD/K) $ PRINT 13, K, SD,SS
100 CONTINUE

C
C   PRINTOUT ISOCHORES.
130 DO 160 I=1,22 $ IF(I-7) 132,131
131 DN = DCRT $ GO TO 133
132 DN = I
133 PRINT 6, DN
138 IF(DN-DTRP) 140,141,141
140 IS = TSATf(DN) $ GO TO 142
141 TS = TTRP*(DN/DTRP)**4
142 IF(I-11) 143,143,144
143 IT = 8 $ GO TO 150
144 IF(I-15) 145,145,146
145 IT = 4 $ GO TO 150
146 IF(I-19) 147,148,148
147 IT = 2 $ GO TO 150
148 IT = 1
150 DO 159 J=90,600,IT $ TT = J $ IF(TT-TS) 159,159,151
151 PP = PVTf(TT,DN) $ PX = DPORf(TT,DN)
153 IF(PP-700.0) 155,155,160
155 PRINT 7, TT,PP, DPDD,DPDT, D2PDT2
159 CONTINUE
160 CONTINUE

C   PRINTOUT ISOTHERMS (NEED FINDSATF).
200 DO 230 I=1,99
201 READ 1, IDD,TT,DS $ IF(IDD) 210,999
210 PRINT 8, TT
211 DM = DTRP*(TT/TTRP)**0.25 $ IF(TT-TCRT) 212,212,213
212 DG = FINDSATf(TT,0) $ DL = FINDSATf(TT,1)
213 DO 220 N=1,500 $ DN = N*DS $ IF(TT-TCRT) 214,215,215
214 IF(DN.GT.DG.AND.DN.LT.DL) 220,215
215 IF(DN.GT.DM) 230,216
216 PP = DPORf(TT,DN) $ IF(PP-750.0) 217,217,230
217 PX = PVTf(TT,DN)
219 PRINT 9, DN,PP, DPDD, DPDT,D2PDT2
220 CONTINUE
230 CONTINUE

999 CONTINUE $ STOP $ END

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SUBROUTINE READIT
C  READ ETHANE PVT DATA OF REAMER ET AL. T,F, PSIA, Z(P,R,T).
C  IND. ENG. CHEM. 36, 956-958, (OCT.,1944).
COMMON/2/NP,NF,ID(999),T(999),F(999),DEN(999)
COMMON/11/ NP4, NP5
DIMENSION TA(7),PSI(22),Z(22,7)
DATA (GKK=0.0831434),(Q=1.01325),(PA=14.69595)
1  FORMAT(24X 7F8.0)
2  FORMAT(I5, F11.0, 8X 7F8.0)
3  FORMAT(I5, F11.0, F16.0)
C  READ THE SUPPLEMENTARY PVT DATA. ONE POINT PER CARD.
9  DO 15 I=1,99 $ READ 3, IDD,PP,ZA $ IF(IDD) 10,16
10 N = NP4 + I
11 ID(N) = IDD $ P(N) = Q*PP/PA $ IF(I-13) 12,12,13
12 TF = 100 $ GO TO 14
13 TF = 160
14 T(N) = 273.15 + (TF-32)/1.8
15 DEN(N) = P(N)/ZA/GKK/T(N)
16 CONTINUE
C  NOW READ 22 ISOBARS OF THE SQUARE TABLE 1.
20 READ 1, (TA(J),J=1,7) $ DO 21 I=1,22
21 READ 2, IDD, PSI(I), (Z(I,J),J=1,7)
C  NOW CONVERT TO ONE POINT PER INDEX, N.
25 DO 29 I=1,22 $ DO 29 J=1,7
26 N = N+1 $ ID(N) = 8 $ P(N) = Q*PSI(I)/PA
27 T(N) = 273.15 + (TA(J)-32)/1.8
28 DEN(N) = P(N)/Z(I,J)/T(N)/GKK
29 CONTINUE $ NP5 = N
30 RETURN $ END

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* SINGLE-BANK COMPILATION.

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SUBROUTINE DSATFIT
C  FIND COEFFS. FOR DENGASF(T), DENLICF(T),  ETHANE.
C  FUNCTIONS VIA GOODWIN LAB. NOTE 73-5.
C  DATA ARRANGED IN ORDER OF INCREASING DENSITIES.
COMMON/1/AL,BE,EP,GK,DCRT,TCRT,PCRT,DTRP,TTRP,PTRP
COMMON/9/IS,NPS,EG,EL,ALS,BES,AL1,AL2,AL3,CG(5),AV(8),AW(5)
COMMON/10/IDS(99),TSS(99),DNS(99)
COMMON/999/ NFUN,Y,F(30)
DIMENSION G(9)
DATA (DGAT = 1.35114E-6)
1  FORMAT(1H19X*SATURATED VAPOR DENSITIES, E =*F6.3//10X6HTTRP =F7.3,
1  8H, TCRT =F8.3, 8H, DCRT =F6.3, 8H, DGAT =E12.5// 7X 5F13.8//
2  13X2HID 7X3HT,K 8X5HMOL/L 8X5HCALCD 4X4HPCNT )
2  FORMAT(10X I5, F10.3, 2E13.4, F8.2)
3  FORMAT(1H19X*SATD. LIQUID DENSITIES, E =* F6.3// 10X6HTTRP =F7.3,
1  8H, TCRT =F8.3, 8H, DCRT =F6.3, 8H, DTRP =F7.3// 9X 3F15.9//
2  13X2HID 7X3HT,K 5X5HMCL/L 5X5HCALCD 5X5HPRCNT)
4  FORMAT(10X I5, 3F10.3, F10.2)
5  FORMAT(1H0 15X 4HNP =I3, 10H, RMSFCT =F6.3)
C  FOR THE SATURATED VAPOR, DEFINE -
C   $Z = (TC/T-1)/(TC/TT-1)$ ,  $Q = Z^{**1/3}$ ,  $ZE = Z^{**E}$ ,
C   $YY = LN(DC/D)/LN(DC/DT)$ , AND THE DEPENDENT VARIABLE -
C   $Y(Z,YY) = (YY-Z)/(ZE-Z)$ , WHEN THE L.S. EQN. IS -
C   $Y(Z,YY) = A1 + A2*Q2 + A3*Q3 + A4*Q4 + A5*Q5$ .
6  ZN=TCRT/TTRP-1 $ YN=LOGF(DCRT/DGAT) $ SSK=1.0E+100
C  EXPLORE VALUES FOR EXPONENT EG.
7  DO 18 I=1,11 $ EG = 0.33 + 0.01*I
8  NFUN = 5 $ DO 12 J=1,99 $ IF(DNS(J)-DCRT) 9,13,13
9  Z = (TCRT/TSS(J)-1)/ZN $ Q = CUBERTF(Z)
10 YY = LOGF(DCRT/DNS(J))/YN $ F(1) = 1 $ DO 11 K=2,5
11 F(K) = Q**K $ Y = (YY-Z)/(Z**EG-Z)
12 CALL FIT
13 NP = J-1 $ CALL CCEFF $ SS = 0 $ DO 14 K=1,5
14 CG(K) = F(K) $ DO 15 J=1,NP $ DC = DENGASF(TSS(J))
15 SS = SS + (DC/DNS(J)-1)**2 $ IF(SS.LT.SSK) 16,18
16 SSK = SS $ EGK = EG $ DO 17 K=1,5
17 G(K) = F(K)
18 CONTINUE $ EG = EGK $ DO 19 K=1,5
19 CG(K) = G(K) $ IF(IS) 20,26
20 PRINT 1, EG, TTRP,TCRT, DCRT,DGAT, (G(K),K=1,5)
21 SS = 0 $ DO 24 J=1,NP $ DC = DENGASF(TSS(J))
22 PCT = 100*(DNS(J)/DC-1) $ SS = SS + PCT**2
24 PRINT 2, IDS(J), TSS(J),DNS(J), DC,PCT
25 SS = SQRTF(SS/NP) $ PRINT 5, NP, SS
C  FOR THE SATURATED LIQUID, DEFINE -
C   $X = (TC-T)/(TC-TT)$ ,  $Q = X^{**1/3}$ ,  $XE = X^{**E}$ ,
C   $YY = (D-DC)/(DT-DC)$ , WHEN THE L.S. EQN. IS -
C   $(YY-X)/(XE-X) = A1 + A2*Q2 + A3*Q3$ .
26 M = NP + 1 $ SSK = 1.0E+100
27 XN = TCRT-TTRP $ YN = DTRP-DCRT
C  EXPLORE VALUES FOR EXPONENT EL.
28 DO 37 I=1,14 $ EL = 0.25 + 0.01*I $ NFUN = 3
29 DO 32 J=M,NPS $ X = (TCRT-TSS(J))/XN
30 Q = CUBERTF(X) $ YY = (DNS(J)-DCRT)/YN
31 F(1)=1 $ F(2)=Q*Q $ F(3)=X $ Y = (YY-X)/(X**EL-X)

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APPENDIX H. (Continued)

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32 CALL FIT $ CALL COEFF $ AL1=F(1) $ AL2=F(2) $ AL3=F(3)
33 SS = 0 $ DO 34 J=M,NPS $ DC = DENLIQF(TSS(J))
34 SS = SS + (DC/DNS(J)-1)**2 $ IF(SS.LT.SSK) 35,37
35 SSK = SS $ ELK = EL $ DO 36 K=1,3
36 G(K) = F(K)
37 CONTINUE $ EL = ELK $ AL1=G(1) $ AL2=G(2) $ AL3=G(3)
38 IF(15) 40,99
40 PRINT 3, EL, TTRP, TCRT, DCRT, DTRP, (G(K),K=1,3)
41 SS = N = 0
42 DO 44 J=M,NPS $ N = N+1 $ DC = DENLIQF(TSS(J))
43 PCT = 100*(DNS(J)/DC-1) $ SS = SS + PCT**2
44 PRINT 4, IDS(J), TSS(J), DNS(J), DC, PCT
45 SS = SQRTF(SS/N) $ PRINT 5, N, SS
99 RETURN $ END
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* SINGLE-BANK COMPILATION.

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SUBROUTINE TSATFIT

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C FIT TSAT DATA VIA FUNCTIONS OF TSATFIT(METHANE), 4/19/74 AT 09.00.
C NOTE, ALS = BES = 0.5, E = 1/4, VAPOR NF=6, LIQUID NF=3.
C NOTE DIFFERENT FUNCTIONS AS DEN L.T. OR G.T. DCRT.
C DEFINE YY(TS) = (TCRT/T-1)/(TCRT/TTRP-1) FOR EACH FUNCTION.
C DATA ARRANGED IN ORDER OF INCREASING DENSITIES.
COMMON/1/AL,BE,EP,GK, DCRT,TCRT,PCRT, DTRP,TTRF,PTRP
COMMON/3/DPDT,D2PDT2,DPSDT,DPMDT, DPDD,DPDR,DTSDR,DTHDR
COMMON/9/IS,NPS,EG,EL,ALS,BES,AL1,AL2,AL3,CG(5),AV(8),AW(5)
COMMON/10/ IDS(99), TSS(99), DNS(99)
COMMON/999/ NFUN,Y,F(30)
DATA (DGAT = 1.35114E-6)
1 FORMAT(1H1 30X *ETHANE SATURATION TEMPERATURES* //
1 16X 4HAL =F6.3, 6H, BE =F6.3, 8H, DGAT =E12.5//
2 16X 6HTTRP =F7.3, 8H, TCRT =F8.3, 8H, DTRP =F7.3;
3 8H, DCRT =F6.3// 2(13X 4F15.9// )
2 FORMAT(1H0 12X 2HID 10X5HMOL/L 11X4HCALC 5X4HPCNT
1 8X3HT,K 6X4HCALC 5X4HPCNT 6X6HDS/DO )
3 FORMAT(10X I5, 2E15.5, F9.2, F11.3, F10.3, F9.2, E12.3)
4 FORMAT(1H0 12X 4HNP =I3, 12H, DNRMSPT =F6.3, 12H, TSRMSPCT =F6.3)
C FOR SAT.VAPOR DEFINE, X=ABS(S-1), XT=ABS(ST-1), WHEN EQN. IS -
C LN(YY) - AL*(1/XT-1/X) = A1*LOG(LN(1+E/S)/LN(1+E/ST)) + W(S),
C W(S) = A2*(Q-QT) + A3*(Q2-QT2) + A4*(S-ST) + A5*(S2-ST2) + . . .
C WHERE, Q = S**1/3, AND QT = ST**1/3.
5 ALS = BES = 0.5 $ E = 0.25 $ YN = TCRT/TTRP - 1
6 ST=DGAT/DCRT $ XT=1-ST $ EK=LOGF(1+E/ST)
7 QT = CUBERTF(ST) $ NFUN = NF = 8
9 DO 16 J=1,NPS $ IF(DNS(J)-DCRT) 10,17,17
10 S = DNS(J)/DCRT $ X = 1-S $ Q = CUBERTF(S)
11 F(1) = LOGF(LOGF(1+E/S)/EK)
12 F(2) = Q-QT $ F(3) = Q*Q - QT*QT
13 DO 14 K=4,NF $ N = K-3
14 F(K) = S**N - ST**N
15 Y = LOGF((TCRT/TSS(J)-1)/YN) - ALS*(1/XT-1/X)
16 CALL FIT
17 NP = J-1 $ CALL COEFF $ DO 18 K=1,NF
18 AV(K) = F(K) $ IF(IS) 20,28
20 PRINT 1, ALS,BES,DGAT, TTRP,TCRT, DTRP,DCRT, (F(K),K=1,NF)
21 PRINT 2 $ SD = SS = N = 0
22 DO 26 J=1,NP $ T = TSS(J) $ C = DNS(J)
23 DC=FINDSATF(T,0) $ DPCT=100*(1-DC/D) $ SD=SD+DPCT**2
24 TC = TSATF(D) $ DTSD = DTSDR/DTRP
25 TPCT = 100*(1-TC/T) $ SS = SS + TPCT**2
26 PRINT 3, IDS(J), D,DC,DPCT, T,TC,TPCT, DTSD
27 SD = SQRTF(SD/NP) $ SS = SQRTF(SS/NP) $ PRINT 4, NP,SD,SS
C FOR SATD. LIQ. USE, X=ABS(S-1), XT=ABS(ST-1) IN THE EQN. -
C LN(YY) = BE*(1/XT-1/X) + B1*(S-ST) + B2*(S2-ST2) + . . .
28 NFUN = NF = 5 $ M = 1 $ ST = DTRP/DCRT $ XT = ST-1
29 DO 35 J=1,NPS $ IF(DNS(J)-DCRT) 30,30,31
30 M = M + 1 $ GO TO 35
31 S = DNS(J)/DCRT $ X = S-1 $ DO 32 K=1,NF
32 F(K) = S**K - ST**K
33 YY = (TCRT/TSS(J)-1)/YN $ Y = LOGF(YY) - BES*(1/XT-1/X)
34 CALL FIT
35 CONTINUE $ CALL COEFF $ DO 36 K=1,NF

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APPENDIX H. (Continued)

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36 AW(K) = F(K) $ IF(IS) 40,99
40 PRINT 1, ALS,BES,DGAT, TTRP,TCRT, DTRP,DCRT, (F(K),K=1,NF)
41 PRINT 2 $ SD = SS = N = 0
42 DO 46 J=M,NPS $ N = N+1 $ D = DNS(J) $ T = TSS(J)
43 DC=FINDSATF(T,1) $ DPCT=100*(1-DC/D) $ SD=SD+DPCT**2
44 TC = TSATF(D) $ DTSDD = DTSOR/DTRP
45 TPCT = 100*(1-TC/T) $ SS = SS + TPCT**2
46 PRINT 3, IDS(J), D,DC,DPCT, T,TC,TPCT, DTSDD
47 SD = SQRTF(SD/N) $ SS = SQRTF(SS/N) $ PRINT 4, N, SD, SS
99 RETURN $ END

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SUBROUTINE PSATFIT
C FIT GOODWIN EQN. TO VAPOR PRESSURE DATA, ALL ON T-68, BAR.
C LN(P/PT) = P1*X + P2*X2 + P3*X3 + P4*X4 + P5*X*(1-X)**1.5.
COMMON/1/AL,BE,EP,GK, DCRT,TCRT,PCRT, DTRP,TTRF,PtrP
COMMON/8/IP,NPP,P1,P2,P3,P4,P5, IOP(99),TPS(99),FPS(99)
COMMON/999/NFUN,Y,F(30)
1 FORMAT(1H1 14X *VAFOR PRESSURES, TTRP =*F7.3, 8H, TCRT =F8.3)
2 FORMAT(1H0 12X 5F13.8)
3 FORMAT(1H0 17X 2HID 7X3HT,K 10X5HP,BAR 10X5HCALCD 6X4HPCNT )
4 FORMAT(15X I5, F10.3, 2E15.5, F10.3)
5 FORMAT(1H0 16X 4HNP =I4, 10H, RMSPCT =F6.3)
6 NFUN = 5 $ XK = 1 - TTRP/TCRT $ DO 10 J=1,NPP
7 X = (1-TTRP/TPS(J))/XK $ QC = X*(1-X)*SQRTF(1-X)
8 F(1)=X $ F(2)=X*X $ F(3)=X*X*X $ F(4)=F(2)*F(2) $ F(5)=QC
9 Y = LOGF(PPS(J)/PtrP)
10 CALL FIT $ CALL COEFF
11 P1=F(1) $ P2=F(2) $ P3=F(3) $ P4=F(4) $ P5=F(5) $ IF(IP) 12,20
12 SS = L = 0 $ PRINT 1, TTRP, TCRT
13 PRINT 2, P1,P2,P3,P4,P5 $ PRINT 3
14 DO 18 J=1,NPP $ P = PPS(J) $ PC = PSATF(TPS(J))
15 L = L+1 $ PCT=100*(P/PC-1) $ SS=SS+PCT**2 $ IF(L-45) 18,17
17 L = 0 $ PRINT 1, TTRP,TCRT $ PRINT 3
18 PRINT 4, IOP(J),TPS(J), P,PC,PCT
19 SS = SQRTF(SS/NPP) $ PRINT 5, NPP, SS
20 RETURN $ END

```

06/05/74

```

SUBROUTINE PEEK
C  EXAMINE BEHAVIOR OF THE COEFFICIENTS.
COMMON B1,B2,B3,B4, ER, E1,E2,E3
COMMON/1/AL,BE,EP,GK, DCRT,TCRT,PCRT, DTRP,TTRP,PTRP
COMMON/6/ TSAT, THETA, PSAT
4  FORMAT(1H1 14X *EQUATION OF STATE, COEFFICIENTS* //
1  15X 6HDTRP =F8.4, 8H, TTRP =F8.3, 8H, PTRP =F13.9/
2  15X 6HDCRT =F8.4, 8H, TCRT =F8.3, 8H, PCRT =F13.9//
3  15X 4HAL =F5.2, 6H, BE =F5.2, 6H, EP =F5.2//
5  12X 3F15.9/ 12X 2F15.9/ )
5  FORMAT(15X 5HMOL/L 6X4HTSAT 5X5HTHETA 6X4HPSAT
1  9X1HB 9X1HC )
6  FORMAT(10X F10.1, 5F10.3)
70 PRINT 4, DTRP,TTRP,PTRP, DCRT,TCRT,PCRT, AL,BE,EP,
1  B1,B2,B3, E1,E2
71 PRINT 5 $ DO 77 J=1,46 $ DN = 0.5*J $ S = DN/DCRT
72 R=DN/DTRP $ R2=R**2 $ R3=R**3
73 B = B1 + B2*R + B3*R2/(1+BE*R2)
74 E = (S-1)*(S-ER)*(E1 + E2*R)
76 TS=TSAT=TSATF(DN) $ TH=THETA F(DN) $ PS=PSATF(TS)
77 PRINT 6, DN, TS,TH,PS, B, E
99 RETURN $ END

```

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```

SUBROUTINE ISOTHERM
C  PRINTOUT THE CRITICAL ISOTHERM.
COMMON/1/AL,BE,EP,GK, DCRT,TCRT,PCRT, DTRP,TTRP,PTRP
COMMON/3/DPDT,D2PDT2,DPSDT,DPMCT,DPDC,DPCR,DTSCP,OTHDR
COMMON/4/XB1,XB2, XC1,XC2, XE1,XE2, DXBOR,DXCDR,CXEDR
1  FORMAT(1H1 14X *THE CRITICAL ISOTHERM* //
1  10X 4HTC =F8.3, 6H, DC =F7.3, 6H, PC =F8.4//
2  11X 4HD/DC 9X4HP/PC 8X5HDP/DD 4X6HOTS/OR 4X6HOTH/OR
3  4X6HDPS/OR 4X6HDXB/OR 4X6HDXC/OR )
2  FORMAT(5X F10.2, 2F13.9, 5F10.5)
5  PRINT 1, TCRT,DCRT,PCRT $ DO 8 J=1,51
6  DR = 0.74 + 0.01*J $ DN = DCRT*DR
7  PR = DPDRF(TCRT,DN)/PCRT $ DPSOR = DPSDT*DTSDR
8  PRINT 2, DR,PR,DPDD, DTSDR,OTHDR,DPSOR, DXBOR,DXEDR
9  RETURN $ END

```

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```

SUBROUTINE SETUP
C  SET UP THE ARRAYS FOR LEAST SQUARES.
COMMON B1,B2,B3,B4, ER, E1,E2,E3
COMMON/1/AL,BE,EP,GK, DCRT,TCRT,PCRT, DTRP,TTRP,PTRP
COMMON/2/NP,NF,ID(999),T(999),P(999),DEN(999)
COMMON/6/ TSAT, THETA, PSAT
COMMON/999/ NFUN,Y,F(30)
1  NFUN = NF $ DO 10 J=1,NP
2  TT = T(J) $ X = TT/TCRT $ D = DEN(J) $ S = D/DCRT
3  R = D/DTRP $ R2 = R*R $ R3 = R*R2 $ RG = R*GK
4  TS=TSAT=TSATF(D) $ THETA=THETAF(D) $ PS=PSATF(TS) $ XS=TS/TCRT
5  XB = XBF(TT,D) $ XE = (S-1)*(S-ER)*XEF(TT,D)
6  F(1)=XB $ F(2)=XB*R $ F(3)=XB*R2/(1+BE*R2)
7  F(4)=XE $ F(5)=XE*R
9  Y = (P(J)/RG/TT-1)*X/R - (PS/RG/TS-1)*XS/R
10 CALL FIT $ CALL COEFF $ CALL STAT
11 B1=F(1) $ B2=F(2) $ B3=F(3)
12 E1=F(4) $ E2=F(5)
30 RETURN $ END

```

06/05/74

```

FUNCTION THETAF(DEN)
C  THETA = TSAT*EXP(U(S)).
C  LET Q = (S-1)/(ST-1), WHERE ST = DTRP/DCRT, THEN -
C  IF S < 1, U = AL*Q**3, IF S > 1, U = -AL*Q**3,
C  YIELDS ALSO THE FIRST DERIVATIVE RSP. TO RHO ≡ DEN/DTRP.
COMMON/1/AL,BE,EP,GK, DCRT,TCRT,PCRT, DTRP,TTRP,PTRP
COMMON/3/DPDT,D2PDT2,OPSDT,OPMOT,OPDC,OPCR,OTSCR,OTHOR
COMMON/6/ TSAT, THETA, PSAT
1  S = DEN/DCRT $ DSDR = DTRP/DCRT $ C = DSDR-1
2  Q = (S-1)/C $ Q2 = Q*Q $ U = AL*Q*Q2
3  U1 = 3*AL*Q2*DSOR/C $ IF(Q) 5,9,4
4  U = -U $ U1 = -U1
5  XP = EXPF(U) $ THETA = TSAT*XP
6  OTHOR = (TSAT*U1 + OTSCR)*XP $ RETURN
9  THETA = TCRT $ OTHOR = 0 $ RETURN $ END

```


06/05/74

```

C      FUNCTION PVTf(T,DEN)
C      YIELDS P,BAR, ALSO DP/DT, D2P/DT2.
      COMMON B1,B2,B3,B4, ER, E1,E2,E3
      COMMON/1/AL,BE,EP,GK, DCRT,TCRT,PCRT, DTRP,TTRP,PTRP
      COMMON/3/DPDT,D2PDT2,OPSDT,OPMDT,CPDD,DPCR,DTSDR,OTHDR
      COMMON/4/XB1,XB2, XC1,XC2, XE1,XE2, OXBDR,DXCDP,CXEDR
      COMMON/6/ TSAT, THETA, PSAT
1  Q = DEN $ S = Q/DCRT $ R = Q/DTRP
2  R2 = R*R $ R3 = R*R2 $ RG = R*GK
3  TS=TSAT=TSATF(Q) $ THETA=THETAf(Q) $ PS=PSATF(TS)
4  XB = XBf(T,Q) $ XE = XEf(T,Q)
5  E = B1 + B2*R + B3*R2/(1+BE*R2)
6  E = (S-1)*(S-ER)*(E1 + E2*R)
9  F = B*XB + E*XE $ F1 = B*XB1 + E*XE1 $ F2 = E*XB2 + E*XE2
11 YS = (PS/RG/TS-1)*TS/TCRT/R
15 PVTf = (T + R*(F+YS)*TCRT)*RG $ DPDT = (1+R*F1)*RG
17 D2PDT2 = R*RG*F2/TCRT $ RETURN $ END

```

06/05/74

```

C      FUNCTION OPDRf(T,DEN)
C      OPDRf = P,BAR. DP/DR IS IN COMMON. GK = 0.0831434*DTRP.
C      EQNSTATE IS Y = YSAT + F(R,T), WHERE Y = (Z-1)*X/R, AND -
C      F(R,T) = B*XB + C*XC + D*XD + E*XE, YIELDS DERIV. -
C      DP/DR = 2*P/R - GK*T + R2*GK*TCRT*(F1 + YS1).
      COMMON B1,B2,B3,B4, ER, E1,E2,E3
      COMMON/1/AL,BE,EP,GK, DCRT,TCRT,PCRT, DTRP,TTRP,PTRP
      COMMON/3/DPDT,D2PDT2,OPSDT,OPMDT,CPDD,DPCR,DTSDR,OTHDR
      COMMON/4/XB1,XB2, XC1,XC2, XE1,XE2, OXBDR,DXCDP,CXEDR
      COMMON/6/ TSAT, THETA, PSAT
      COMMON/7/ XB,XC,XD,XE
1  X=T/TCRT $ Q=DEN $ S=Q/DCRT $ CSDR=DTRP/DCRT
2  R=Q/DTRP $ R2=R*R $ R3=R*R2 $ RG = R*GK
3  TS=TSAT=TSATF(Q) $ THETA=THETAf(Q) $ PS=PSATF(TS) $ XS=TS/TCRT
4  XB = XBf(T,Q) $ XE = XEf(T,Q)
5  BS = 1 + BE*R2 $ BS1 = 2*BE*R
6  E = B1 + B2*R + B3*R2/BS
7  ED = B2 + B3*(2*R/BS - R2*BS1/BS/BS)
8  SX = (S-1)*(S-ER) $ E = E1 + E2*R
9  ED = SX*E2 + (2*S - 1 - ER)*DSDR*E $ E = SX*E
12 F = B*XB + E*XE $ YS = (PS/RG/TS-1)*XS/R
13 F1 = B*DXBDR + BD*XB + E*DXEDR + ED*XE
16 YS1 = (TS - R*DTSDR + OPSDT*DTSDR/GK - 2*PS/RG)/TCRT
17 G = (F+YS)*R/X $ OPDR = (1 + 2*Q + (R2*F1 + YS1)/X)*GK*T
18 CPDRf = (1+Q)*RG*T $ CPDD = CPCR/DTRP $ RETURN $ END

```

06/05/74

```

      FUNCTION XBF(T,D)
C     XBF = SQRT(T/TC)*LN(T/TS) = Q(T)*Z(R,T),
C     Z(R,T) = LN(U), U(R,T) = T/TS(R).
      COMMON/1/AL,BE,EP,GK,DCRT,TCRT,PCRT,DTRP,TTRP,PTRP
      COMMON/3/DPDT,D2PDT2,DPSDT,DPMCT,DPOD,DPCR,DTSDR,DTHDR
      COMMON/4/XB1,XB2, XC1,XC2, XE1,XE2, OXBDR,DXCDR,DXEDR
      COMMON/6/ TSAT, THETA, PSAT
1     TC = TCRT $ TS = TSAT $ X = T/TC
2     U = T/TS $ U1X = TC/TS $ U1R = -U*DTSDR/TS
3     Z = LOGF(U) $ Z1R=U1R/U $ Z1X=U1X/U $ Z2X=-Z1X*Z1X
4     G = SQRTF(X) $ Q1 = 0.5/Q $ Q2 = -Q1/2/X
5     XBF = Q*Z $ OXBDR = Q*Z1R $ XB1 = Q*Z1X + G1*Z
6     XB2 = Q*Z2X + 2*Q1*Z1X + Q2*Z $ RETURN $ END

```

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```

      FUNCTION XEF(T,D)
C     XEF = PSI-PSISAT, PSI = (1-W*LN(1+1/W))/X, W = EP*(T/TH-1).
C     XEF = F(R,T)/X - FS(R)/XS . . . . .
C     F(R,T) = 1-W*P(R,T), P(R,T) = LN(U), U = 1+1/W(R,T),
C     FS(R) = 1-WS*PS(R), PS(R) = LN(V), V = 1+1/WS(R).
      COMMON/1/AL,BE,EP,GK,DCRT,TCRT,PCRT,DTRP,TTRP,PTRP
      COMMON/3/DPDT,D2PDT2,DPSDT,DPMCT,DPOD,DPCR,DTSDR,DTHDR
      COMMON/4/XB1,XB2, XC1,XC2, XE1,XE2, OXBDR,DXCDR,DXEDR
      COMMON/6/ TSAT, THETA, PSAT
1     E=EP $ TC=TCRT $ TH=THETA $ TS=TSAT $ W=E*(T/TH-1) $ IF(W) 30,30,2
2     WW = W*W $ W1X = E*TC/TH $ W1R = -E*T*DTHDR/TH/TH
3     U=1+1/W $ U1R=-W1R/WW $ U1X=-W1X/WW $ U2X = -2*U1X*W1X/W
4     F=LOGF(U) $ P1R=U1R/U $ P1X=U1X/U $ P2X = U2X/U - P1X*P1X
5     F = 1 - W*P $ F1R = -W*P1R - W1R*P
6     F1X = -W*P1X - W1X*P $ F2X = -W*P2X - 2*W1X*P1X
7     WS = E*(TS/TH-1) $ IF(WS) 8,8,9
8     FS = 1 $ FS1 = 0 $ GO TO 12
9     WS1 = E*(DTSDR - TS*DTHDR/TH)/TH $ U = 1+1/WS
10    PS = LOGF(U) $ PS1 = -WS1/U/WS/WS
11    FS = 1-WS*PS $ FS1 = -WS*PS1 - WS1*PS
12    X=T/TC $ X2=X*X $ XS=TS/TC $ XS1=DTSDR/TC
13    XEF = F/X - FS/XS $ XE1 = F1X/X - F/X2
14    XE2 = F2X/X - 2*F1X/X2 + 2*F/X/X2
15    OXEDR = F1R/X - FS1/XS + FS*XS1/XS/XS $ RETURN
30   XEF = XE1 = XE2 = OXEDR = 0 $ RETURN $ END

```

06/05/74

```

      FUNCTION DENGASF(T)
C     ETHANE SATD. VAPOR DENSITIES, MCL/L, VIA LAB. NOTE 73-4, 73-5.
C      $Y = A1 + A2*Q2 + A3*Q3 + . . .$ ,  $NF = AL$ ,  $YN = LN(DCRT/DTRP)$ ,
C      $U = Z + (ZE-Z)*Y$ ,  $DEN = DCRT*EXP(-YN*U)$ .
      COMMON/1/AL,BE,EP,GK, DCRT,TCRT,FCRT, DTRP,TTRP,Ptrp
      COMMON/9/IS,NPS,EG,EL,ALS,BES,AL1,AL2,AL3,CG(5),AV(8);AW(5)
      DATA (DGAT = 1.35114E-6)
1     FORMAT(1H0 9X *DENGASF = 0, T EXCEEDS TCRT. * / )
2     IF(TCRT-T) 3,4,5
3     PRINT 1 $ STOP
4     DENGASF = DCRT $ RETURN
5      $YN = LOGF(DCRT/DGAT)$  $  $Z = (TCRT/T-1)/(TCRT/TTRP-1)$ 
6      $G = CUBERTF(Z)$  $  $Y = CG(1)$  $ DO 7 K=2,5
7      $Y = Y + CG(K)*Q**K$  $  $U = Z + (Z**EG-Z)*Y$ 
8      $DENGASF = DCRT*EXP(-YN*U)$  $ RETURN $ END

```

06/05/74

```

      FUNCTION DENLIQF(T)
C     ETHANE SATD. LIQUID DENSITIES, MOL/L, VIA LAB. NOTE 73-5.
C      $Y = A1 + A2*Q2 + A3*Q3 + . . .$ ,  $YN = DTRP-DCRT$ ,
C      $DEN = DCRT + YN*(X + (XE-X)*Y)$ .
      COMMON/1/AL,BE,EP,GK, DCRT,TCRT,FCRT, DTRP,TTRP,Ptrp
      COMMON/9/IS,NPS,EG,EL,ALS,BES,AL1,AL2,AL3,CG(5),AV(8);AW(5)
1     FORMAT(1H0 9X *DENLIQF = 0, T EXCEEDS TCRT. * / )
2     IF(TCRT-T) 3,4,5
3     PRINT 1 $ STOP
4     DENLIQF = DCRT $ RETURN
5      $X = (TCRT-T)/(TCRT-TTRP)$  $  $W = X**EL - X$ 
6      $G = CUBERTF(X)$  $  $Y = AL1 + AL2*G*Q + AL3*X$ 
7      $DENLIQF = DCRT + (DTRP-DCRT)*(X + W*Y)$  $ RETURN $ END

```

06/05/74

```

      FUNCTION PMELTF(T)
C     ETHANE MELT P TO 42 ATM., CLUSIUS/WEIGAND, 1940.
C     SIMON EQN.,  $P = PTRP + A*(X**2 - 1)$ ,  $X = T/TTRP$ .
      COMMON/3/DPDT,D2PDT2,DPSDT,DPMOT,DPOD,DPCR,DTSDR,DTHDR
      DATA (TTRP=89.899),(PTRP=9.967E-6),(A=2840.0),(Q=1.01325)
1      $X = T/TTRP$  $  $PMELTF = Q*(PTRP + A*(X*X-1))$ 
2      $DPMOT = Q*A*2*X/TTRP$  $ RETURN $ END

```

* SINGLE-BANK COMPILATION.

ROGRAM LENGTH 00063

06/05/74

FUNCTION PSATF(T)

```

C   ETHANE V.P., BAR, VIA LAB. NOTE 73-3.
COMMON/1/AL,BE,EP,GK, DCRT,TCRT,PCRT, DTRP,TTRP,PTRP
COMMON/3/DPDT,D2PDT2,DPSDT,DPMDT,DPDD,DPDR,DTSDR,DTHDR
COMMON/8/IP,NPP,P1,P2,P3,P4,P5, IDP(99),TPS(99),PPS(99)
1  FORMAT(1H0 9X *PSATF = 0, T EXCEEDS TCRT. * / )
2  XN = 1-TTRP/TCRT $ DXDT = TTRP/XN/T/T
3  X=(1-TTRP/T)/XN $ X2=X*X $ X3=X*X2 $ X4=X2*X2
4  V = 1-X $ IF(V) 5,6,7
5  PSATF = DPSDT = 0 $ PRINT 1 $ RETURN
6  Z = Z1 = 0 $ GO TO 9
7  Q = SQRTF(V) $ W = V*Q $ W1 = -3*Q/2
8  Z = X*W $ Z1 = W + X*W1
9  F = P1*X + P2*X2 + P3*X3 + P4*X4 + P5*Z
10 F1 = P1 + 2*P2*X + 3*P3*X2 + 4*P4*X3 + P5*Z1
11 PSATF = PTRP*EXP(F) $ DPSDT = F1*DXDT*PSATF $ RETURN $ END

```

06/05/74

FUNCTION TSATF(DEN)

```

C   THIS NEW TSATF VIA TSATFIT, 4/19/74 AT 09.00.
COMMON/1/AL,BE,EP,GK, DCRT,TCRT,PCRT, DTRP,TTRP,PTRP
COMMON/3/DPDT,D2PDT2,DPSDT,DPMDT,DPDD,DPDR,DTSDR,DTHDR
COMMON/9/IS,NPS,EG,EL,ALS,BES,AL1,AL2,AL3,CG(5),AV(8),AW(5)
DATA (NFG=8),(NFL=5)
DATA (E = 0.25),(DGAT = 1.35114E-6)
C   SATD. VAPOR TEMPS. CONSTRAINED AT T.P. BY SUBTRACTION -
C   DEFINE X = ABS(S-1), XT = ABS(ST-1), WHEN THE EQN. IS -
C   LN(YY) = AL*(1/XT-1/X) + A1*LOG(LN(1+E/S)/LN(1+E/ST)) + W(S),
C   W(S) = A2*(Q-QT) + A3*(Q2-QT2) + A4*(S-ST) + A5*(S2-ST2) + . . .
C   WHERE, Q = S**1/3, AND QT = ST**1/3.
1  S = DEN/DCRT $ DSDR = DTRP/DCRT $ QS = S-1 $ IF(QS) 2,30
2  X = ABSF(QS) $ X1 = DSDR*QS/X $ YN = TCRT/TTRP - 1
3  V=1/X $ V1=-DSDR/X/QS $ ST=DGAT/DCRT $ IF(QS) 4,30,15
4  XT=1-ST $ VT=1/XT $ U=ALS*(VT-V) $ U1=-ALS*V1 $ EK=LOGF(1+ E/ST)
5  P = 1 + E/S $ P1 = -E*DSDR/S/S $ PG = LOGF(P)/EK
6  G = LOGF(PG) $ G1 = P1/P/PG/EK
7  Q = CUBERTF(S) $ QT = CUBERTF(ST) $ Q1 = Q*DSDR/3/S
8  W = U + AV(1)*G + AV(2)*(Q-QT) + AV(3)*(Q*Q-QT*QT)
9  W1 = U1 + AV(1)*G1 + AV(2)*Q1 + AV(3)*2*Q*Q1
10 DO 11 K=4,NFG $ N = K-3 $ W = W + AV(K)*(S**N-ST**N)
11 W1 = W1 + N*DSDR*AV(K)*S**(N-1) $ GO TO 18
C   SATD. LIQUID TEMPS. CONSTRAINED AT THE T.P. BY SUBTRACTION, -
C   EQN., LN(YY) = W(S), WHERE X=ABS(S-1), XT=ABS(ST-1), AND -
C   W(S) = BE*(1/XT - 1/X) + B1*(S-ST) + B2*(S2-ST2) + . . .
15 ST = DSDR $ XT = ST-1 $ W = BES*(1/XT-V) $ W1 = -BES*V1
16 DO 17 K=1,NFL $ W = W + AW(K)*(S**K - ST**K)
17 W1 = W1 + AW(K)*K*DSDR*S**(K-1)
18 F = EXPF(W) $ F1 = W1*F $ Q = 1 + YN*F
19 TSATF = TCRT/Q $ DTSDR = -YN*F1*TSATF/Q $ RETURN
30 TSATF = TCRT $ DTSDR = 0 $ RETURN $ END

```


06/05/74

```

      FUNCTION FINDENF(T,P,DI)
C     ON ISOTHERM T, ITERATE DEN TO MINIMIZE (P-PCALC).
C     NEWTON-RAPHSON ITERATION.  INITIAL DEN = DI.
C     NOTE STATEMENTS 14,15 FOR ETHANE.
      COMMON/1/AL,BE,EP,GK, DCRT,TCRT,PCRT, DTRP,TTRP,PTRP
      COMMON/3/DPDT,D2PDT2,DPSOT,DPMOT,DPDD,DPOR,DTSOR,OTHDR
1     FORMAT(1H0 9X *FINDENF = 0,  FAILS TO CONVERGE.* / )
2     FORMAT(1H0 9X *FINDENF = DCRT,  DP/DR ZERO OR NEG.* / )
3     FORMAT(1H0 9X *FINDENF = 0,  DI INSIDE DCME.* / )
4     D=DI $ DM=DTRP*(T/TTRP)**0.25 $ DX=DM+1 $ IF(T-TCRT) 5,7,8
5     DG=DENGASF(T) $ DL=DENLIQF(T) $ PS=PSATF(T)
6     IF(D.GT.DG.AND.D.LT.DL) 32,8
7     DG=DL=DCRT $ PS=PCRT $ IF(D.EQ.DCRT) 33,8
8     DO 30 J=1,50 $ DP = P - DPORF(T,D)
9     IF(ABSF(DP/P)-1.0E-6) 31,31,10
10    IF(DPDD) 33,33,11
11    CD = DP/DPDD $ IF(ABSF(CD/D)-1.0E-6) 31,31,12
12    D = D + DD $ IF(D.GT.0.001) 14,13
13    D = 0.001 $ GO TO 30
14    IF(D.GT.DX) 15,16
15    D = DM $ GO TO 30
16    IF(T-TCRT) 17,22,30
17    IF(P.LT.PS) 18,20
18    IF(D.GT.DG) 19,30
19    D = DG $ GO TO 30
20    IF(D.LT.DL) 21,30
21    D = DL $ GO TO 30
22    IF(P.LT.PCRT) 23,25
23    IF(D.LT.DCRT) 30,24
24    D = DCRT - 0.02 $ GO TO 30
25    IF(D.GT.DCRT) 30,26
26    D = DCRT + 0.02
30    CONTINUE $ FINDENF = 0 $ PRINT 1 $ RETURN
31    FINDENF = D $ RETURN
32    FINDENF = 0 $ PRINT 3 $ RETURN
33    FINDENF = DCRT $ PRINT 2 $ RETURN $ END

```

* SINGLE-BANK COMPILATION.

06/05/74

```

FUNCTION FINDSATF(T,M)
C  ITERATE DEN TO MINIMIZE (T-TS) VIA TSATF(DEN).
C  THIS FINDSATF ADJUSTED FOR ETHANE.
C  M = 0 FOR VAPOR, M = 1 FOR LIQUID.
COMMON/1/AL,BE,EP,GK, DCRT,TCRT,PCRT, DTRP,TTRP,PTRP
COMMON/3/OPDT,D2PDT2,OPSOT,DPMCT,DPDD,OPCR,DTSOR,OTHOR
DATA (DGT=5.0E-7),(DLT=23.0)
1  FORMAT(1H0 9X *FINDSATF = 0, FAILS TO CONVERGE.* / )
2  FORMAT(1H0 9X *FINDSATF = 0, T EXCEEDS TCRT.* / )
3  IF(T-TCRT) 4,22,23
4  IF(M.EQ.0) 5,6
5  D = DENGASF(T) $ GO TO 7
6  D = DENLIQF(T)
7  DO 20 J=1,50 $ DT=T-TSATF(D) $ IF(ABSF(DT/T)-1.0E-6) 21,21,8
8  DTDD = DTSOR/DTRP $ IF(DTDD.EQ.0.0) 22,9
9  DD = DT/DTDD $ IF(ABSF(DD/D)-1.0E-6) 21,21,10
10 D = D + DD $ IF(M.EQ.0) 11,15
11 IF(D.GT.DGT) 13,12
12 D = DGT $ GO TO 20
13 IF(D.LT.DCRT) 20,14
14 D = DCRT - 0.02 $ GO TO 20
15 IF(D.GT.DLT) 16,17
16 D = DLT $ GO TO 20
17 IF(D.GT.DCRT) 20,18
18 D = DCRT + 0.02
20 CONTINUE $ FINDSATF = 0 $ PRINT 1 $ RETURN
21 FINDSATF = D $ RETURN
22 FINDSATF = DCRT $ RETURN
23 FINDSATF = 0 $ PRINT 2 $ RETURN $ END

```

06/05/74

```

FUNCTION ZIPF(T,D)
C  ETHANE VIRIAL EQN. VIA LAB. NOTE 73-4.
DIMENSION B(5), C(3)
DATA (TCRT=305.33),(VCRT=0.14556),(TB=740.0),(TC=217.8)
DATA(B = 7.993156, -10.672497, 9.217322, -2.481668, 0.842328)
DATA(C = 0.253773, 0.865299, 0.556075)
1  S = D*VCRT $ X = T/TCRT $ Q = X**0.25
2  X2 = X*X $ X3 = X*X2 $ X5 = X2*X3
3  ZB = 1 - (TB/T)**0.25 $ ZC = 1 - TC/T
4  BV = ZB*(B(1) + B(2)/Q + B(3)/X + B(4)/X2 + B(5)/X3)
5  CV = ZC*(C(1)/X + C(2)/X3 + C(3)/X5)
6  ZIPF = 1 + BV*S + CV*S*S $ RETURN $ END

```

05/09/74

```

SUBROUTINE FITTER
COMMON/999/ NCOF,Y,G(30)
DIMENSION A(30,31),B(30,31)
COMMON /777/ A,SY,SYY,RES
TYPE DOUBLE SY,SYY,RES,A,B
DATA (NTR=-1),(NDIM=30)
EQUIVALENCE (A,B)
37 FORMAT(*1THE COEFFICIENTS AND THEIR ESTIMATED ERRORS ARE0*//)
38 FORMAT(*0*/*0*/*0*ESTIMATED RESIDUAL SUM OF SQUARES =*E17.9/
1          * ESTIMATED REGRESSION SUM OF SQUARES =*E17.9/
2          * ESTIMATED TOTAL SUM OF SQUARES =*E17.9/
3* VARIANCE OF FIT =*E17.9/* DETERMINANT OF THE MATRIX =*E17.9/
4* CORRELATION COEFFICIENT =*E17.9/* NUMBER OF POINTS =*I5)
45 FORMAT(*1THE ARRAYS IN THE FITTING PROGRAM ARE TOO SMALL TO HOLD T
1HE NUMBER OF CONSTRAINTS AND FUNCTIONS ASKED FOR IN THE CALLING PR
2OGRAM*)
371 FORMAT(E19.10,* +OR-*E9.2)
C  ENTER HERE TO FIT THE DATA
ENTRY FIT
IF(NTR) 1,3,3
1 NP=0
NF=NCOF
IF(NF.GT.NDIM) GO TO 44
NCON=0
SY=0.
SYY=0.
NY=NF+1
DO 2 I=1,NY
DO 2 J=1,NF
2 A(J,I)=0.
IF(NTR.EQ.0) GO TO 11
NTR=0
3 SY=Y+SY
SYY=SYY+Y*Y
DO 4 J=1,NF
A(J,NY)=A(J,NY)+Y*G(J)
DO 4 I=1,NF
4 A(I,J)=A(I,J)+G(I)*G(J)
NP=NP+1
RETURN
C  ENTER HERE TO CONSTRAIN THE EQUATION
ENTRY CONSTR
IF(NTR) 10,11,11
10 NTR=0
GO TO 1
11 N=NY-1
IF((NY+NCON+2).GT.NDIM) GO TO 44
DO 12 I=1,N
A(I,NY+1)=A(I,NY)
A(NDIM-NCON,I)=G(I)
A(NY,I)=G(I)
12 A(I,NY)=G(I)
NCON=NCON+1
DO 13 I=NF,N
A(NY,I+1)=0.0

```

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13 A(I+1,NY)=0.0

NY=NY+1

A(NY-1,NY)=Y

RETURN

C ENTER HERE TO INVERT MATRIX AND GET COEFFICIENTS

ENTRY COEFF

N=NY-1

DO 20 I=1,NF

20 G(I)=A(I,NY)

DO 22 I=2,N

DO 21 J=I,NY

21 A(I-1,J)=A(I-1,J)/A(I-1,I-1)

DO 22 J=I,N

DO 22 K=I,NY

22 A(J,K)=A(J,K)-A(J,I-1)*A(I-1,K)

A(N,NY)=A(N,NY)/A(N,N)

DO 24 I=2,N

L=N-I+2

DO 24 J=L,N

24 A(L-1,NY)=A(L-1,NY)-A(L-1,J)*A(J,NY)

RES=SY

DO 25 I=1,NF

RES=RES-A(I,NY)*G(I)

25 G(I)=A(I,NY)

DF=NP-NF+NCON

Y=NCON

NTR=-1

RETURN

C ENTER HERE FOR STATISTICS OF COEFFICIENTS

ENTRY STAT

DO 27 I=1,NCON

DO 27 J=1,NF

27 RES=RES-A(NDIM-I+1,J)*A(J,NY)*A(NF+I,NY)

TOT=SY-SY*SY/NP

REG=TOT-RES

SYY=RES/DF

ST=1.96+2.72/DF+8.04/DF**3

DET=1.

DO 30 I=1,NF

DET=DET*B(I,I)

30 A(I,I)=1.0/A(I,I)

DO 32 I=2,NF

DO 32 J=2,I

SY=0.

DO 31 K=J,I

31 SY=SY-A(I,K-1)*A(K-1,J-1)

32 A(I,J-1)=SY*A(I,I)

PRINT 37

DO 36 I=1,NF

L=NF-I

DO 33 J=1,L

K=NF-J

DO 33 M=1,J

N=NF-M+1

33 A(K,I)=A(K,I)-A(K,N)*A(N,I)

APPENDIX H. (Continued)

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```

DO 34 J=2,I
34 A(J-1,I)=A(I,J-1)*SYY
DO 35 J=1,I
35 A(I,J)=A(I,J)*SYY
BB=B(I,I)
C BB IS THE VARIANCE OF THE COEFFICIENTS
IF(BB.LT.0.0)BB=-BB
FF=ST*SQRT(BB)
BBB=B(I,NY)
36 PRINT 371,BBB,FF
IF(SYY.LT.0.0) SYY=-SYY
CORR=REG/TOT
PRINT 38,RES,REG,TOT,SYY,DET,CORR,NP
Y=SQRT(RES/DF)
RETURN
44 PRINT 45
STOP
END

```

* SINGLE-BANK COMPILATION.

APPENDIX I.

Computer Programs for Thermofunctions

06/06/74

```

PROGRAM ETHERMO2
C START ETHANE PROVISIONAL THERMOFUNCTIONS, 14 FEB., 1974.
COMMON B1,B2,B3, ER, E1,E2
COMMON/1/AL,BE,EP,GK, DCRT,TCRT,PCRT, DTRP,TTRP,PTRP
COMMON/3/DPDT,D2PDT2,DPSDT,DPMCT,DPDD,DTSOR,DTHDR
COMMON/4/ XB1,XB2, XE1,XE2, DXEDR,DXEDR
COMMON/6/ TSAT, THETA, PSAT
COMMON/7/ TB,PB, HB,SB
COMMON/8/ P,T,DEN, E,H,S, CV,CP,CSAT, W,WK
COMMON/9/ EI(60),SI(60),CVI(60)
COMMON/10/ DF(34),EF(34),SF(34),CVF(34)
COMMON/99/ TI,EZZ, EZ,SZ,CVZ, FZ,CPZ
DIMENSION PP(99)
3 FORMAT(1H1 11X *LOOP CLOSURE CHECK FOR SATURATED LIQUID,* /
1 12X *ENTHALPY, H, VIA FURTADO CP(T). HC VIA CLAPEYRON EGN.* //
2 12X 3HT,K 9X1HH 8X2HHC 7X3HPCT 9X1HS 8X2HSC 7X3HPCT )
4 FORMAT(5X 3F10.0, 4F10.2)
5 FORMAT(1X)
10 FORMAT(1H1 9X *ETHANE FUNCTIONS AT TB ON THE CP ISOBAR AT PE.*//
1 10X 5HTB =F8.3, 6H, PB =F8.3, 6H, DB =F8.4//
2 10X 5HEZ =F10.2, 6H, E =F10.2//
3 10X 5HHZ =F10.2, 6H, H =F10.2//
4 10X 5HSZ =F10.4, 6H, S =F10.4//
5 10X 5HCVZ =F10.3, 6H, CV =F10.3//
6 10X 5HCPZ =F10.3, 6H, CP =F10.3//
7 10X 21HFURTADOS VALUE, CP =F10.3)
15 FORMAT(3F10.0)
16 FORMAT(///////// 1H1 16X * ETHANE ISOBAR AT P =*F6.1, 4H EAR//
1 19X 1HT 6X3HDEN 6X3HVOL 5X5HDP/DT 5X5HDP/DD 8X1HE 8X1HH 8X1HS
2 6X2HCV 6X2HCP 5X1HW /
3 15X 5HDEG K 4X5HMCL/L 4X5HL/MOL 5X5HBAR/K 1X9HBAR-L/MOL 4X5HJ/MOL
4 4X5HJ/MOL 2X7HJ/MCL/K 1X7HJ/MCL/K 1X7HJ/MOL/K 1X5HM/SEC )
17 FOPMAT(10X F10.3, F9.3, F9.5, F10.4, F10.3, 2F9.1,F9.3,2F8.2,F6.0)
18 FORMAT(10X F10.3, F9.5, F9.3, F10.6, F10.3, 2F9.1,F9.3,2F8.2,F6.0)
C
C CONSTANTS OF EQNSTATE, 6/5/74 AT 8.21.
C NOTE, EZZ FROM TESTER.
30 WM = 30.07 $ WK = 100000/WM $ Q = 1.01325 $ GKK = 0.0831434
31 TTRP = 89.899 $ DTRP = 21.68 $ PTRP = 0*9.967E-6
32 TCRT = 305.37 $ DCRT = 6.74 $ PCRT = PSATF(TCRT)
33 GK = DTRP*GKK $ EZZ = 4.1868*4827.2
34 AL = 2 $ BE = 1 $ EP = 0.5 $ ER = 1.90
35 E1 = 1.848167996 $ E2 = 1.569704511 $ B3 = 5.560186452
36 E1 = -1.042842462 $ E2 = 0.224978299
C INTEGRATE ON ISOTHERM TB UP TO POINT (TB,PB), THEN -
C GET FURTADO,S CP(T) FOR COMPARISON, AND PRINT ALL VALUES.
40 TP = T = 340 $ PB = P = 137.895
41 CALL SAVIDEAL $ CALL HOMOTHRM $ TI = T $ CALL IDEAL
42 HB = H $ SB = S $ CPX = CPXF(T)
43 PRINT 10, T,P,DEN, EZ,E, HZ,H, SZ,S, CVZ,CV, CFZ,CP, CPX
44 CALL MEMORY
C
C NOW COMPARE SATLIQ FUNCTIONS VIA FURTADO WITH CLAPEYRON.
50 PRINT 3 $ DO 60 J=1,43 $ T = 85 + 5*J
51 P = PS = PSATF(T) $ CALL SATGSTRM $ DG = DEN

```

APPENDIX I. (Continued)

ETHERMO2

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```

52 DL = FINDSATF(T,1)  $  Q = 100*T*DPSDT*(1/DL-1/DG)
53 HC = H + Q  $  SC = S + Q/T
55 CALL SATLQTRM  $  HF = 100*(HC/H-1)  $  SR = 100*(SC/S-1)
60 PRINT 4, T, H,HC,HR, S,SC,SR
98 CALL JTLOCUS  $  CALL TABLIQ

C
C  COMPUTE THERMOFUNCTIONS ON ISOBARS.
C  EACH ISOBAR STARTS ON THE MELTING LINE.
C  ISOBARS AT P UNDER PCRT TRAVERSE THE DOME.
C  LET THE FIRST ISOBAR BE AT P = 0.1 BAR.
C  ENTER COMPRESSED LIQUID VIA FURTACC CP(T) ON 137.895 PARISCOBAR.
C
100 NI = 68  $  PP(1) = 0.1  $  READ 15, (PP(I),I=2,NI)
102 DO 300 I=1,NI  $  P = PP(I)  $  PRINT 16, P
103 CALL MELTHERM  $  V = 1/DEN
104 PRINT 17, T,DEN,V, CPDT,DPDD, E,H,S, CV,CP,W
105 IT = T/10  $  IF(P.LT.PCRT) 110,199

C
C  CASES FOR P LESS THAN PCRT.
110 TS = FINDTSF(P)  $  TX = TS + 10  $  K = L = 0
111 DO 150 J=1,99  $  T = JT = 10*(IT+J)
112 IF(T.LT.TS) 113,115
113 CALL LIQ THERM  $  V = 1/DEN
114 PRINT 17, T,DEN,V, CPDT,DPDD, E,H,S, CV,CP,W  $  GO TO 150
115 IF(T.LT.TX) 118,130

C  CASE FOR THE SATURATED LIQUID AND VAPOR.
118 T = TS  $  CALL SATLQTRM  $  V = 1/DEN
119 PRINT 17, T,DEN,V, CPDT,DPDD, E,H,S, CV,CP,W  $  PRINT 5
120 CALL SATGSTRM  $  V = 1/DEN
121 IF(P.LT.20.0) 122,123
122 PRINT 18, T,DEN,V, DPDT,DPDD, E,H,S, CV,CP,W  $  GO TO 124
123 PRINT 17, T,DEN,V, CPDT,DPDD, E,H,S, CV,CP,W
124 T = JT

C  CASES FOR THE HOMOGENEOUS DOMAIN.
130 IF(JT-500) 135,135,131
131 K = K+1  $  T = JT = JT + 10*K
132 IF(JT-500) 135,135,300
135 CALL HOMOTHRM  $  V = 1/DEN
136 IF(P.LT.20.0) 137,138
137 PRINT 18, T,DEN,V, DPDT,DPDD, E,H,S, CV,CP,W  $  GO TO 150
138 PRINT 17, T,DEN,V, DPDT,DPDD, E,H,S, CV,CP,W
150 CONTINUE

C
C  CASES FOR P GREATER THAN PCRT.
199 K = L = 0
200 DO 250 J=1,99  $  T = JT = 10*(IT+J)
201 IF(T.LT.TB) 202,210
202 IF(T.GT.TCRT) 203,205
203 PX = PVT(T,DCRT,0)  $  IF(P.GT.PX) 205,220

C  CASE FOR THE COMPRESSED LIQUID.
205 CALL LIQ THERM  $  V = 1/DEN
206 PRINT 17, T,DEN,V, DPDT,DPDD, E,H,S, CV,CP,W  $  GO TO 250

C  CASES FOR THE HOMOGENEOUS DOMAIN.
210 IF(JT-500) 220,220,211
211 K = K+1  $  T = JT = JT + 10*K

```

APPENDIX I. (Continued)

ETHERMO2

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```

212 IF(JT-600) 220,220,300
220 CALL HOMOTHRM $ V = 1/DEN
221 PRINT 17, T,DEN,V, DPOT,DP00, E,H,S, CV,CP,W
250 CONTINUE
300 CONTINUE
999 STOP $ END

```

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```

SUBROUTINE SAIDEAL
C MEMORIZE IDEAL GAS FUNCTIONS EVERY 10 K THRU 600 K.
C NOTE USE BY HOMOTHRM ONLY.
COMMON/9/ EI(60),SI(60),CVI(60)
COMMON/99/ TI,EZZ, EZ,SZ, CVZ, HZ,CPZ
1 DO 9 J=9,60 $ TI = 10*J $ CALL IDEAL
2 EI(J) = EZ $ SI(J) = SZ $ CVI(J) = CVZ
9 CONTINUE $ RETURN $ END

```

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```

SUBROUTINE MEMORY
C MEMORIZE CPSUMIT RESULTS EVERY 10 K FROM 90 TO 340 K.
C NOTE USE BY LIQTHERM ONLY.
COMMON/3/P,T,DEN, E,H,S, CV,CP,CSAT, W,WK
COMMON/10/ DF(34),EF(34),SF(34),CVF(34)
1 DO 9 J=9,33 $ T = 10*J $ CALL CPSUMIT
2 DF(J) = DEN $ EF(J) = E $ SF(J) = S $ CVF(J) = CV
9 CONTINUE $ RETURN $ END

```


APPENDIX I. (Continued)

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```

SUBROUTINE JTLOCUS
C  DERIVE THE J-T INVERSION CURVE.  USE ROUTINE DELTAF(T,DI).
  DIMENSION TT(99),PP(99),DN(99)
  DATA (DCRT=6.76),(TCRT=305.43)
  1  FORMAT(1H1 16X *THE JOULE-THOMSON INVERSION LOCUS FOR ETHANE*//
  1  17X3HT,K 5X5HP,BAR 5X5HMOL/L 7X3HT,K 5X5HP,BAR 5X5HMOL/L)
  2  FORMAT(10X F10.0, F10.1, F10.2, F10.0, F10.1, F10.2)
  6  TA = 240 $ NP = 72
  7  PRINT 1 $ DO 25 I=1,NP $ DX = 1.6
  8  T = TA + 5*I $ X = T/TCRT
  9  DI = DCRT*(2.40 - 0.58*X + 0.24/X)
 10  IF(T-TCRT) 11,12,12
 11  DL = DENLIQF(T) $ IF(DI-DL) 25,12,12
 12  SS = DELTAF(T,DI) $ DO 20 IT=1,15
 14  D=DI-DX $ SL=DELTAF(T,D) $ D=DI+DX $ SP=DELTAF(T,D)
 15  IF(SS-SL) 18,16,16
 16  IF(SP-SL) 19,17,17
 17  SS = SL $ DI = DI - DX $ GC TC 20
 18  IF(SS-SP) 20,20,19
 19  SS = SP $ DI = DI + DX
 20  DX = DX/2
 23  TT(I) = T $ DN(I) = DI $ PP(I) = PVTf(T,DI,0)
 25  CONTINUE $ N = NP/2 $ DO 29 J=1,N
 29  PRINT 2, TT(J),PP(J),DN(J), TT(J+N),PP(J+N),DN(J+N)
 30  RETURN $ END

```

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```

FUNCTION DELTAF(T,D)
C  GET (T*DP/DT - D*DP/DD) FOR THE J-T INVERSION CURVE.
  COMMON/3/DPDT,D2PDT2,DPSDT,DPMOT,DPOD,DTSDF,DTHDF
  DATA (DCRT=6.76),(TCRT=305.43)
  1  IF(T-TCRT) 2,4,4
  2  DL = DENLIQF(T) $ IF(D-DL) 3,3,4
  3  DELTAF = 1.0E+100 $ RETURN
  4  P = PVTf(T,D,1)
  5  DELTAF = ABSF(T*DPDT-D*DPDD) $ RETURN $ END

```

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```

SUBROUTINE TABLIQ
C  TABULATE THE ETHANE SATURATED LIQUID FUNCTIONS.
COMMON/1/AL,BE,EP,GK, DCRT,TCRT,PCRT, DTRP,TTRP,PTRP
COMMON/3/DPDT,D2PDT2,DPSDT,DPMOT,DPDD,DTSOR,DTHDR
COMMON/8/ P,T,DEN, E,H,S, CV,CP,CSAT, W,WK
DIMENSION TSA(46), PSA(46)
4  FORMAT(1H1 13X *PROPERTIES OF SATURATED LIQUID ETHANE* //
1  14X1HT 10X1HP 5X3HDEN 4X5HV,LIQ 6X5HV,GAS 5X6HOPS/DT 3X6HODL/DT
2  6X5HDP/DT 6X5HDP/DD 2X5HQ,VAP 2X5HQ,XPT /
3  10X5HDEG K 8X3HBAR 3X5HMOL/L 4X5HL/MOL 6X5HL/MOL 6X5HBAR/K
4  2X7HMOL/L/K 6X5HBAR/K 2X9HBAR-L/MOL 2X5HJ/MOL 2X5HJ/MOL )
5  FORMAT(5XF10.3, E11.3, F8.3, F9.5, 2E11.3, F9.4, 2E11.3, 2F7.0)
11 FORMAT(1H1 13X *PROPERTIES OF SATURATED LIQUID ETHANE* //
1  14X1HT 11X1HP 9X1HE 9X1HH 9X1HS
2  6X2HCV 6X2HCS 6X2HCP 6X1HW 2X6HCS,XPT /
3  10X5HDEG K 9X3HBAR 5X5HJ/MOL 5X5HJ/MOL 3X7HJ/MOL/K
4  1X7HJ/MOL/K 1X7HJ/MOL/K 1X7HJ/MOL/K 2X5HM/SEC 1X7HJ/MOL/K )
12 FORMAT(5X F10.3, E12.3, 2F10.1, F10.3, 3F8.2, F7.0, F8.2)
C  FOR PAGE ONE OF TABLIQ.
140 PRINT 4 $ NP = 46
141 DO 151 J=1,NP $ IF(J.EQ.1) 142,143
142 T = TTRP $ GO TO 147
143 IF(J.EQ.NP) 144,146
144 T = TCRT $ DG = DL = DCRT $ DOLDT = 0
145 VG = VL = 1/DG $ GO TO 149
146 T = 80 + 5*J
147 DL = FINDSATF(T,1) $ DOLDT = DTRP/DTSOR
148 DG = FINDSATF(T,0) $ VG = 1/DG $ VL = 1/DL
149 TSA(J) = T $ PSA(J) = PS = PSATF(T)
150 QC = 100*T*DPSDT*(VG-VL) $ PX = PVT(T,DL,1) $ QX = GVAFX(T)
151 PRINT 5, T,PS,DL, VL,VG, DPSDT,DOLDT, DPDT,DPDD, QC,QX
C  FOR PAGE TWO OF TABLIQ.
C  NOW INTEGRATE ALONG FB, THEN ON ISOTHERM T DOWN TO THE SATLIQ.
C  USE SUBROUTINE SATLQTRM FOR THIS OPERATION.
160 PRINT 11 $ DO 165 J=1,NP
161 T = TSA(J) $ P = PSA(J)
162 CALL SATLQTRM $ CSX = CSATXF(T)
165 PRINT 12, T,P, E,H,S, CV,CSAT,CP, W, CSX
999 RETURN $ END

```

* SINGLE-BANK COMPILATION.

APPENDIX I. (Continued)

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```

FUNCTION PVTF(T,D,M)
C  PVTF = P,BAR. M=0 YIELDS DP/DT,C2P/DT2. M=1 YIELDS ALSO DP/DC.
C  NOTE GK = 0.0831434*DTPP, AND R = DEN/DTRP.
C  P = PS(R) + R*GK*(T-TS) + R2*GK*TC*(B*XB + E*XE).
COMMON B1,B2,B3, ER, E1,E2
COMMON/1/AL,BE,EP,GK, DCRT,TCRT,FCRT, DTRP,TTRP,PTRP
COMMON/3/DPDT,D2PDT2,DPSDT,DPMCT,DPDD,DTSOR,DTHDR
COMMON/4/ XB1,XB2, XE1,XE2, DXBDR,DXEOR
COMMON/6/ TSAT, THETA, PSAT
1 S = D/DCRT $ DSDR = DTRP/DCRT $ R = D/DTRP
2 R2=R*R $ R3=R*R2 $ R4=R2*R2 $ RG = R*GK
3 TC = TCRT $ TS = TSAT = TSATF(D) $ THETA = THETA F(D)
4 PS = PSATF(TS) $ XB = XBF(T,D) $ XE = XEF(T,D)
5 BN = 1+BE*R2 $ B = B1*R2 + B2*R3 + B3*R4/BN
6 EM = E1*R2 + E2*R3 $ SX = (S-1)*(S-ER) $ E = SX*EM
7 F = B*XB + E*XE $ F1 = B*XB1 + E*XE1 $ F2 = B*XB2 + E*XE2
8 PVTF = PS + (T-TS)*RG + GK*TC*F
9 DPDT = RG + GK*F1 $ D2PDT2 = GK*F2/TC $ IF(M.EQ.1) 10,20
10 BD = 2*B1*R + 3*B2*F2 + (2-BE*R2/BN)*2*B3*R3/BN
11 ED = SX*(2*E1*R + 3*E2*R2) + (2*S-1-ER)*EM*DSOR
12 F1 = B*DXBDR + BD*XE + E*DXEOR + ED*XE
13 DPDR = DPSDT*DTSOR + GK*(T-TS-R*DTSOR) + GK*TC*F1
14 DPDD = DPDR/DTRP
20 RETURN $ END

```

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```

FUNCTION THETA F(DEN)
C  THETA = TSAT*EXP(U(S)).
C  LET Q = (S-1)/(ST-1), WHERE ST = DTRP/DCRT, THEN -
C  IF S < 1, U = AL*Q**3, IF S > 1, U = -AL*Q**3,
C  YIELDS ALSO THE FIRST DERIVATIVE RSP. TO RHO = DEN/DTRP.
COMMON/1/AL,BE,EP,GK, DCRT,TCRT,FCRT, DTRP,TTRP,PTRP
COMMON/3/DPDT,D2PDT2,DPSDT,DPMCT,DPDD,DTSOR,DTHDR
COMMON/6/ TSAT, THETA, PSAT
1 S = DEN/DCRT $ DSDR = DTRP/DCRT $ C = DSDR-1
2 Q = (S-1)/C $ Q2 = Q*Q $ U = AL*Q*Q2
3 U1 = 3*AL*Q2*DSOR/C $ IF(Q) 5,9,4
4 U = -U $ U1 = -U1
5 XP = EXPF(U) $ THETA F = TSAT*XP
6 DTHDR = (TSAT*U1 + DTSOR)*XP $ RETURN
9 THETA F = TCRT $ DTHDR = 0 $ RETURN $ END

```

APPENDIX I. (Continued)

06/06/74

FUNCTION XBF(T,D)

C XBF = SQRT(T/TC)*LN(T/TS) = Q(T)*Z(R,T),
 C Z(R,T) = LN(U), U(R,T) = T/TS(R).
 COMMON/1/AL,BE,EP,GK, DCRT,TCRT,PCRT, DTRP,TTRP,PTRP
 COMMON/3/DPDT,D2PDT2,DPSDT,DPMOT,DPDD,DTSDR,DTHDR
 COMMON/4/ XB1,XB2, XE1,XE2, DXBDR,DXEDR
 COMMON/6/ TSAT, THETA, PSAT
 1 TC = TCRT \$ TS = TSAT \$ X = T/TC
 2 U = T/TS \$ U1X = TC/TS \$ U1R = -U*DTSDR/TS
 3 Z = LOGF(U) \$ Z1R=U1R/U \$ Z1X=U1X/U \$ Z2X=-Z1X*Z1X
 4 Q = SQRTF(X) \$ Q1 = 0.5/Q \$ Q2 = -Q1/2/X
 5 XBF = Q*Z \$ DXBDR = Q*Z1R \$ XB1 = Q*Z1X + Q1*Z
 6 XB2 = Q*Z2X + 2*Q1*Z1X + Q2*Z \$ RETURN \$ END

06/06/74

FUNCTION XEF(T,D)

C XEF = PSI-PSISAT, PSI = (1-W*LN(1+1/W))/X, W = EP*(T/TH-1).
 C XEF = F(R,T)/X - FS(R)/XS
 C F(R,T) = 1-W*P(R,T), P(R,T) = LN(U), U = 1+1/W(R,T),
 C FS(R) = 1-WS*PS(R), PS(R) = LN(V), V = 1+1/WS(R).
 COMMON/1/AL,BE,EP,GK, DCRT,TCRT,PCRT, DTRP,TTRP,PTRP
 COMMON/3/DPDT,D2PDT2,DPSDT,DPMOT,DPDD,DTSDR,DTHDR
 COMMON/4/ XB1,XB2, XE1,XE2, DXBDR,DXEDR
 COMMON/6/ TSAT, THETA, PSAT
 1 E=EP \$ TC=TCRT \$ TH=THETA \$ TS=TSAT \$ W=E*(T/TH-1) \$ IF(W) 30,30,2
 2 WW = W*W \$ W1X = E*TC/TH \$ W1R = -E*T*DTHDR/TH/TH
 3 U=1+1/W \$ U1R=-W1R/WW \$ U1X=-W1X/WW \$ U2X = -2*U1X*W1X/W
 4 P=LOGF(U) \$ P1R=U1R/U \$ P1X=U1X/U \$ P2X = U2X/U - P1X*P1X
 5 F = 1 - W*P \$ F1R = -W*P1R - W1R*P
 6 F1X = -W*P1X - W1X*P \$ F2X = -W*P2X - 2*W1X*P1X
 7 WS = E*(TS/TH-1) \$ IF(WS) 8,8,9
 8 FS = 1 \$ FS1 = 0 \$ GO TO 12
 9 WS1 = E*(DTSDR - TS*DTHDR/TH)/TH \$ U = 1+1/WS
 10 PS = LOGF(U) \$ PS1 = -WS1/U/WS/WS
 11 FS = 1-WS*PS \$ FS1 = -WS*PS1 - WS1*PS
 12 X=T/TC \$ X2=X*X \$ XS=TS/TC \$ XS1=DTSDR/TC
 13 XEF = F/X - FS/XS \$ XE1 = F1X/X - F/X2
 14 XE2 = F2X/X - 2*F1X/X2 + 2*F/X/X2
 15 DXEDR = F1R/X - FS1/XS + FS*XS1/XS/XS \$ RETURN
 30 XFF = XE1 = XE2 = DXEDR = 0 \$ RETURN \$ END

06/06/74

```

      FUNCTION DENGASF(T)
C      Y = A1 + A2*Q2 + A3*Q3 + . . . , NF = AL, YN = LN(DCRT/DTRP),
C      U = Z + (ZE-Z)*Y, DEN = DCRT*EXP(-YN*U).
      DIMENSION A(5)
      DATA (TTRP=89.899), (DTRP=1.35114E-6)
      DATA (TCRT=305.37), (DCRT=6.74), (E=0.39)
      DATA (A = 0.21587515, -0.08522342, -0.61523457,
1      0.25452490, 0.15177230)
1      FORMAT(1H0 9X *DENGASF = 0, T EXCEEDS TCRT. * / )
2      IF(TCRT-T) 3,4,5
3      PRINT 1 $ STOP
4      DENGASF = DCRT $ RETURN
5      ZN=TCRT/TTRP-1 $ YN=LOGF(DCRT/DTRP) $ Z=(TCRT/T-1)/ZN
6      Q = CUBERTF(Z) $ X = Z**E - Z $ Y = A(1) $ DO 8 K=2,5
8      Y = Y + A(K)*Q**K $ U = Z + X*Y
9      DENGASF = DCRT*EXP(-YN*U) $ RETURN $ END

```

06/06/74

```

      FUNCTION DENLIQF(T)
C      ETHANE SATD. LIQUID DENSITIES, MOL/L, VIA LAB. NOTE 73-5.
C      Y = A1 + A2*Q2 + A3*Q3 + . . . , YN = DTRP-DCRT,
C      DEN = DCRT + YN*(X + (XE-X)*Y).
      DATA (TTRP=89.899), (DTRP=21.68)
      DATA (TCRT=305.37), (DCRT=6.74), (E=0.33)
      DATA (A=0.721909438), (B=0.296577899), (C=-0.300365476)
1      FORMAT(1H0 9X *DENLIQF = 0, T EXCEEDS TCRT. * / )
2      IF(TCRT-T) 3,4,5
3      PRINT 1 $ STOP
4      DENLIQF = DCRT $ RETURN
5      XN = TCRT-TTRP $ YN = DTRP-DCRT $ X = (TCRT-T)/XN
6      W = CUBERTF(X) $ G = X**E - X $ Y = A + B*W*W + C*X
8      DENLIQF = DCRT + (X + G*Y)*YN $ RETURN $ END

```

06/06/74

```

      FUNCTION PMELTF(T)
C      ETHANE MELT P TO 42 ATM., CLUSIUS/WEIGAND, 1940.
C      SIMON EQN., P = PTRF + A*(X**2 - 1), X = T/TTRF.
      COMMON/3/DPOT, D2PDT2, DPSDT, DPMCT, DPDD, DTSDF, DTHDF
      DATA (TTRP=89.899), (PTRP=9.967E-6), (A=2840.0), (Q=1.01325)
1      X = T/TTRP $ PMELTF = Q*(PTRF + A*(X*X-1))
2      DPMCT = Q*A*2*X/TTRF $ RETURN $ END

```

06/06/74

FUNCTION PSATF(T)

C ETHANE V.P., BAR, VIA LAB. NOTE 73-3.
COMMON/3/DPDT,D2PDT2,DPSDT,DPMOT,DPDO,DTSDR,DTHDR
DATA (TTRP=89.899),(TCRT=305.37),(PTRP=9.967E-6)
DATA (P1=10.79549166),(P2=8.35899001),(P3=-3.11490770),
1 (P4=-0.64969799),(P5=6.07349549)
2 FORMAT(1H0 9X *PSATF = 0, T EXCEEDS TCRT. * /)
3 XN = 1-TTRP/TCRT \$ DXDT = TTRP/XN/T/T
3 X=(1-TTRP/T)/XN \$ X2=X*X \$ X3=X*X2 \$ X4=X2*X2
4 V = 1-X \$ IF(V) 5,6,7
5 PSATF = DPSDT = 0 \$ PRINT 1 \$ RETURN
6 Z = Z1 = 0 \$ GO TO 9
7 Q = SQRTF(V) \$ W = V*Q \$ W1 = -3*Q/2
8 Z = X*W \$ Z1 = W + X*W1
9 F = P1*X + P2*X2 + P3*X3 + P4*X4 + P5*Z
10 F1 = P1 + 2*P2*X + 3*P3*X2 + 4*P4*X3 + P5*Z1
11 PSATF = 1.01325*PTRF*EXP(F)
12 DPSDT = F1*DXDT*PSATF \$ RETURN \$ END

06/06/74

FUNCTION TSATF(DEN)

C THIS NEW TSATF VIA TSATFIT, 4/19/74 AT 09.00.
COMMON/3/DPDT,D2PDT2,DPSDT,DPMCT,DPDO,DTSDR,DTHDF
DIMENSION AV(8), AW(5)
DATA (ALS=0.5),(BES=0.5),(E=0.25),(DTRP=21.68),(DGAT=1.35114E-6)
DATA (TTRP=89.899),(TCRT=305.37),(DCRT=6.74)
DATA(AV = 0.868105174, 0.015169784, -0.729604322, 1.009654932,
1 -8.734027096, 21.107128228, -31.449940867, 17.863703965)
DATA(AW = 23.724518399, -14.886051613, 5.431774425,
1 -1.071505659, 0.091351825)
C SATD. VAPOR TEMPS. CONSTRAINED AT T.P.
C DEFINE X = ABS(S-1), XT = ABS(ST-1), WHEN THE EQN. IS -
C LN(YY) = AL*(1/XT-1/X) + A1*LOG(LN(1+E/S)/LN(1+E/ST)) + W(S),
C W(S) = A2*(Q-QT) + A3*(Q2-QT2) + A4*(S-ST) + A5*(S2-ST2) + . . .
1 S = DEN/DCRT \$ DSDR = DTRP/DCRT \$ QS = S-1 \$ IF(QS) 2,30
2 X = ABSF(QS) \$ X1 = DSDR*QS/X \$ YN = TCRT/TTRP - 1
3 V=1/X \$ V1=-DSOR/X/GS \$ ST=DGAT/DCRT \$ IF(QS) 4,30,15
4 XT=1-ST \$ VT=1/XT \$ U=ALS*(VT-V) \$ U1=-ALS*V1 \$ EK=LOGF(1+ E/ST)
5 P = 1 + E/S \$ P1 = -E*DSOR/S/S \$ PG = LOGF(P)/EK
6 G = LOGF(PG) \$ G1 = P1/P/PG/EK
7 Q = CUBERTF(S) \$ QT = CUBERTF(ST) \$ Q1 = Q*DSOR/3/S
8 W = U + AV(1)*G + AV(2)*(Q-QT) + AV(3)*(Q*Q-QT*QT)
9 W1 = U1 + AV(1)*G1 + AV(2)*Q1 + AV(3)*2*G*Q1
10 DO 11 K=4,8 \$ N = K-3 \$ W = W + AV(K)*(S**N-ST**N)
11 W1 = W1 + N*DSOR*AV(K)*S**(N-1) \$ GO TO 18
C SATD. LIQUID TEMPS. CONSTRAINED AT THE T.F.
C EQN., LN(YY) = W(S), WHERE X=APS(S-1), XT=APS(ST-1), AND -
C W(S) = BE*(1/XT - 1/X) + B1*(S-ST) + B2*(S2-ST2) + . . .
15 ST = DSDR \$ XT = ST-1 \$ W = BES*(1/XT-V) \$ W1 = -BES*V1
16 DO 17 K=1,5 \$ W = W + AW(K)*(S**K - ST**K)
17 W1 = W1 + AW(K)*K*DSOR*S**(K-1)
18 F = EXPF(W) \$ F1 = W1*F \$ G = 1 + YN*F
19 TSATF = TCRT/Q \$ DTSOR = -YN*F1*TSATF/Q \$ RETURN
30 TSATF = TCRT \$ DTSOR = 0 \$ RETURN \$ END

APPENDIX I. (Continued)

06/06/74

```

FUNCTION FINDTMF(P)
C  GIVEN MELTING PRESSURE P, ITERATE T TO MINIMIZE (P-PC).
    COMMON/3/DPDT,02PDT2,DPSDT,DPMCT,DPDD,DTSDR,DTHOR
1  FORMAT(1H0 9X *FINDTMF = 0,  FAILS TO CONVERGE) * / )
2  T = 100 $ DO 6 J=1,50 $ DP = P-PMELTF(T) $ ADP = ABSF(DP)
3  IF(ADP/P-1.0E-6) 7,7,4
4  IF(ADP/DPMDT/T-1.0E-6) 7,7,5
5  T = T + DP/DPMDT
6  CONTINUE $ FINDTMF = 0 $ PRINT 1 $ RETURN
7  FINDTMF = T $ RETURN $ END

```

06/06/74

```

FUNCTION FINDTSF(P)
C  GIVEN VAPOR PRESSURE P, ITERATE T TO MINIMIZE (P-PC).
    COMMON/1/AL,BE,EP,GK, DCRT,TCRT,PCRT, DTRP,TTRP,PTRP
    COMMON/3/DPDT,02PDT2,DPSDT,DPMCT,DPDD,DTSDP,DTHOR
1  FORMAT(1H0 9X *FINDTSF = 0,  FAILS TO CONVERGE. * / )
2  FORMAT(1H0 9X *FINDTSF = 0,  P EXCEEDS PCRT. * / )
3  IF(P-PCRT) 4,11,12
4  T = 200 $ DO 9 J=1,50 $ DP = P - PSATF(T) $ ADP = ABSF(DP)
5  IF(ADP/P-1.0E-6) 10,10,6
6  IF(ADP/DPSDT/T-1.0E-6) 10,10,7
7  T = T + DP/DPSDT $ IF(T-TCRT) 9,9,8
8  T = TCRT
9  CONTINUE $ FINDTSF = 0 $ PRINT 1 $ RETURN
10 FINDTSF = T $ RETURN
11 FINDTSF = TCRT $ RETURN
12 FINDTSF = 0 $ PRINT 2 $ RETURN $ END

```

06/06/74

```

      FUNCTION FINDENF(T,P)
C      ON ISOTHERM T, FIND DEN, MOL/L, TO MINIMIZE (P-PC) VIA EQNSTATE.
      COMMON/1/AL,BE,EP,GK, DCRT,TCRT,FCRT, DTRP,TTRP,PTRP
      COMMON/3/DPDT,D2PDT2,DPSDT,DPMOT,DPDD,DTSDR,OTHDR
      DATA (DM=23.0),(DGAT=1.35114E-6)
41  FORMAT(1H0 9X *FINDENF = 0, FAILS TO CONVERGE. * / )
42  FORMAT(1H0 9X *FINDENF = DCRT, DP/DR ZERO OR NEG. * / )
43  FORMAT(1H0 9X *FINDENF = 0, DOUBLE-VALUED AT P = PSAT. * / )
      1 IF(T-TCRT) 2,5,8
      2 DG=FINDSATF(T,0) $ DL=FINDSATF(T,1) $ PS=PSATF(T) $ IF(P-PS) 3,32,4
      3 D = DG/2 $ GO TO 11
      4 D = (DL+DM)/2 $ GO TO 11
      5 DG=DL=DCRT $ PS=PCRT $ IF(P-PS) 6,33,7
      6 D = DCRT/2 $ GO TO 11
      7 D = 2*DCRT $ GO TO 11
      8 IF(T.LT.400.0) 9,10
      9 PC = PVTG(T,DCRT,0) $ IF(P-PC) 6,33,7
     10 D = DCRT
     11 DO 30 J=1,50 $ DP=P-PVTG(T,D,1) $ IF(ABSF(DP/P)-1.0E-6) 31,31,12
     12 IF(DPDD) 34,34,13
     13 DD = DP/DPDD $ IF(ABSF(DD/D)-1.0E-6) 31,31,14
     14 C = D + DD $ IF(D.GT.DGAT) 16,15
     15 D = DGAT $ GO TO 30
     16 IF(D.GT.DM) 17,18
     17 D = DTRP $ GO TO 30
     18 IF(T-TCRT) 19,24,30
     19 IF(P.LT.PS) 20,22
     20 IF(D.GT.DG) 21,30
     21 D = DG $ GO TO 30
     22 IF(D.LT.DL) 23,30
     23 D = DL $ GO TO 30
     24 IF(P.LT.PCRT) 25,27
     25 IF(D.LT.DCRT) 30,26
     26 D = DCRT - 0.02 $ GO TO 30
     27 IF(D.GT.DCRT) 30,28
     28 D = DCRT + 0.02
     30 CONTINUE $ FINDENF = 0 $ PRINT 41 $ RETURN
     31 FINDENF = D $ RETURN
     32 FINDENF = 0 $ PRINT 43 $ RETURN
     33 FINDENF = DCRT $ RETURN
     34 FINDENF = DCRT $ PRINT 42 $ RETURN $ END

```

* SINGLE-BANK COMPILATION.

06/06/74

```

      FUNCTION FINDSATF(T,M)
C      ITERATE DEN TO MINIMIZE (T-TS) VIA TSATF(DEN).
C      M = 0 FOR VAPOR, M = 1 FOR LIQUID.
      COMMON/1/AL,BE,EP,GK, DCRT,TCRT,PCRT, DTRP,TTRP,PTRP
      COMMON/3/DPDT,D2PDT2,DPSDT,DPMOT,DPOD,DTSDR,DTHDR
      DATA (DM=23.0),(DGAT=1.35114E-6)
      1 FORMAT(1H0 9X *FINDSATF = 0, FAILS TO CONVERGE.* / )
      2 FORMAT(1H0 9X *FINDSATF = 0, T EXCEEDS TCRT.* / )
      3 IF(T-TCRT) 4,22,23
      4 IF(M.EQ.0) 5,6
      5 D = DENGASF(T) $ GO TO 7
      6 D = DENLIQF(T)
      7 DO 20 J=1,50 $ DT=T-TSATF(D) $ IF(ABSF(DT/T)-1.0E-6) 21,21,8
      8 DTDD = DTSDR/DTRP $ IF(DTDD.EQ.0.0) 22,9
      9 DD = DT/DTDD $ IF(ABSF(DD/D)-1.0E-6) 21,21,10
      10 C = D + DD $ IF(M.EQ.0) 11,15
      11 IF(D.GT.DGAT) 13,12
      12 D = DGAT $ GO TO 20
      13 IF(D.LT.DCRT) 20,14
      14 D = DCRT - 0.02 $ GO TO 20
      15 IF(D.GT.DM) 16,17
      16 C = DM $ GO TO 20
      17 IF(D.GT.DCRT) 20,18
      18 D = DCRT + 0.02
      20 CONTINUE $ FINDSATF = 0 $ PRINT 1 $ RETURN
      21 FINDSATF = D $ RETURN
      22 FINDSATF = DCRT $ RETURN
      23 FINDSATF = 0 $ PRINT 2 $ RETURN $ END

```

06/06/74

```

      SUBROUTINE IDEAL
C      ETHANE IDEAL GAS (1 ATM) THERMOFUNCTIONS (CHAO, 1973).
C      EQN.,  $Y = (EZ-EZZ)/RT = 3 + F(X)$ ,  $X = T/100$ ,  $Q = X^{1/3}$ ,
C       $F(X) = A1*Q^4 + A2*Q^5 + A3*Q^6 + \dots + AN*Q^{(N+3)}$ .
C       $(HZ-HZZ)/RT = 1 + Y$ ,  $CVN = CVZ/R = D(EZ/R)/DT$ ,  $CPZ/R = 1 + CVZ/F$ ,
C       $SZ/R = AZ + \text{INTEGRAL}(CVZ/R/X + 1/X)*DX$ .
      COMMON/99/TI, EZZ, EZ,SZ,CVZ, HZ,CPZ
      DIMENSION A(9)
      DATA (R=8.3143),(AZ=21.705718)
      DATA(A = 65.498641, -362.0115914, 853.3408616, -1123.601622,
      1 906.2184427, -459.2302545, 143.0300226, -25.07495605,1.897540044)
      1 X = TI/100 $ Q = CUBERTF(X) $ DQDX = Q/3/X $ F = F1 = S = 0
      2 DO 4 J=1,9 $ K = J+3 $ L = J+6
      3 Y = A(J)*Q**K $ F = F + Y $ F1 = F1 + K*Y/Q
      4 S = S + L*Y/K $ S = AZ + S + 4*LOGF(X)
      5 Y = 3 + F $ CV = Y + X*F1*CQDX
C      CONVERT TO DIMENSIONED RESULTS, JCULES, MCLES, KELVINS.
      6 EZ = R*TI*Y $ HZ = R*TI*(1+Y) $ CPZ = R*(1+CV)
      9 SZ = R*S $ CVZ = R*CV $ RETURN $ END

```

06/06/74

SUBROUTINE HOMOTHRM

```

C   GIVEN P,T, GET DEN AND FUNCTIONS FOR HOMOGENEOUS DOMAIN.
C   USE MEMORIZED IDEAL GAS FUNCTIONS EVERY 10 K.
COMMON/1/AL,BE,EP,GK, DCRT,TCRT,PCRT, DTRP,TTRP,PTRP
COMMON/3/DPDT,D2PDT2,DPSOT,DPMOT,DPDD,DTSDR,DTHDR
COMMON/8/ P,T,DEN, E,H,S, CV,CP,CSAT, W,WK
COMMON/9/ EI(60),SI(60),CVI(60)
COMMON/99/TI,EZZ, EZ,SZ,CVZ,HZ,CPZ
DATA (DA=0.0),(Q=1.01325),(G=0.0831434)
1  K = T/10 $  EZ = EI(K) $  SZ = SI(K) $  CVZ = CVI(K)
2  DEN = DB = FINDENF(T,P) $  N = 5*(1+DB)
3  E = EZZ + EZ + ESUMF(N,T,DA,DB) $  H = E + 100*P/DB
4  S = SZ + SSUMF(1,N,T,DA,DB) - 100*G*LOGF(G*T*DB/G)
5  X = 10.0*ABSF(T/TCRT-1) $  IF(X.LT.3.0) 6,7
6  N = N + DB*DB*EXPF(-X)
7  CV = CVZ + CSUMF(N,T,DA,DB) $  PX = PVTF(T,DB,1)
8  CP = CV + 100*T/DPDD*(DPDT/DB)**2
9  W = SQRTF(WK*CP*DPDD/CV) $  RETURN $  END

```

06/06/74

SUBROUTINE LIQTHERM

```

C   FOR DEN ABOVE DCRT, AND T UNDER TB = 340 K.
C   GIVEN P,T, GET DEN ETC.  FIRST USE CPSUMIT TO GET FUNCTIONS
C   AT POINT (T,PB,DB), THEN INTEGRATE ALONG ISOTHERM T.
C   USE MEMORIZED FUNCTIONS FROM CPSUMIT ON ISOBAR PB(FURTADO).
COMMON/3/DPDT,D2PDT2,DPSOT,DPMOT,DPDD,DTSDR,DTHDR
COMMON/8/ P,T,DEN, E,H,S, CV,CP,CSAT, W,WK
COMMON/10/ DF(34),EF(34),SF(34),CVF(34)
1  K = T/10 $  DB = DF(K) $  DEN = DN = FINDENF(T,P)
2  E = EF(K) $  S = SF(K) $  CV = CVF(K)
C   INTEGRATE ALONG ISOTHERM T FROM DB TO DN.
3  CX = ABSF(DN-DB) $  N = 5*(1+CX)
4  E = E + ESUMF(N,T,DB,DN) $  H = E + 100*P/DN
5  S = S + SSUMF(0,N,T,DB,DN) $  N = N + DX*DX
6  CV = CV + CSUMF(N,T,DB,DN) $  PX = PVTF(T,DN,1)
7  CP = CV + 100*T/DPDD*(DPDT/DN)**2
9  W = SQRTF(WK*CP*DPDD/CV) $  RETURN $  END

```

06/06/74

SUBROUTINE SATGSTRM

```

C   GIVEN P,T AT SATURATION, GET DEN ETC. -
COMMON/1/AL,BE,EP,GK, DCRT,TCRT,PCRT, DTRP,TTRP,FTRP
COMMON/3/DPDT,D2PDT2,DFSOT,DPMOT,DPDD,DTSOR,DTHDR
COMMON/8/ P,T,DEN, E,H,S, CV,CF,CSAT, W,WK
COMMON/99/ TI,EZZ, EZ,SZ,CVZ, HZ,CPZ
DATA (A=0.0),(Q=1.01325),(G=0.0831434)
1  TI = T    $    CALL IDEAL
2  DEN = DG = FINDSATF(T,0)    $    N = 5*(1+DG)
3  E = EZZ + EZ + ESUMF(N,T,A,DG)    $    H = E + 100*P/DG
4  S = SZ + SSUMF(1,N,T,A,DG) - 100*G*LOGF(G*T*DG/Q)
5  IF(T.EQ.TCRT) 6,7
6  CF = CV = W = 0    $    RETURN
7  N = N + DG*DG    $    CV = CVZ + CSUMF(N,T,A,DG)
8  PX = PVTf(T,DG,1)    $    CP = CV + 100*T/DPDD*(DPDT/DG)**2
9  W = SQRTF(WK*CP*DPDD/CV)    $    RETURN    $    END

```

06/06/74

SUBROUTINE SATLQTRM

```

C   GIVEN P,T AT SATURATION, GET DEN ETC. -
C   AT TEMP. T, GET FUNCTIONS AT P = PB VIA CPSUMIT,
C   THEN INTEGRATE ON ISOTHERM T FROM DB DOWN TO DL OF THE SATLIC.
COMMON/1/AL,BE,EP,GK, DCRT,TCRT,PCRT, DTRP,TTRP,PTRP
COMMON/3/DPDT,D2PDT2,DFSOT,DPMCT,DPDD,DTSOR,DTHDR
COMMON/8/ P,T,DEN, E,H,S, CV,CP,CSAT, W,WK
1  CALL CPSUMIT    $    DB = DEN    $    DEN = DL = FINDSATF(T,1)
2  DX = ABSF(DB-DL)    $    N = 5*(1+DX)
3  S = S + SSUMF(0,N,T,DB,DL)    $    E = E + ESUMF(N,T,DB,DL)
4  H = E + 100*P/DL    $    IF(T.EQ.TCRT) 5,6
5  CSAT = CV = CP = W = 0    $    RETURN
6  N = N + DX*DX    $    CV = CV + CSUMF(N,T,DB,DL)
7  PX = PVTf(T,DL,1)    $    CDLDT = CTRF/DTSOR
8  CSAT = CV-100*T*DPDT*CDLDT/DL/DL    $    CP = CV+100*T/DPDD*(DPCT/DL)**2
9  W = SQRTF(WK*CP*DPDD/CV)    $    RETURN    $    END

```

06/06/74

SUBROUTINE MELTHERM

```

C   GIVEN P, GET T,DEN, ETC. FOR FREEZING LIQUID.
COMMON/3/DPDT,D2PDT2,DFSOT,DPMCT,DPDD,DTSOR,DTHDR
COMMON/8/ P,T,DEN, E,H,S, CV,CP,CSAT, W,WK
1  T = FINDTMF(P)    $    CALL CPSUMIT    $    DB = DEN
2  DEN = DM = FINDENF(T,P)
C   NOW INTEGRATE ON ISOTHERM T FROM DB TO DM
3  N = 5 + 5*ABSF(DM-DE)    $    E = E + ESUMF(N,T,DB,DM)
4  H = E + 100*P/DM    $    S = S + SSUMF(0,N,T,DB,DM)
5  CV = CV + CSUMF(N,T,DB,DM)    $    PX = PVTf(T,DM,1)
6  CP = CV + 100*T/DPDD*(DPDT/DM)**2
9  W = SQRTF(WK*CP*DPDD/CV)    $    RETURN    $    END

```

06/06/74

SUBROUTINE CPSUMIT

```

C USE FURTADO CP(T) ALONG ISOBAR PB = 137.895 BAR.
C START AT TB = 340 K WITH VALUES HB, SB, THEN -
C INTEGRATE DOWN TO ANY T, YIELDS DEN, E, H, S, CP, CV, AT (T,PB).
COMMON/3/DPDT,D2PDT2,DPSDT,DPMDT,DPDD,DTSOR,OTHDR
COMMON/7/ TB,PB, HB,SB
COMMON/8/ P,T,DEN, E,H,S, CV,CP,CSAT, W,WK
DATA (TX = 250.0)
1 H = HB $ S = SB $ IF(T.LT.TX) 6,2
2 TR = T-TB $ N = 2+ABSF(TR) $ DT = TR/N
3 DO 5 J=1,N $ TJ = TB + (J-0.5)*DT $ CP = CPXF(TJ)
4 H = H + CP*DT $ S = S + CP*DT/TJ
5 CONTINUE $ GO TO 15
6 TR= TX-TB $ N = 2+ABSF(TR) $ DT = TR/N
7 DO 9 J=1,N $ TJ = TB + (J-0.5)*DT $ CP = CPXF(TJ)
8 H = H + CP*DT $ S = S + CP*DT/TJ
9 CONTINUE
10 TR = T-TX $ N = 2+ABSF(TR)/2 $ DT = TR/N
11 DO 13 J=1,N $ TJ = TX + (J-0.5)*DT $ CP = CPXF(TJ)
12 H = H + CP*DT $ S = S + CP*DT/TJ
13 CONTINUE
15 DEN = FINDENF(T,PB) $ CP = CPXF(T)
16 E = H - 100*PB/DEN $ PX = PVTf(T,DEN,1)
20 CV = CP - 100*T/DPDD*(DPDT/DEN)**2 $ RETURN $ END

```


APPENDIX I. (Continued)

06/06/74

```

      FUNCTION CSUMF(N,T,DA,DB)
C   DELTA CV = -T*INTEGRAL((D2P/DT2)/C**2)*DD.
      COMMON/3/DPDT,D2PDT2,DPSDT,DPMOT,DPDD,DTSDR,DTHDR
2   DX = (DB-DA)/N $ CSUMF = 0 $ DO 5 J=1,N
3   DN = DA + (J-0.5)*DX $ P = PVTF(T,DN,0)
5   CSUMF = CSUMF - D2PDT2*DX/DN/DN
9   CSUMF = 100*CSUMF $ RETURN $ END

```

06/06/74

```

      FUNCTION ESUMF(N,T,DA,DB)
C   GET DELTA E OVER DENSITY RANGE FROM DA TO DB.
C   DELTA E = INTEGRAL(P-T*(DP/DT))*DX/DN**2.
      COMMON/3/DPDT,D2PDT2,DPSDT,DPMOT,DPDD,DTSDR,DTHDR
2   DX = (DB-DA)/N $ ESUMF = 0.0
3   DO 5 J=1,N $ DN = DA + (J-0.5)*DX $ P = PVTF(T,DN,0)
5   ESUMF = ESUMF + (P-T*DPDT)*DX/DN/DN
9   ESUMF = 100*ESUMF $ RETURN $ END

```

06/06/74

```

      FUNCTION SSUMF(L,N,T,DA,DB)
C   DENSITY-DEPENDENT CHANGE OF S FROM DA TO DB.
C   DELTA S = INTEGRAL(GK-(DP/DT)/DN)*DX/DN.
      COMMON/3/DPDT,D2PDT2,DPSDT,DPMOT,DPDD,DTSDR,DTHDR
      DATA (GC = 0.0831434)
1   SSUMF = 0 $ DX = (DB-DA)/N $ IF(L.EQ.0) 4,2
2   DO 3 J=1,N $ DN = DA + (J-0.5)*DX $ P = PVTF(T,DN,0)
3   SSUMF = SSUMF + (GC-DPDT/DN)*DX/DN $ GO TO 9
4   DO 5 J=1,N $ DN = DA + (J-0.5)*DX $ P = PVTF(T,DN,0)
5   SSUMF = SSUMF - DPDT*DX/DN/DN
9   SSUMF = 100*SSUMF $ RETURN $ END

```

APPENDIX I. (Continued)

06/86/74

FUNCTION CPXF(T)

C ETHANE CP, J/MOL/K, OF ANDRE FURTADO AT P = 137.895 BAR.
 C DEFINE X = (T-TTRP)/(TMAX-TTRP), WHEN THE EQN. IS -
 C $\ln(CM-CP) = A1 + A2*X2/(1-X) + A3*X2 + A4*X3 + A5*X4$.
 C NOTE THIS FORMULA VALID ONLY UP TO 345 K.
 C NOTE FACTOR 1.874 FOR ETHANE VS. METHANE CONVERSION.
 DIMENSION A(5)
 DATA (TTRP=89.899), (TM=354.0), (CM=62.60)
 DATA (A = 3.2632884, -0.1544225, -0.1414889, -0.5064375, 0.2769915)
 1 X = (T-TTRP)/(TM-TTRP) \$ X2 = X*X
 2 Y = A(1) + A(2)*X2/(1-X) + A(3)*X2 + A(4)*X*X2 + A(5)*X2*X2
 3 CPXF = 1.874335*(CM - EXPF(Y)) \$ RETURN \$ END

10/15/74

FUNCTION CSATXF(T)

C FORMULATION OF ETHANE DATA OF AUTHORS -
 C WIEBE/HUBBARD/BREVOORT, AND WITT/KEMP, J/MOL/K.
 C VIA PROGRAM CSAT-2, 3/27/74.
 C FOR 59 POINTS, THE RMS IS 0.50 PCT.
 C $CS = A + B*X + C*X/(1-X)**E$, X = T/TCRT.
 C REVISED FOR TCRT = 305.37, 10/7/74.
 DATA (E=0.5), (TC=305.37)
 DATA (A=67.3153), (B=-16.5876), (C=16.3526)
 1 X = T/TC \$ U = 1-X \$ IF(U) 2,2,3
 2 CSATXF = 0 \$ RETURN
 3 CSATXF = A + B*X + C*X/U**E \$ RETURN \$ END

10/15/74

FUNCTION QVAPXF(T)

C VIA PROGRAM QVAP-2, 3/27/74, USING DATA OF -
 C DOUSLIN, RIEDEL, FURTADO. FOR 49 POINTS, RMS = 0.56 PCT.
 C DEFINE X = (TC-T)/(TC-TT), U = X**1/3, WHEN EQN. IS -
 C $QV = A1*U + A2*U2 + \dots + A6*U6$.
 C REVISED FOR TCRT = 305.37, 10/7/74.
 DIMENSION A(6)
 DATA (TT=89.899), (TC=305.37)
 DATA (A = 12.102730, 11.165588, 16.539265,
 1 -71.854695, 82.166239, -32.610514)
 1 U = CUBERTF((TC-T)/(TC-TT)) \$ Q = 0 \$ DO 2 K=1,6
 2 Q = Q + A(K)*U**K \$ QVAPXF = 1000*Q \$ RETURN \$ END

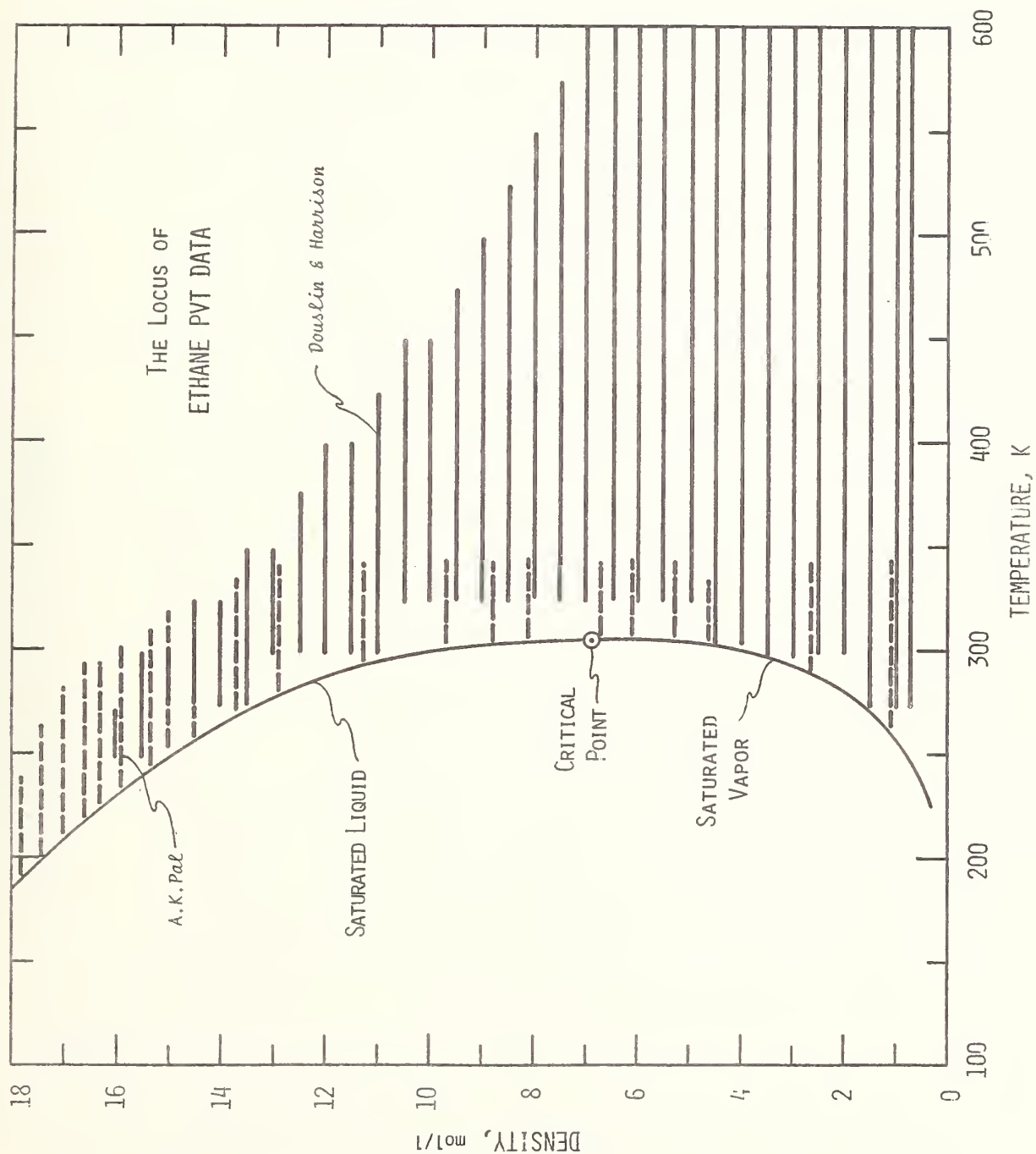


Figure 1. The locus of recent P-p-T data.

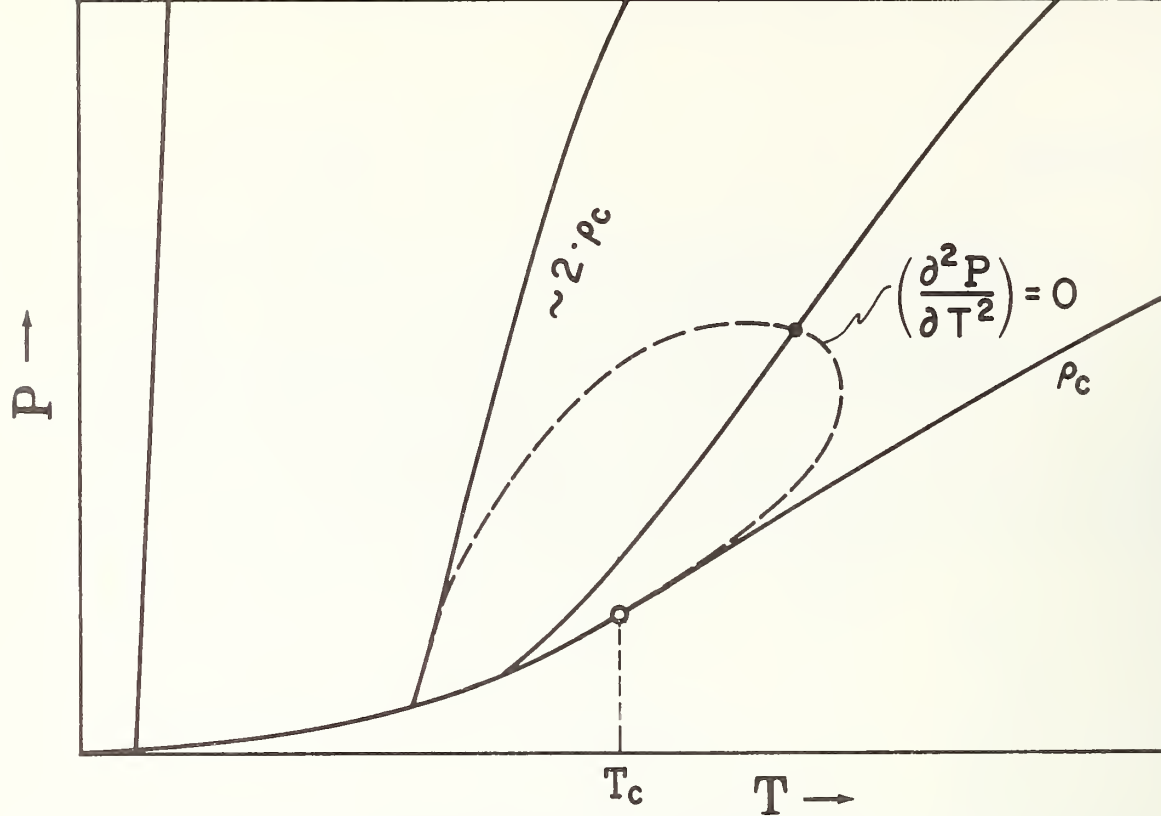


Figure 2. Generalized locus of isochore inflection points.

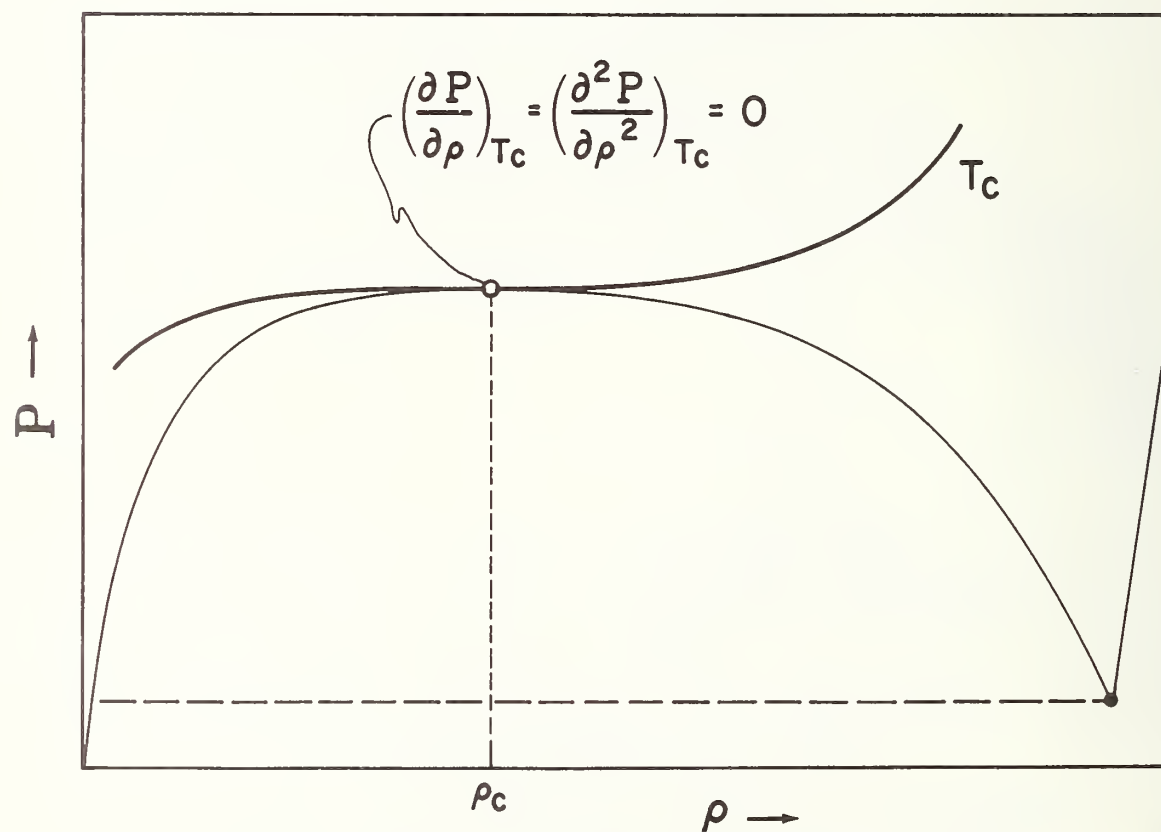


Figure 3. Generalized behavior of the critical isotherm.

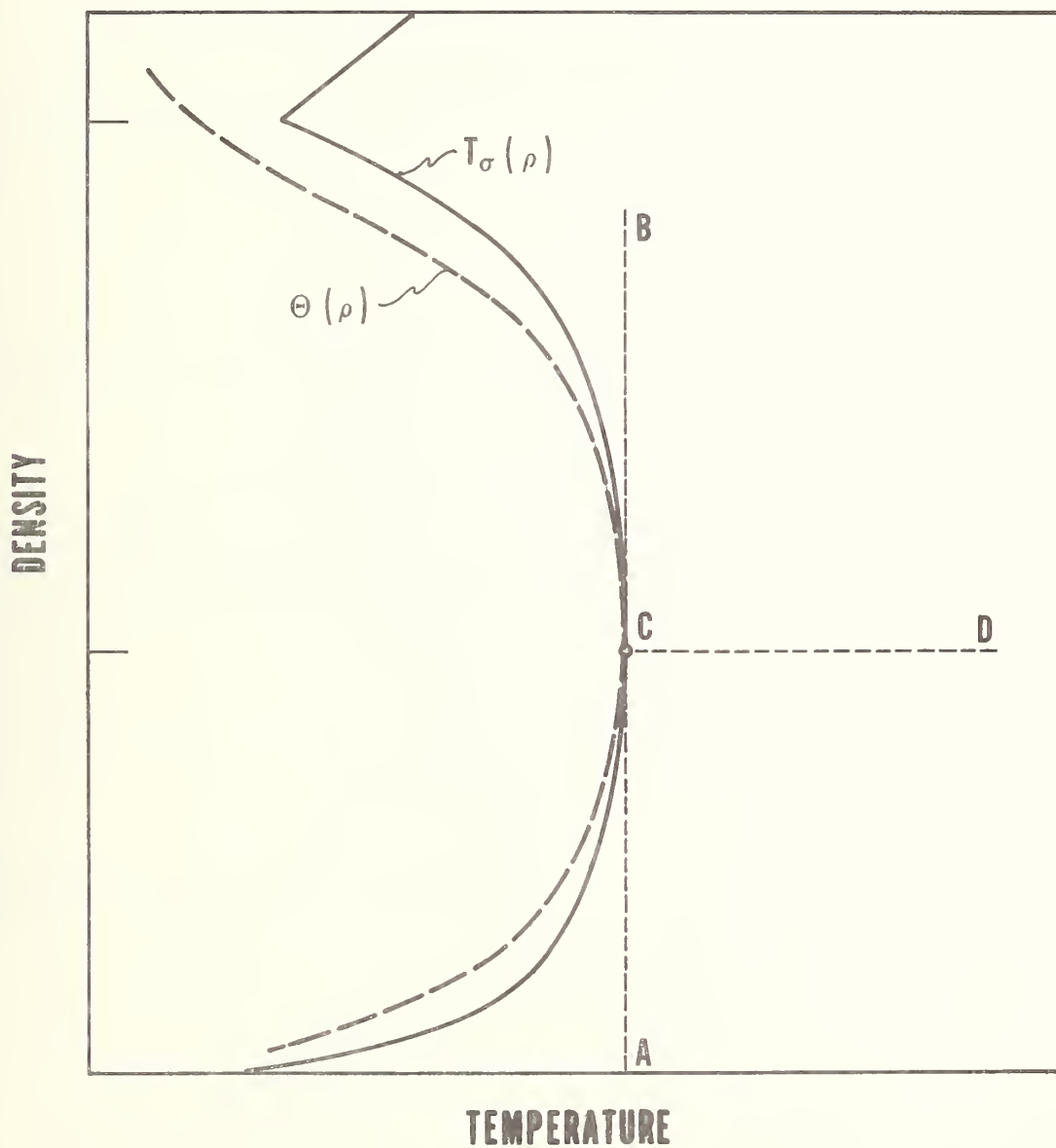


Figure 4. Generalized behavior of the locus $\theta(\rho)$.

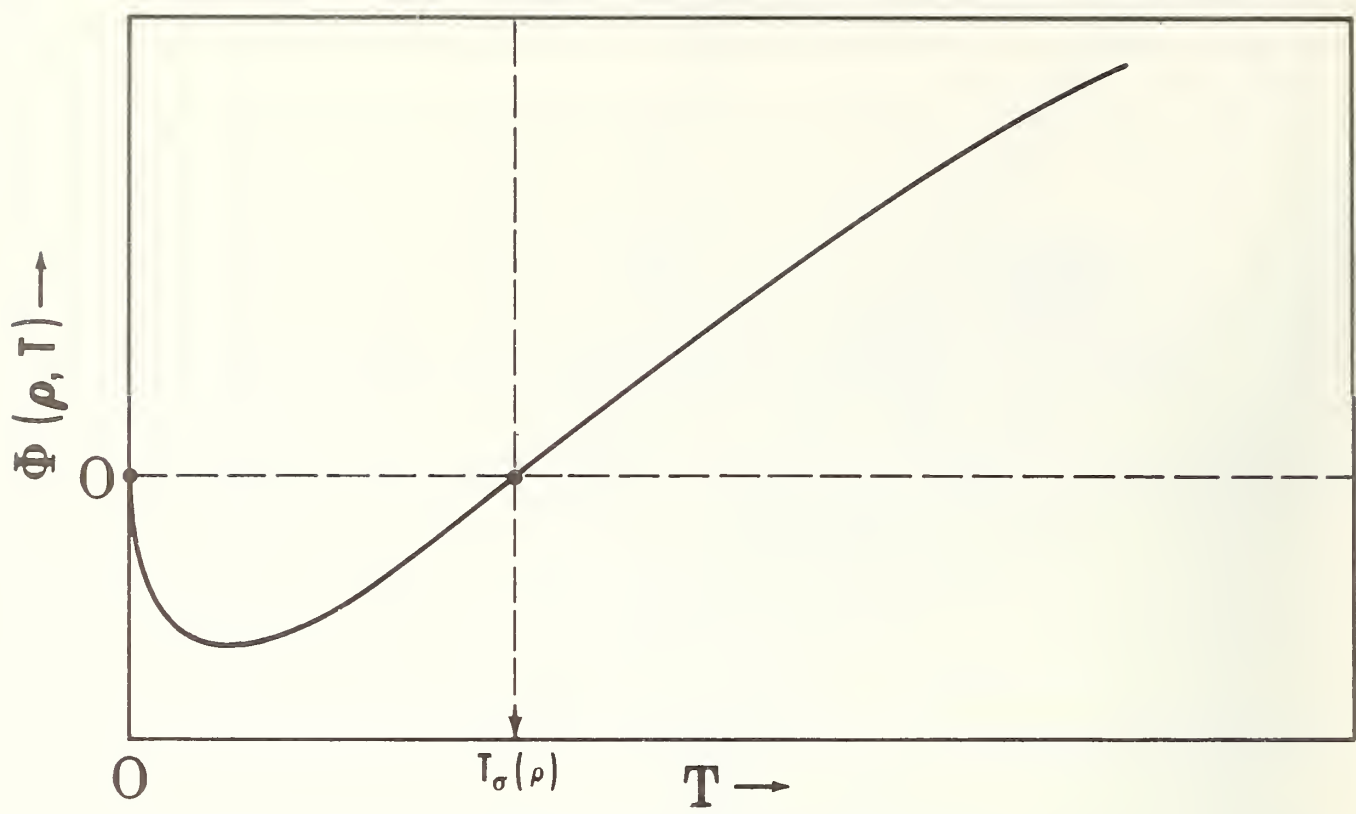


Figure 5. Generalized behavior of the function $\Phi(\rho, T)$.

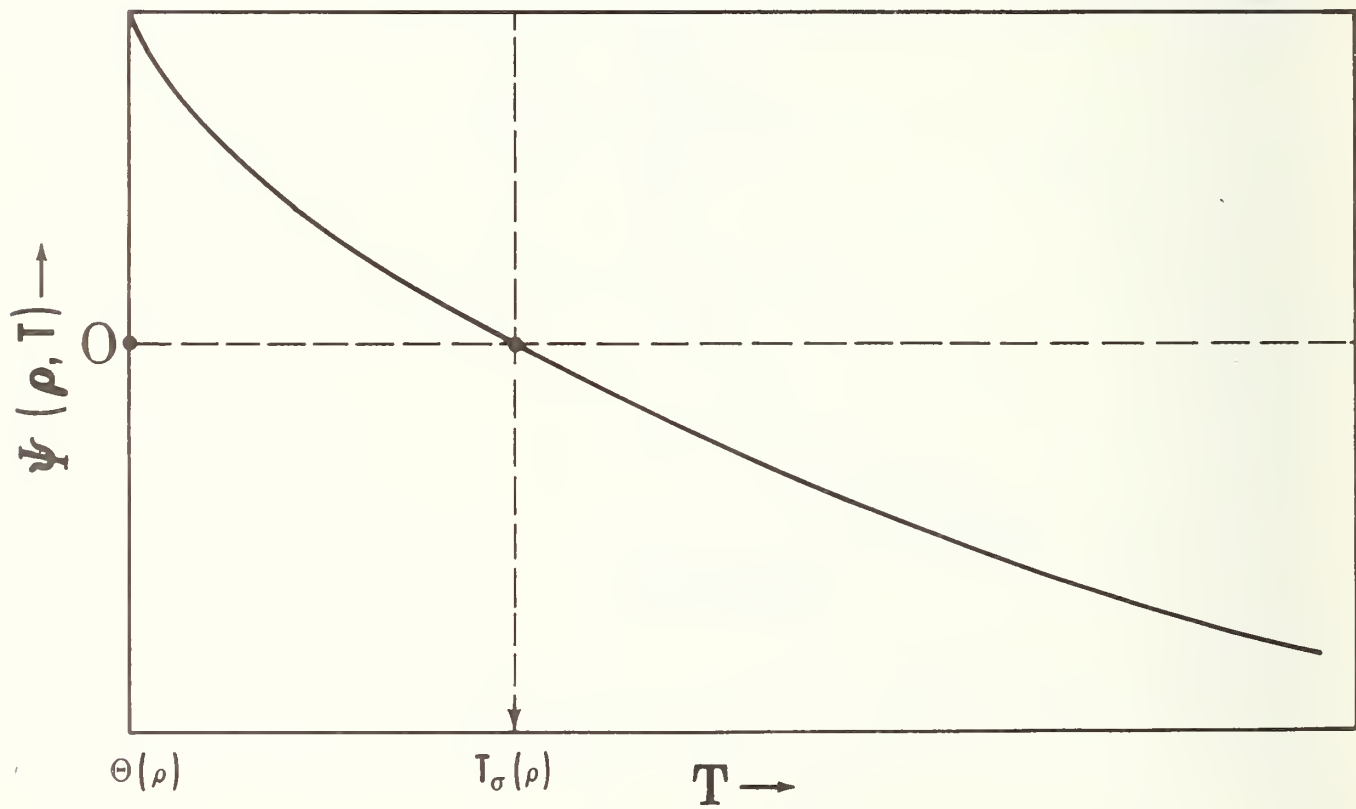


Figure 6. Generalized behavior of the function $\Psi(\rho, T)$.

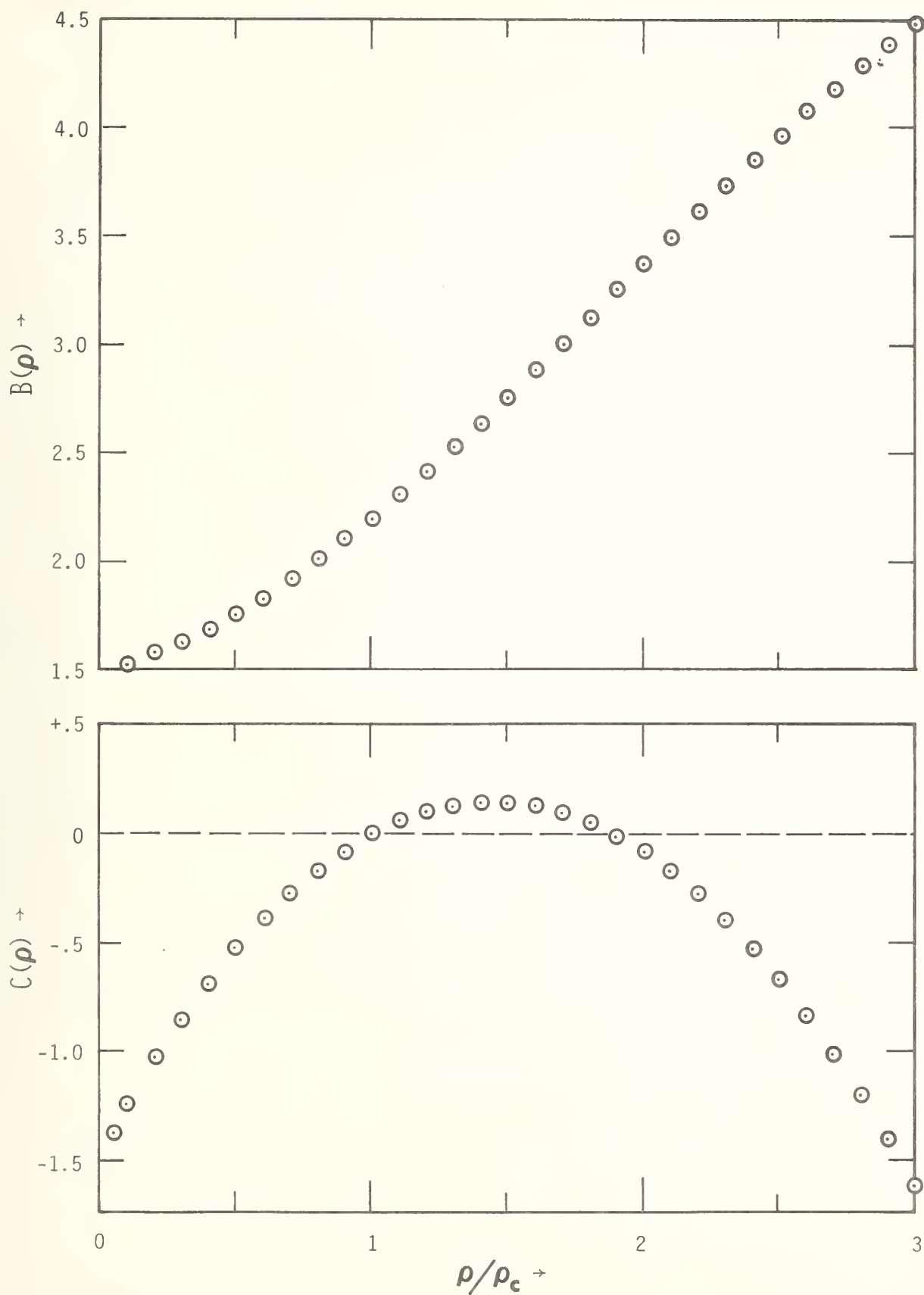


Figure 7. Behavior of coefficients $B(\rho)$, $C(\rho)$ for methane.

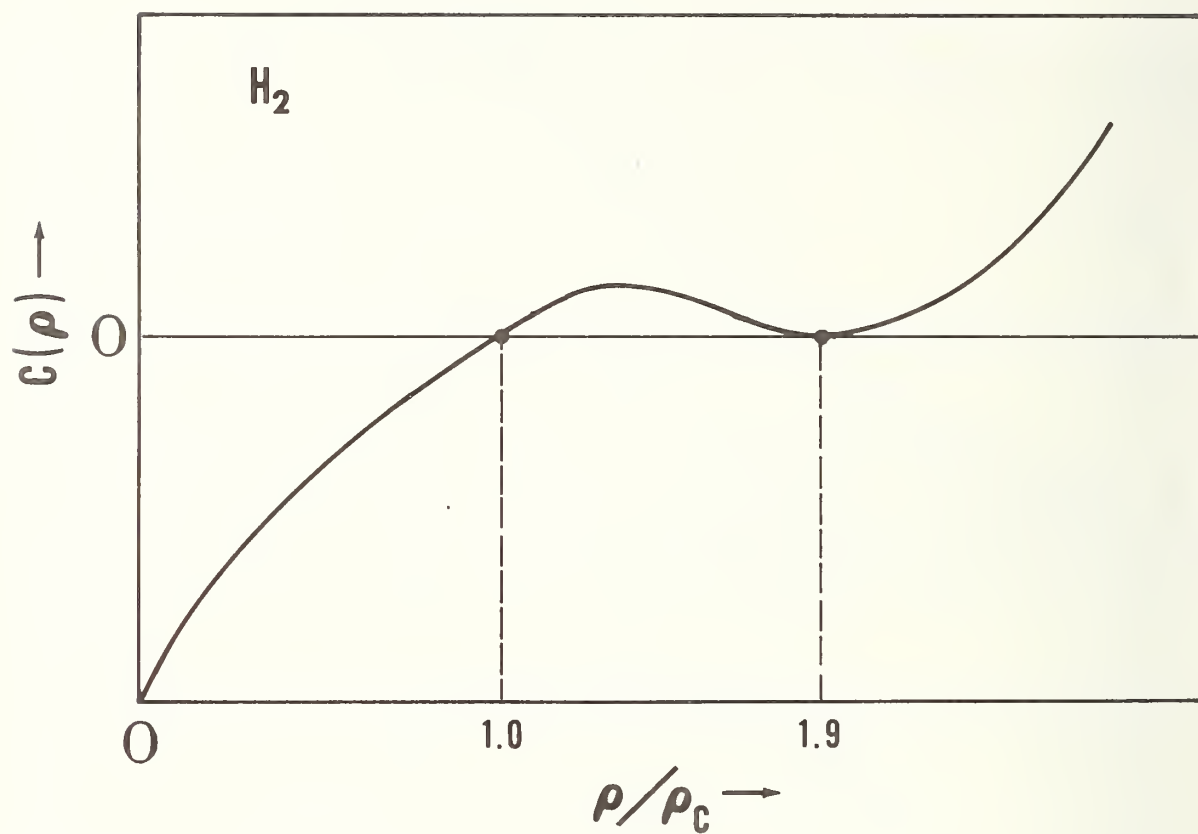


Figure 8. Presumed behavior of $C(\rho)$ for hydrogen.

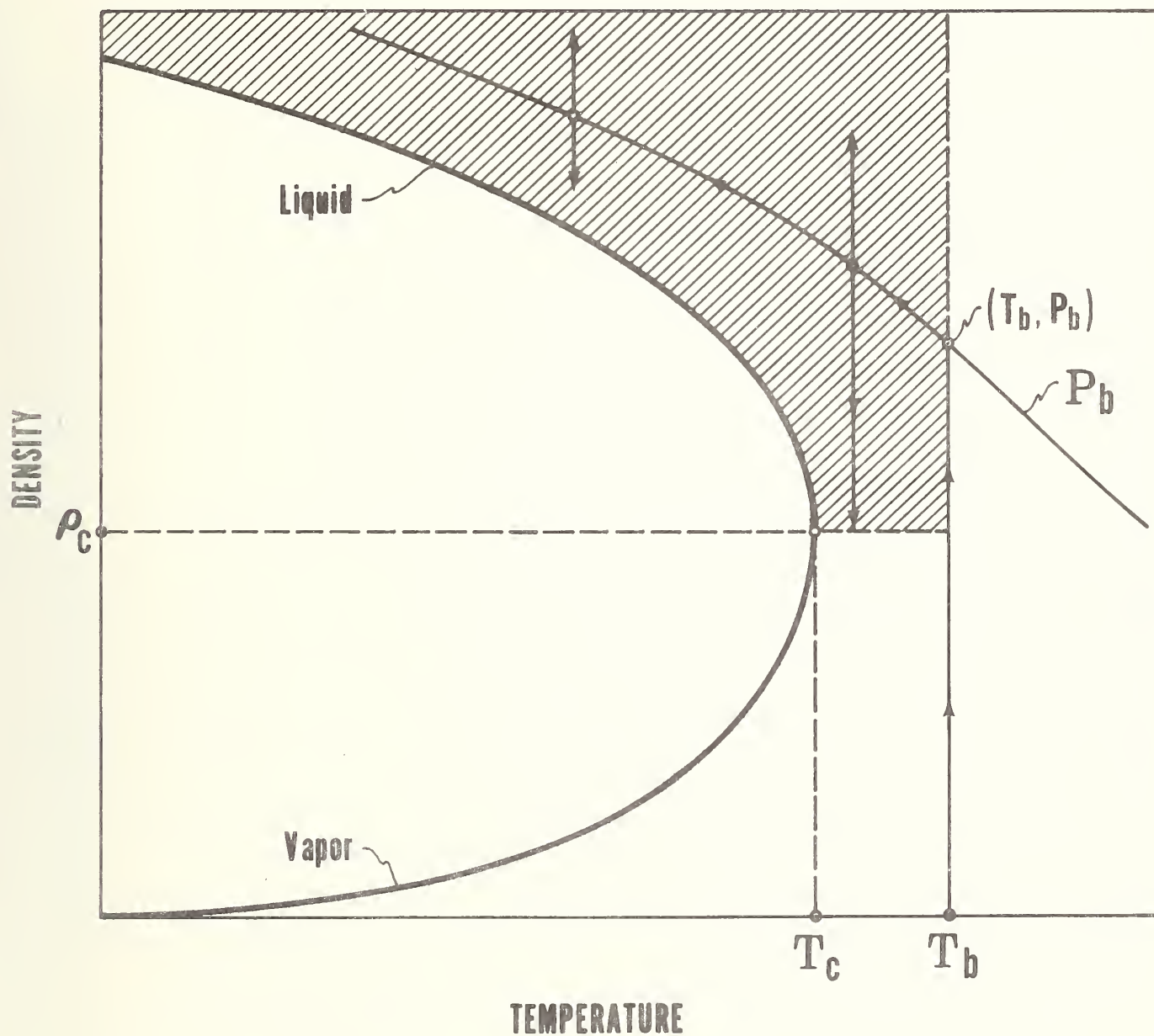


Figure 9. Generalized density-temperature phase diagram.

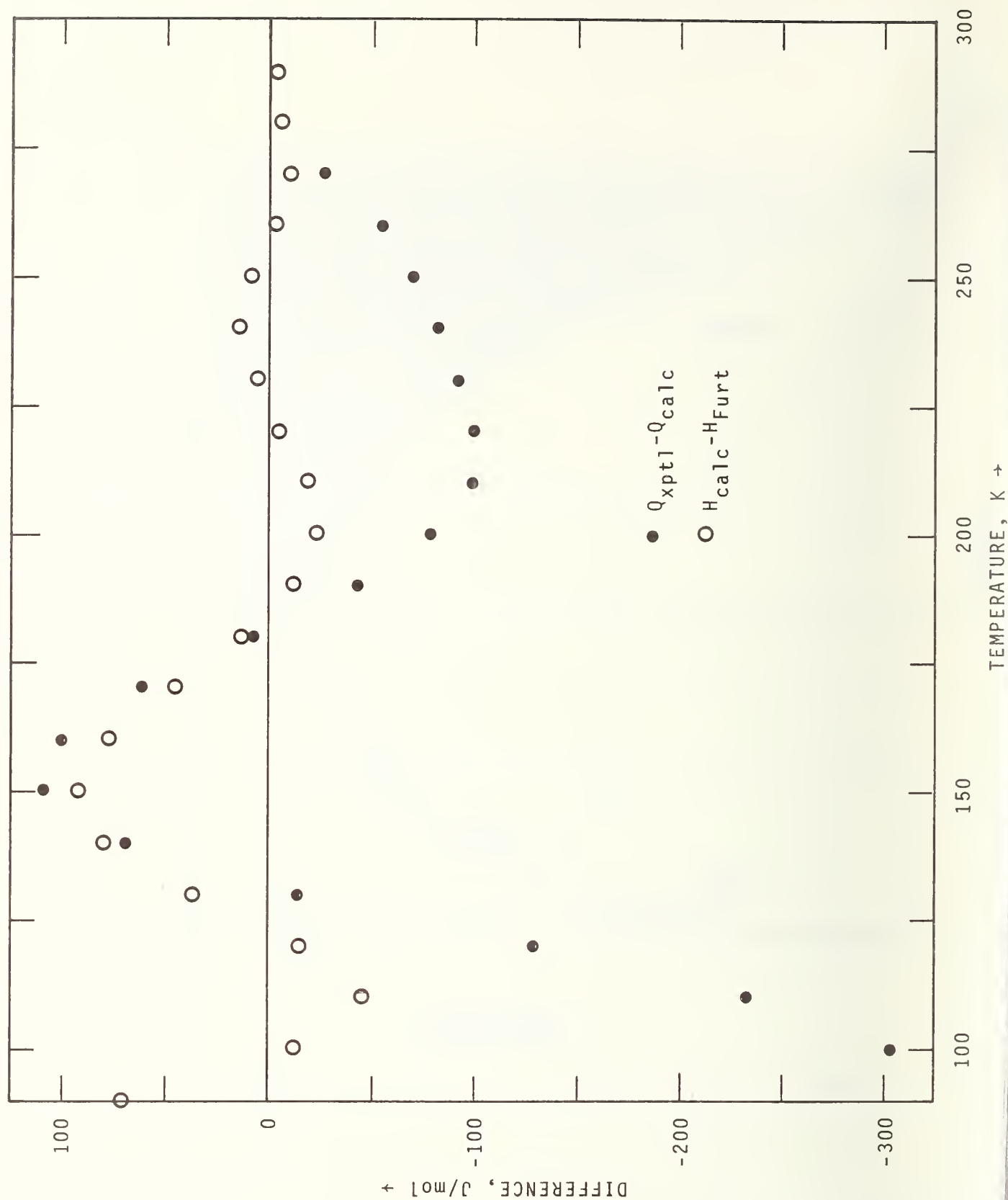


Figure 10. Comparisons for saturated liquid ethane. Q is heat of vaporization, and H is enthalpy. Calculated values are via the Clapeyron equation. See section 4.3 of the text.

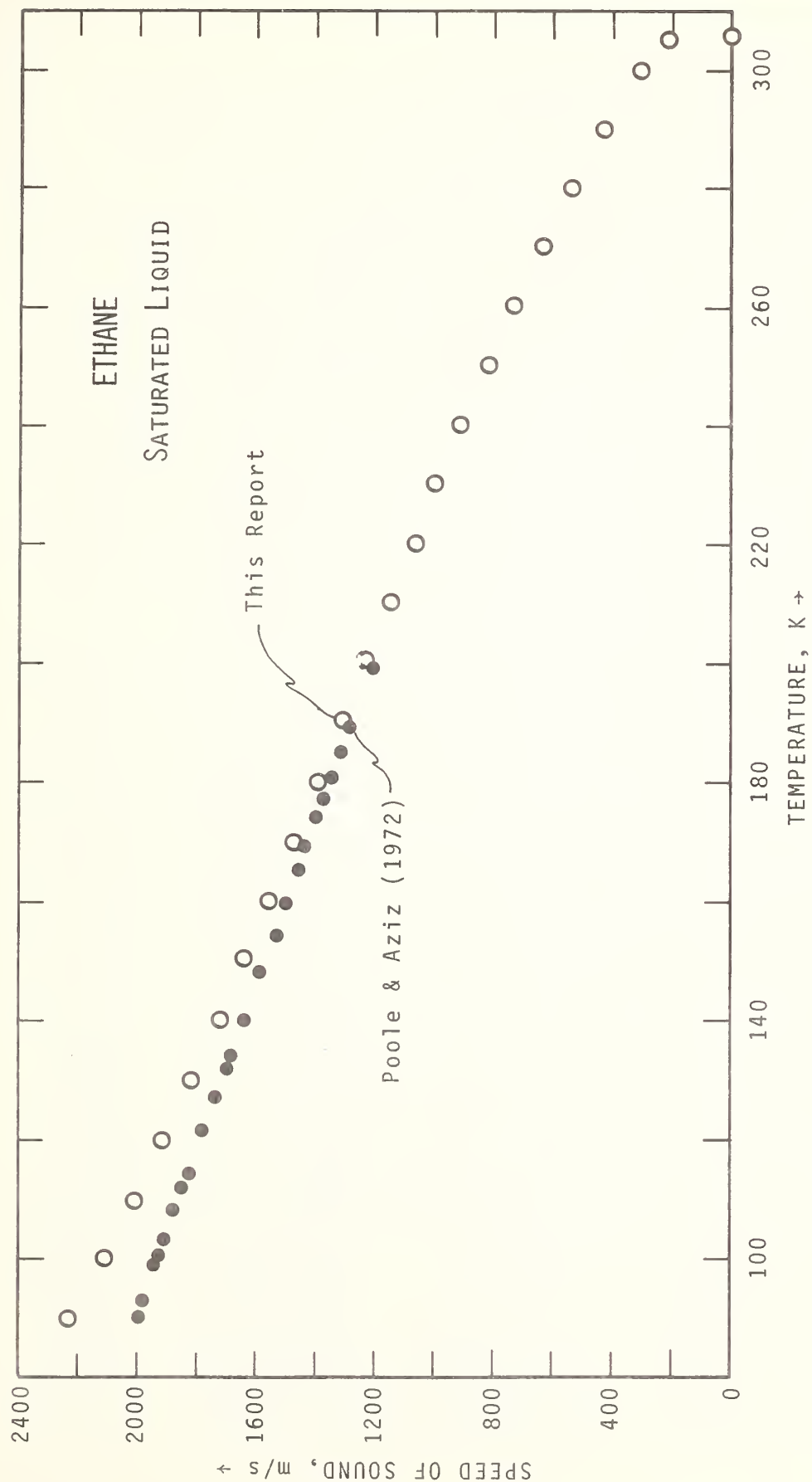


Figure 11. Speeds of sound for saturated liquid ethane

Table 1. Experimental and calculated vapor pressures.

ID: (4) Pal; (7) Ziegler; (9) Pope; (10) Douslin

VAPOR PRESSURES, TTRP = 89.899, TCRT = 305.370

10.79549166 8.35899001 -3.11490770 -0.64969799 6.07349549

ID	T,K	P,BAR	CALCD	PGNT
7	90.010	1.03991-005	1.04012-005	-0.020
7	100.010	1.11231-004	1.11214-004	0.015
7	109.998	7.46205-004	7.46084-004	0.016
7	119.989	3.53971-003	3.54004-003	-0.009
7	129.987	1.28963-002	1.29009-002	-0.035
7	139.992	3.82929-002	3.83041-002	-0.029
7	150.000	9.67387-002	9.67415-002	-0.003
7	160.010	2.14770-001	2.14725-001	0.021
7	170.019	4.29490-001	4.29303-001	0.044
7	180.027	7.88547-001	7.88122-001	0.054
7	184.550	1.01325+000	1.01269+000	0.055
9	198.216	1.99985+000	2.00235+000	-0.125
4	214.334	3.97283+000	3.96786+000	0.125
4	224.130	5.71141+000	5.71485+000	-0.060
4	229.782	6.94778+000	6.95075+000	-0.043
4	234.581	8.13995+000	8.14562+000	-0.070
9	234.715	8.18108+000	8.18100+000	0.001
10	238.150	9.12908+000	9.12702+000	0.023
9	238.792	9.30599+000	9.31232+000	-0.068
4	239.864	9.62177+000	9.62783+000	-0.063
4	240.534	9.82448+000	9.82894+000	-0.045
10	243.150	1.06455+001	1.06436+001	0.018
4	243.377	1.07162+001	1.07165+001	-0.003
4	246.830	1.18689+001	1.18715+001	-0.022
4	247.831	1.22099+001	1.22225+001	-0.103
10	248.150	1.23369+001	1.23360+001	0.007
4	249.755	1.29310+001	1.29184+001	0.097
4	250.160	1.30694+001	1.30685+001	0.007
4	251.600	1.36207+001	1.36124+001	0.061
4	252.556	1.39895+001	1.39824+001	0.051
10	253.150	1.42169+001	1.42160+001	0.007
4	254.301	1.46818+001	1.46766+001	0.036
4	257.552	1.60349+001	1.60361+001	-0.007
10	258.150	1.62966+001	1.62958+001	0.005
10	263.150	1.85895+001	1.85882+001	0.007
4	263.386	1.86989+001	1.87019+001	-0.016
4	267.539	2.07916+001	2.07864+001	0.025
10	268.150	2.11078+001	2.11067+001	0.005
4	271.750	2.30678+001	2.30680+001	-0.001
9	272.949	2.37622+001	2.37499+001	0.052
10	273.150	2.38670+001	2.38656+001	0.006
4	275.921	2.54917+001	2.55038+001	-0.047
4	276.362	2.57931+001	2.57719+001	0.082
4	276.384	2.57863+001	2.57854+001	0.004

Table 1. Experimental and calculated vapor pressures, (continued).

ID	T,K	P,BAR	CALCD	PCNT
4	276.513	2.58857+001	2.58642+001	0.083
4	277.811	2.66672+001	2.66676+001	-0.002
10	278.150	2.68824+001	2.68805+001	0.007
4	280.038	2.80710+001	2.80889+001	-0.064
4	282.243	2.95400+001	2.95509+001	-0.037
10	283.150	3.01708+001	3.01685+001	0.008
4	284.630	3.11740+001	3.11970+001	-0.074
9	284.840	3.13657+001	3.13450+001	0.066
4	287.648	3.33652+001	3.33761+001	-0.033
10	288.150	3.37524+001	3.37495+001	0.009
4	288.257	3.38323+001	3.38295+001	0.008
4	290.034	3.51469+001	3.51795+001	-0.093
9	290.208	3.53369+001	3.53139+001	0.065
4	292.229	3.69269+001	3.69041+001	0.062
4	293.091	3.75729+001	3.75992+001	-0.070
10	293.150	3.76506+001	3.76472+001	0.009
9	293.259	3.77610+001	3.77359+001	0.067
4	296.339	4.02866+001	4.03123+001	-0.064
10	298.150	4.18973+001	4.18927+001	0.011
4	299.657	4.32194+001	4.32470+001	-0.064
9	299.855	4.34545+001	4.34277+001	0.062
4	300.196	4.37369+001	4.37404+001	-0.008
4	301.242	4.46929+001	4.47120+001	-0.043
10	302.150	4.55769+001	4.55712+001	0.013
10	303.150	4.65413+001	4.65354+001	0.013
4	303.462	4.68154+001	4.68403+001	-0.053
4	303.468	4.68930+001	4.68462+001	0.100
9	304.002	4.73934+001	4.73730+001	0.043
4	304.039	4.73895+001	4.74097+001	-0.043
10	304.150	4.75255+001	4.75201+001	0.011
4	304.350	4.77171+001	4.77197+001	-0.005
4	304.435	4.78455+001	4.78048+001	0.085
4	304.508	4.78280+001	4.78781+001	-0.105
4	304.723	4.80594+001	4.80947+001	-0.073
4	304.785	4.81482+001	4.81574+001	-0.019
4	304.913	4.83164+001	4.82871+001	0.061
4	304.969	4.83453+001	4.83440+001	0.003
4	305.110	4.84837+001	4.84878+001	-0.008
4	305.142	4.85152+001	4.85205+001	-0.011
10	305.150	4.85339+001	4.85287+001	0.011
10	305.250	4.86354+001	4.86313+001	0.008

NP = 85, RMSPCT = 0.050

Table 3. Experimental and calculated saturated liquid densities

ID: (5) via isochores of Pal; (10) Douslin; (12) Chui;
(13) Klosek; (14) Miller; (16) Tomlinson

SATD. LIQUID DENSITIES, $E = 0.330$

TTRP = 89.899, TCRT = 305.370, DCRT = 6.740, DTRP = 21.680

0.721909438

0.296577899

-0.300365476

ID	T,K	MOL/L	CALCD	PRCNT
10	304.150	8.737	8.740	-0.03
10	303.150	9.201	9.200	0.01
10	302.150	9.544	9.544	0.00
10	298.150	10.499	10.487	0.12
10	293.150	11.297	11.292	0.05
10	283.150	12.458	12.454	0.04
10	273.150	13.342	13.344	-0.02
10	263.150	14.089	14.091	-0.02
5	255.963	14.554	14.570	-0.11
10	253.150	14.753	14.747	0.04
5	247.962	15.050	15.060	-0.07
5	240.700	15.455	15.475	-0.13
5	229.917	16.037	16.048	-0.07
5	222.618	16.423	16.413	0.06
5	214.942	16.754	16.781	-0.16
5	207.941	17.125	17.103	0.13
5	197.888	17.529	17.548	-0.11
5	188.451	17.941	17.950	-0.05
5	176.512	18.446	18.440	0.03
5	167.366	18.823	18.805	0.10
12	161.360	19.027	19.040	-0.06
5	156.875	19.226	19.213	0.07
13	133.150	20.126	20.107	0.10
13	127.594	20.323	20.312	0.05
13	122.039	20.521	20.516	0.02
13	116.483	20.717	20.719	-0.01
12	115.770	20.747	20.745	0.01
14	115.050	20.771	20.771	0.00
13	110.928	20.915	20.921	-0.03
14	108.110	21.025	21.023	0.01
12	108.150	21.027	21.022	0.02
14	100.020	21.313	21.315	-0.01
14	91.010	21.639	21.640	-0.00

NP = 33, RMSPCT = 0.068

Table 4. Vapor densities via vapor-pressure and virial equations

ETHANE SATD. VAPOR DENSITIES VIA V.P. AND VIRIAL EQNS.

ID	T,K	P,ATM	PLANK/KAMB	MOL/L	PCT
1	89.899	9.9670-006	1.3511-006	1.3511-006	0.00
1	90.000	1.0238-005	1.3863-006	1.3863-006	0.00
1	95.000	3.5808-005	4.5936-006	4.5936-006	0.00
1	100.000	1.0952-004	1.3347-005	1.3347-005	0.00
1	105.000	2.9851-004	3.4649-005	3.4648-005	0.00
1	110.000	7.3654-004	8.1615-005	8.1612-005	0.00
1	115.000	1.6670-003	1.7671-004	1.7670-004	0.01
1	120.000	3.4991-003	3.5558-004	3.5552-004	0.01
1	125.000	6.8762-003	6.7110-004	6.7093-004	0.02
1	130.000	1.2752-002	1.1974-003	1.1970-003	0.04
1	135.000	2.2468-002	2.0336-003	2.0323-003	0.06
1	140.000	3.7834-002	3.3064-003	3.3033-003	0.09
1	145.000	6.1192-002	5.1721-003	5.1653-003	0.13
1	150.000	9.5478-002	7.8184-003	7.8043-003	0.18
1	155.000	1.4426-001	1.1464-002	1.1436-002	0.24
1	160.000	2.1176-001	1.6358-002	1.6308-002	0.31
1	165.000	3.0288-001	2.2781-002	2.2694-002	0.38
1	170.000	4.2317-001	3.1042-002	3.0899-002	0.46
1	175.000	5.7882-001	4.1479-002	4.1252-002	0.55
1	180.000	7.7662-001	5.4457-002	5.4111-002	0.64
1	185.000	1.0239+000	7.0359-002	6.9860-002	0.73
1	190.000	1.3287+000	8.9635-002	8.8911-002	0.81
1	195.000	1.6991+000	1.1271-001	1.1171-001	0.89
1	200.000	2.1440+000	1.4006-001	1.3872-001	0.97
1	205.000	2.6726+000	1.7222-001	1.7047-001	1.03
1	210.000	3.2943+000	2.0973-001	2.0750-001	1.08
1	215.000	4.0188+000	2.5321-001	2.5043-001	1.11
1	220.000	4.8561+000	3.0331-001	2.9993-001	1.13
1	225.000	5.8165+000	3.6077-001	3.5674-001	1.13
1	230.000	6.9105+000	4.2642-001	4.2173-001	1.11
1	235.000	8.1487+000	5.0120-001	4.9585-001	1.08
1	240.000	9.5420+000	5.8618-001	5.8025-001	1.02
1	245.000	1.1102+001	6.8262-001	6.7626-001	0.94
1	250.000	1.2839+001	7.9203-001	7.8551-001	0.83
1	255.000	1.4766+001	9.1618-001	9.0997-001	0.68
1	260.000	1.6895+001	1.0572+000	1.0522+000	0.48
1	265.000	1.9238+001	1.2179+000	1.2154+000	0.21
1	270.000	2.1810+001	1.4016+000	1.4041+000	-0.18
1	275.000	2.4624+001	1.6125+000	1.6245+000	-0.74
1	280.000	2.7697+001	1.8563+000	1.8861+000	-1.58
1	285.000	3.1047+001	2.1404+000	2.2047+000	-2.91
1	290.000	3.4693+001	2.4754+000	2.6108+000	-5.19

Table 5. Experimental and calculated saturated vapor densities

ID: (1) from Table 4; (10) Douslin

SATURATED VAPOR DENSITIES, E = 0.390

TTRP = 89.899, TCRT = 305.370, DCRT = 6.740, DGAT = 1.35114-006

0.21587515 -0.08522342 -0.61523457 0.25452490 0.15177230

ID	T,K	MOL/L	CALCD	PCNT
1	90.000	1.3863-006	1.3863-006	0.00
1	100.000	1.3347-005	1.3356-005	-0.06
1	110.000	8.1612-005	8.1689-005	-0.09
1	120.000	3.5552-004	3.5564-004	-0.03
1	130.000	1.1970-003	1.1962-003	0.06
1	140.000	3.3033-003	3.2989-003	0.13
1	150.000	7.8043-003	7.7922-003	0.16
1	160.000	1.6308-002	1.6286-002	0.13
1	170.000	3.0899-002	3.0875-002	0.08
1	180.000	5.4111-002	5.4107-002	0.01
1	190.000	8.8911-002	8.8968-002	-0.06
1	200.000	1.3872-001	1.3888-001	-0.12
1	210.000	2.0750-001	2.0781-001	-0.15
1	220.000	2.9992-001	3.0040-001	-0.16
1	230.000	4.2172-001	4.2231-001	-0.14
1	240.000	5.8025-001	5.8083-001	-0.10
1	245.000	6.7626-001	6.7677-001	-0.07
10	248.150	7.4490-001	7.4384-001	0.14
1	250.000	7.8551-001	7.8586-001	-0.04
10	253.150	8.6310-001	8.6220-001	0.10
10	263.150	1.1530+000	1.1516+000	0.12
10	273.150	1.5370+000	1.5357+000	0.09
10	283.150	2.0670+000	2.0669+000	0.00
10	293.150	2.8800+000	2.8748+000	0.18
10	298.150	3.5020+000	3.5051+000	-0.09
10	302.150	4.3070+000	4.3068+000	0.01
10	303.150	4.6040+000	4.6122+000	-0.18
10	304.150	5.0350+000	5.0298+000	0.10

NP = 28, RMSPCT = 0.107

Table 6. Experimental and calculated liquid saturation temperatures

ID: (5) via isochores of Pal; (10) Douslin; (12) Chui;
(13) Klosek; (14) Miller

TTRP = 89.899, TCRT = 305.370, DTRP = 21.680, DCRT = 6.740									
23.724518399 -14.886051613 5.431774425 -1.071505659									
0.091351825									
ID	MOL/L	CALC	PCNT	T,K	CALC	PCNT	OTS/DD		
10	8.73700+000	8.74092+000	-0.04	304.150	304.157	-0.00	-1.821+000		
10	9.20100+000	9.19581+000	0.06	303.150	303.137	0.00	-2.593+000		
10	9.54400+000	9.54113+000	0.03	302.150	302.141	0.00	-3.222+000		
10	1.04990+001	1.04963+001	0.03	298.150	298.136	0.00	-5.224+000		
10	1.12970+001	1.13066+001	-0.08	293.150	293.218	-0.02	-7.131+000		
10	1.24580+001	1.24637+001	-0.05	283.150	283.207	-0.02	-1.015+001		
10	1.33420+001	1.33450+001	-0.02	273.150	273.188	-0.01	-1.253+001		
10	1.40890+001	1.40844+001	0.03	263.150	263.083	0.03	-1.452+001		
5	1.45540+001	1.45591+001	-0.04	255.963	256.043	-0.03	-1.575+001		
10	1.47530+001	1.47350+001	0.12	253.150	252.858	0.12	-1.626+001		
5	1.50500+001	1.50472+001	0.02	247.962	247.915	0.02	-1.702+001		
5	1.54550+001	1.54613+001	-0.04	240.700	240.814	-0.05	-1.804+001		
5	1.60370+001	1.60362+001	0.00	229.917	229.901	0.01	-1.945+001		
5	1.64230+001	1.64033+001	0.12	222.618	222.218	0.18	-2.036+001		
5	1.67540+001	1.67735+001	-0.12	214.942	215.354	-0.19	-2.111+001		
5	1.71250+001	1.70989+001	0.15	207.941	207.369	0.28	-2.193+001		
5	1.75290+001	1.75485+001	-0.11	197.888	198.332	-0.22	-2.280+001		
5	1.79410+001	1.79542+001	-0.07	188.451	188.763	-0.17	-2.365+001		
5	1.84460+001	1.84483+001	-0.01	176.512	176.569	-0.03	-2.463+001		
5	1.88230+001	1.88145+001	0.05	167.366	167.150	0.13	-2.533+001		
12	1.90273+001	1.90499+001	-0.12	161.360	161.940	-0.36	-2.568+001		
5	1.92260+001	1.92233+001	0.01	156.875	156.804	0.05	-2.601+001		
13	2.01262+001	2.01134+001	0.06	133.150	132.802	0.26	-2.723+001		
13	2.03228+001	2.03168+001	0.03	127.594	127.428	0.13	-2.742+001		
13	2.05207+001	2.05188+001	0.01	122.039	121.985	0.04	-2.758+001		
13	2.07171+001	2.07198+001	-0.01	116.483	116.558	-0.06	-2.769+001		
12	2.07466+001	2.07456+001	0.01	115.770	115.741	0.02	-2.770+001		
14	2.07715+001	2.07715+001	-0.00	115.050	115.051	-0.00	-2.771+001		
13	2.09146+001	2.09202+001	-0.03	110.928	111.083	-0.14	-2.775+001		
14	2.10247+001	2.10217+001	0.01	108.110	108.027	0.08	-2.776+001		
12	2.10266+001	2.10203+001	0.03	108.150	107.974	0.16	-2.776+001		
14	2.13129+001	2.13133+001	-0.00	100.020	100.030	-0.01	-2.771+001		
14	2.16394+001	2.16395+001	-0.00	91.010	91.014	-0.00	-2.749+001		

NP = 33, ONRMSPECT = 0.062, TSRMSPECT = 0.127

Table 7. Experimental and calculated vapor saturation temperatures.

TTRP = 89.899, TCRT = 305.370, DTRP = 21.680, DCRT = 6.740									
ID	MOL/L	CALC	PCNT	T, K	CALC	PCNT	OTS/DO		
1	1.38632-006	1.38631-006	0.00	90.000	90.000	0.00	2.836+006		
1	1.33473-005	1.33231-005	0.18	100.000	100.009	-0.01	3.725+005		
1	8.16117-005	8.12917-005	0.39	110.000	110.024	-0.02	7.547+004		
1	3.55524-004	3.54355-004	0.33	120.000	120.025	-0.02	2.111+004		
1	1.19696-003	1.19589-003	0.09	130.000	130.008	-0.01	7.535+003		
1	3.30328-003	3.30835-003	-0.15	140.000	139.984	0.01	3.243+003		
1	7.80430-003	7.82616-003	-0.28	150.000	149.965	0.02	1.613+003		
1	1.63081-002	1.63504-002	-0.26	160.000	159.962	0.02	8.966+002		
1	3.08987-002	3.09388-002	-0.13	170.000	169.978	0.01	5.435+002		
1	5.41110-002	5.40912-002	0.04	180.000	180.007	-0.00	3.523+002		
1	8.89114-002	8.87651-002	0.16	190.000	190.035	-0.02	2.404+002		
1	1.38721-001	1.38434-001	0.21	200.000	200.049	-0.02	1.708+002		
1	2.07500-001	2.07182-001	0.15	210.000	210.040	-0.02	1.251+002		
1	2.99925-001	2.99825-001	0.03	220.000	220.009	-0.00	9.395+001		
1	4.21725-001	4.22114-001	-0.09	230.000	229.972	0.01	7.182+001		
1	5.80249-001	5.81153-001	-0.16	240.000	239.950	0.02	5.554+001		
1	6.76262-001	6.77273-001	-0.15	245.000	244.951	0.02	4.891+001		
10	7.44900-001	7.44404-001	0.07	248.150	248.172	-0.01	4.507+001		
1	7.85506-001	7.86416-001	-0.12	250.000	249.961	0.02	4.305+001		
10	8.63100-001	8.62708-001	0.05	253.150	253.166	-0.01	3.964+001		
10	1.15300+000	1.15155+000	0.13	263.150	263.194	-0.02	3.026+001		
10	1.53700+000	1.53526+000	0.11	273.150	273.189	-0.01	2.239+001		
10	2.06700+000	2.06882+000	-0.09	283.150	283.122	0.01	1.565+001		
10	2.88000+000	2.87935+000	0.02	293.150	293.156	-0.00	9.602+000		
10	3.50200+000	3.50420+000	-0.06	298.150	298.136	0.00	6.553+000		
10	4.30700+000	4.30072+000	0.15	302.150	302.173	-0.01	3.652+000		
10	4.60400+000	4.60953+000	-0.12	303.150	303.134	0.01	2.846+000		
10	5.03500+000	5.03402+000	0.02	304.150	304.152	-0.00	1.923+000		

NP = 28, DNRMSPCT = 0.162, TSRMSPCT = 0.014

Table 8. Experimental and calculated second virial coefficients

ID: (3) Michels; (6) McGlashan; (10) Douslin

0.552671 -1.106244 -0.592947 -0.041944 0.000000

ID	T,K	T/TC	B*	CALC	DIFF	PCNT
6	150.000	0.4912	-5.183	-5.185	0.002	0.03
6	160.000	0.5240	-4.489	-4.487	-0.001	-0.03
6	170.000	0.5567	-3.935	-3.933	-0.002	-0.04
6	180.000	0.589+	-3.485	-3.483	-0.001	-0.04
6	190.000	0.6222	-3.112	-3.112	-0.001	-0.02
6	200.000	0.6549	-2.800	-2.800	0.000	0.01
6	210.000	0.6877	-2.535	-2.536	0.001	0.04
6	220.000	0.720+	-2.307	-2.309	0.002	0.07
6	230.000	0.7532	-2.110	-2.111	0.002	0.09
6	240.000	0.7859	-1.937	-1.939	0.002	0.10
6	250.000	0.8187	-1.785	-1.786	0.002	0.10
6	260.000	0.8514	-1.650	-1.651	0.001	0.08
6	270.000	0.8842	-1.529	-1.530	0.001	0.05
6	280.000	0.9169	-1.421	-1.421	0.000	0.00
6	290.000	0.9497	-1.323	-1.323	-0.001	-0.06
6	300.000	0.982+	-1.235	-1.233	-0.002	-0.14
3	273.150	0.8945	-1.493	-1.494	0.002	0.12
10	273.150	0.8945	-1.498	-1.494	-0.003	-0.21
3	298.150	0.9763	-1.251	-1.249	-0.002	-0.14
10	298.150	0.976+	-1.252	-1.249	-0.003	-0.26
10	303.150	0.9927	-1.209	-1.207	-0.002	-0.21
3	322.748	1.0569	-1.058	-1.058	-0.000	-0.01
10	323.150	1.0582	-1.056	-1.055	-0.001	-0.14
3	347.652	1.1385	-0.898	-0.900	0.002	0.18
10	348.150	1.1401	-0.896	-0.897	0.001	0.07
3	372.522	1.2199	-0.769	-0.770	0.001	0.13
10	373.150	1.2220	-0.766	-0.767	0.001	0.14
3	397.844	1.3023	-0.659	-0.659	-0.000	-0.02
10	398.150	1.3033	-0.656	-0.657	0.001	0.23
3	422.700	1.3842	-0.566	-0.566	0.000	0.02
10	423.150	1.3857	-0.563	-0.564	0.001	0.12
10	448.150	1.4676	-0.483	-0.484	0.001	0.13
10	473.150	1.549+	-0.415	-0.414	-0.000	-0.09
10	498.150	1.6313	-0.353	-0.353	-0.000	-0.07
10	523.150	1.7132	-0.300	-0.299	-0.001	-0.37
10	548.150	1.7950	-0.251	-0.251	-0.001	-0.30
10	573.150	1.8769	-0.208	-0.208	-0.001	-0.36
10	598.150	1.9583	-0.168	-0.169	0.000	0.10
10	623.150	2.0406	-0.132	-0.134	0.001	1.06

NP = 39, MEANPCT = 0.139

Table 8. Experimental and calculated second virial coefficients (Continued)

ID: (1) Eucken; (2) Lambert; (4) Hoover; (5) Pope; (8) Gunn; (9) Hamann via Dymond/Smith.

ID	T,K	T/TC	B*	CALC	DIFF	PCNT
1	200.000	0.6549	-3.053	-2.800	-0.253	-9.03
2	200.000	0.6549	-3.060	-2.800	-0.260	-9.27
5	209.534	0.6862	-2.485	-2.547	0.063	2.46
1	210.000	0.6877	-2.763	-2.536	-0.227	-8.97
2	210.000	0.6877	-2.763	-2.536	-0.227	-8.97
4	215.000	0.7041	-2.296	-2.418	0.123	5.07
1	220.000	0.7204	-2.494	-2.309	-0.185	-8.02
2	220.000	0.7204	-2.528	-2.309	-0.219	-9.48
1	230.000	0.7532	-2.244	-2.111	-0.133	-6.30
2	230.000	0.7532	-2.298	-2.111	-0.187	-8.85
5	236.769	0.7819	-1.935	-1.959	0.024	1.24
1	240.000	0.7859	-2.056	-1.939	-0.117	-6.03
2	240.000	0.7859	-2.076	-1.939	-0.137	-7.07
4	240.000	0.7859	-1.864	-1.939	0.075	3.88
1	250.000	0.8187	-1.887	-1.786	-0.101	-5.64
2	250.000	0.8187	-1.907	-1.786	-0.121	-6.77
5	254.807	0.8344	-1.700	-1.719	0.019	1.11
1	260.000	0.8514	-1.725	-1.651	-0.074	-4.51
2	260.000	0.8514	-1.752	-1.651	-0.101	-6.14
1	270.000	0.8842	-1.584	-1.530	-0.054	-3.53
2	270.000	0.8842	-1.618	-1.530	-0.088	-5.73
4	273.150	0.8945	-1.506	-1.494	-0.011	-0.76
5	273.150	0.8945	-1.479	-1.494	0.016	1.06
8	273.200	0.8947	-1.498	-1.494	-0.004	-0.25
1	280.000	0.9169	-1.442	-1.421	-0.021	-1.50
2	280.000	0.9169	-1.483	-1.421	-0.062	-4.35
2	290.000	0.9497	-1.382	-1.323	-0.059	-4.47
8	298.200	0.9765	-1.260	-1.249	-0.011	-0.89
2	300.000	0.9824	-1.281	-1.233	-0.047	-3.85
5	306.062	1.0023	-1.181	-1.183	0.002	0.13
9	310.940	1.0182	-1.111	-1.144	0.033	2.87
3	323.200	1.0584	-1.062	-1.054	-0.007	-0.68
9	344.270	1.1274	-0.913	-0.920	0.006	0.68
9	377.600	1.2365	-0.741	-0.746	0.004	0.60
3	377.600	1.2365	-0.737	-0.746	0.009	1.14
8	410.000	1.3456	-0.604	-0.608	0.004	0.67
9	410.940	1.3457	-0.609	-0.608	-0.001	-0.24
9	444.270	1.4549	-0.500	-0.496	-0.004	-0.91
8	444.300	1.4550	-0.499	-0.496	-0.003	-0.65
9	477.600	1.5640	-0.404	-0.403	-0.001	-0.27
3	477.600	1.5640	-0.415	-0.403	-0.013	-3.11
8	510.900	1.6731	-0.344	-0.325	-0.019	-5.92
9	510.940	1.6732	-0.319	-0.324	0.005	1.53

Table 9. Experimental and calculated third virial coefficients

ID: (7) Chueh; (10) Douslin; (4) Hoover; (5) Pope

217.800 0.244226 0.832529 0.534875 0.000000

ID	T,K	T/TCRT	C*	CALCD	DIFF
7	210.000	0.6877	-0.241	-0.237	-0.004
7	220.000	0.7214	0.053	0.053	0.000
7	230.000	0.7532	0.239	0.238	0.002
7	240.000	0.7859	0.353	0.352	0.001
7	250.000	0.8137	0.419	0.421	-0.002
7	260.000	0.8514	0.454	0.460	-0.005
10	273.150	0.8945	0.471	0.480	-0.010
10	298.150	0.9754	0.482	0.471	0.011
10	303.150	0.9927	0.472	0.465	0.007
10	323.150	1.0532	0.438	0.436	0.003
10	348.150	1.1411	0.393	0.395	-0.001
10	373.150	1.2220	0.351	0.355	-0.004
10	398.150	1.3036	0.316	0.319	-0.003
10	423.150	1.3857	0.284	0.288	-0.004
10	448.150	1.4676	0.258	0.261	-0.003
10	473.150	1.5494	0.240	0.238	0.002
10	498.150	1.6313	0.220	0.218	0.002
10	523.150	1.7132	0.204	0.201	0.003
10	548.150	1.7950	0.188	0.186	0.002
10	573.150	1.8759	0.175	0.173	0.002
10	598.150	1.9536	0.161	0.162	-0.001
10	623.150	2.0406	0.149	0.151	-0.003
NP = 22, MEANDIFF = 0.003					

ID	T,K	T/TCRT	C*	CALCD	DIFF
5	209.534	0.6862	-2.667	-0.254	-2.412
4	219.000	0.7041	-3.230	-0.076	-3.154
5	238.769	0.7819	0.168	0.341	-0.173
4	240.000	0.7859	-0.117	0.352	-0.469
5	254.307	0.8344	0.386	0.443	-0.056
5	273.150	0.8945	0.471	0.480	-0.010
4	273.150	0.8945	0.482	0.480	0.002
4	273.150	0.8945	0.517	0.480	0.036
4	298.138	0.9753	0.488	0.471	0.017
5	306.062	1.0023	0.456	0.461	-0.006
4	322.748	1.0559	0.439	0.436	0.003
4	347.652	1.1335	0.390	0.395	-0.006
4	372.522	1.2139	0.350	0.356	-0.006
4	397.844	1.3028	0.318	0.320	-0.002
4	422.700	1.3842	0.290	0.289	0.001

Table 11. Coefficients of the equation of state

DTRP = 21.6800, TTRP = 89.899, PTRP = 0.000010099

DCRT = 6.7400, TCRT = 305.370, PCRT = 48.755014373

AL = 2.00, BE = 1.00, EP = 0.50

1.848167996 1.569704511 5.560186452
 -1.042842462 0.224978299

MOL/L	TSAT	THETA	PSAT	B	C
0.5	235.219	203.322	8.315	1.887	-1.754
1.0	258.239	230.548	16.335	1.932	-1.540
1.5	272.349	249.833	23.407	1.983	-1.340
2.0	282.050	264.599	29.421	2.040	-1.152
2.5	289.067	276.149	34.440	2.102	-0.978
3.0	294.268	285.179	38.565	2.170	-0.817
3.5	298.122	292.103	41.868	2.243	-0.668
4.0	300.905	297.215	44.397	2.321	-0.532
4.5	302.825	300.790	46.220	2.404	-0.408
5.0	304.083	303.124	47.454	2.491	-0.296
5.5	304.868	304.520	48.242	2.583	-0.197
6.0	305.290	305.215	48.672	2.678	-0.109
6.5	305.370	305.367	48.755	2.777	-0.032
7.0	305.370	305.367	48.755	2.880	0.032
7.5	305.339	305.258	48.723	2.985	0.086
8.0	305.101	304.735	48.478	3.094	0.128
8.5	304.546	303.552	47.916	3.204	0.159
9.0	303.623	301.528	46.998	3.317	0.180
9.5	302.281	298.493	45.696	3.432	0.190
10.0	300.467	294.288	43.990	3.548	0.189
10.5	298.130	288.775	41.875	3.665	0.178
11.0	295.227	281.851	39.366	3.783	0.157
11.5	291.719	273.446	36.497	3.902	0.126
12.0	287.576	263.540	33.323	4.021	0.086
12.5	282.779	252.156	29.915	4.140	0.035
13.0	277.314	239.372	26.358	4.260	-0.024
13.5	271.175	225.313	22.746	4.379	-0.093
14.0	264.365	210.151	19.179	4.498	-0.171
14.5	256.890	194.102	15.752	4.616	-0.258
15.0	248.763	177.416	12.556	4.734	-0.354
15.5	240.000	160.367	9.668	4.851	-0.458
16.0	230.619	143.243	7.149	4.967	-0.571
16.5	220.643	126.336	5.038	5.082	-0.692
17.0	210.093	109.923	3.351	5.196	-0.821
17.5	198.992	94.264	2.075	5.309	-0.958
18.0	187.364	79.584	1.176	5.420	-1.102
18.5	175.236	66.069	0.595	5.530	-1.254
19.0	162.640	53.856	0.260	5.639	-1.414
19.5	149.619	43.037	0.094	5.747	-1.580
20.0	136.230	33.650	0.026	5.853	-1.754
20.5	122.556	25.688	0.005	5.957	-1.935
21.0	108.713	19.098	0.001	6.060	-2.122
21.5	94.854	13.788	0.000	6.162	-2.316
22.0	81.182	9.635	0.000	6.262	-2.516
22.5	67.940	6.494	0.000	6.361	-2.722
23.0	55.403	4.205	0.000	6.458	-2.934

Table 12. Experimental and calculated P- ρ -T data

The following pages compare experimental P- ρ -T (compressibility) data with densities and pressures computed by the equation of state (5).

The first column identifies sources of the data (as in Table 10):

<u>ID</u>	<u>Authors</u>
2	Virial equation (4).
8	Reamer et al [57].
9	Michels et al [47].
10	Douslin and Harrison [14].
100 ⁺	A. K. Pal, via Pope [54].

The equation of state was adjusted only to data of ID = 2, 9, 10, and 1300⁺. Remaining data validate our extrapolation to higher pressures. Density deviations should be ignored near the critical point, and pressure deviations should be ignored for compressed liquid at low temperatures for reasons given in the text.

Table 12. Experimental and calculated P- ρ -T data

EQUATION OF STATE VS. PVT DATA

ID	T, K	MOL/L	CALCD	C, PCT	P, BAR	CALCD	P, PCT
2	230.000	0.4000	0.4003	-0.07	6.693	6.689	0.06
2	240.000	0.4000	0.4003	-0.07	7.070	7.066	0.06
2	250.000	0.4000	0.4002	-0.06	7.442	7.438	0.05
2	260.000	0.4000	0.4002	-0.06	7.811	7.807	0.05
2	270.000	0.4000	0.4002	-0.06	8.177	8.173	0.05
2	280.000	0.4000	0.4002	-0.05	8.541	8.537	0.05
2	290.000	0.4000	0.4002	-0.05	8.902	8.898	0.05
2	300.000	0.4000	0.4002	-0.05	9.262	9.258	0.04
2	310.000	0.4000	0.4002	-0.04	9.621	9.617	0.04
2	320.000	0.4000	0.4002	-0.04	9.978	9.974	0.04
2	330.000	0.4000	0.4002	-0.04	10.334	10.330	0.04
2	340.000	0.4000	0.4002	-0.04	10.689	10.686	0.04
2	350.000	0.4000	0.4001	-0.04	11.044	11.040	0.03
2	360.000	0.4000	0.4001	-0.03	11.397	11.393	0.03
2	370.000	0.4000	0.4001	-0.03	11.750	11.746	0.03
2	380.000	0.4000	0.4001	-0.03	12.102	12.099	0.03
2	390.000	0.4000	0.4001	-0.03	12.454	12.451	0.03
2	400.000	0.4000	0.4001	-0.03	12.805	12.802	0.03
2	410.000	0.4000	0.4001	-0.02	13.156	13.153	0.02
2	420.000	0.4000	0.4001	-0.02	13.506	13.503	0.02
2	430.000	0.4000	0.4001	-0.02	13.856	13.853	0.02
2	440.000	0.4000	0.4001	-0.02	14.205	14.203	0.02
2	450.000	0.4000	0.4001	-0.02	14.555	14.552	0.02
2	460.000	0.4000	0.4001	-0.02	14.904	14.901	0.02
2	470.000	0.4000	0.4001	-0.02	15.252	15.250	0.02
2	480.000	0.4000	0.4001	-0.02	15.601	15.598	0.02
2	490.000	0.4000	0.4001	-0.01	15.949	15.947	0.01
2	500.000	0.4000	0.4001	-0.01	16.297	16.295	0.01
2	510.000	0.4000	0.4001	-0.01	16.645	16.643	0.01
2	520.000	0.4000	0.4001	-0.01	16.993	16.990	0.01
2	530.000	0.4000	0.4001	-0.01	17.340	17.338	0.01
2	540.000	0.4000	0.4001	-0.01	17.687	17.685	0.01
2	550.000	0.4000	0.4001	-0.01	18.035	18.032	0.01
2	560.000	0.4000	0.4001	-0.01	18.382	18.379	0.01
2	570.000	0.4000	0.4001	-0.01	18.729	18.726	0.01
2	580.000	0.4000	0.4001	-0.01	19.076	19.073	0.01
2	590.000	0.4000	0.4001	-0.02	19.423	19.420	0.02
2	600.000	0.4000	0.4001	-0.02	19.769	19.766	0.02

NP = 38, DNRMS PCT = 0.035, PMEAN PCT = 0.028

Table 12. Experimental and calculated P- ρ -T data- - - (Continued)
EQUATION OF STATE VS. PVT DATA

ID	T,K	MOL/L	CALCD	C,PCT	P,BAR	CALCD	P,PCT
8	310.928	3.5245	3.5650	-1.15	48.263	48.071	0.40
8	310.928	4.5021	4.5925	-2.01	51.711	51.498	0.41
8	310.928	5.5178	5.6358	-2.14	53.434	53.287	0.28
8	310.928	7.2697	7.2407	0.40	55.158	55.192	-0.06
8	310.928	8.3632	8.1814	2.17	56.537	56.923	-0.68
8	310.928	8.8480	8.7333	1.30	57.916	58.294	-0.65
8	310.928	9.1894	9.1054	0.91	59.295	59.673	-0.64
8	310.928	9.4447	9.3856	0.63	60.674	61.010	-0.55
8	310.928	9.6593	9.6110	0.50	62.053	62.385	-0.54
8	310.928	9.8423	9.8000	0.43	63.432	63.771	-0.54
8	310.928	9.9921	9.9633	0.29	64.811	65.074	-0.41
8	310.928	10.1321	10.1072	0.25	66.190	66.444	-0.38
8	310.928	10.2579	10.2362	0.21	67.569	67.815	-0.36
8	344.261	4.9251	4.9626	-0.76	75.842	75.550	0.39
8	344.261	5.8407	5.8663	-0.44	82.737	82.542	0.24
8	344.261	6.7517	6.7335	0.27	89.632	89.785	-0.17
8	344.261	7.5579	7.5011	0.75	96.527	97.080	-0.57
8	344.261	8.2287	8.1557	0.89	103.421	104.275	-0.83
8	344.261	8.7434	8.6989	0.51	110.316	110.943	-0.57
8	344.261	9.1754	9.1501	0.28	117.211	117.636	-0.36
8	344.261	9.5504	9.5302	0.21	124.106	124.503	-0.32
8	344.261	9.8679	9.8559	0.12	131.000	131.275	-0.21
8	310.928	0.5889	0.5911	-0.36	13.790	13.745	0.32
8	344.261	0.5165	0.5173	-0.16	13.790	13.769	0.15
8	377.594	0.4620	0.4623	-0.07	13.790	13.780	0.07
8	410.928	0.4189	0.4190	-0.04	13.790	13.785	0.04
8	444.261	0.3838	0.3839	-0.03	13.790	13.785	0.03
8	477.594	0.3544	0.3546	-0.04	13.790	13.784	0.04
8	510.928	0.3295	0.3297	-0.07	13.790	13.780	0.07
8	310.928	1.3468	1.3519	-0.38	27.579	27.500	0.29
8	344.261	1.1212	1.1222	-0.09	27.579	27.558	0.08
8	377.594	0.9762	0.9762	-0.00	27.579	27.578	0.00
8	410.928	0.8711	0.8708	0.03	27.579	27.587	-0.03
8	444.261	0.7892	0.7893	-0.02	27.579	27.574	0.02
8	477.594	0.7233	0.7238	-0.06	27.579	27.563	0.06
8	510.928	0.6684	0.6694	-0.15	27.579	27.540	0.14
8	310.928	2.4961	2.5158	-0.79	41.369	41.196	0.42
8	344.261	1.8567	1.8601	-0.18	41.369	41.312	0.14
8	377.594	1.5546	1.5549	-0.02	41.369	41.363	0.01
8	410.928	1.3605	1.3589	0.12	41.369	41.411	-0.10
8	444.261	1.2172	1.2168	0.03	41.369	41.382	-0.03
8	477.594	1.1066	1.1068	-0.01	41.369	41.364	0.01
8	510.928	1.0165	1.0180	-0.14	41.369	41.312	0.14
8	310.928	7.2697	7.2407	0.40	55.158	55.192	-0.06
8	344.261	2.8018	2.8142	-0.44	55.158	55.002	0.28
8	377.594	2.2130	2.2174	-0.28	55.158	55.074	0.15
8	410.928	1.8902	1.8895	0.04	55.158	55.175	-0.03
8	444.261	1.6685	1.6684	0.00	55.158	55.159	-0.00
8	477.594	1.5040	1.5043	-0.03	55.158	55.145	0.02
8	510.928	1.3733	1.3755	-0.16	55.158	55.073	0.15
8	310.928	10.3736	10.3532	0.20	68.948	69.201	-0.37
8	344.261	4.0959	4.1261	-0.74	68.948	68.679	0.39

Table 12. Experimental and calculate P- ρ -T data- - - (Continued)
EQUATION OF STATE VS. PVT DATA

ID	T,K	MOL/L	CALCD	D,FCT	P,BAR	CALCD	P,PCT
8	377.594	2.9702	2.9796	-0.32	68.948	68.789	0.23
8	410.928	2.4628	2.4656	-0.12	68.948	68.882	0.09
8	444.261	2.1426	2.1447	-0.10	68.948	68.887	0.09
8	477.594	1.9142	1.9163	-0.11	68.948	68.876	0.10
8	510.928	1.7377	1.7417	-0.23	68.948	68.798	0.22
8	310.928	11.2820	11.3103	-0.25	86.184	85.486	0.81
8	344.261	6.3137	6.3109	0.05	86.184	86.207	-0.03
8	377.594	4.0652	4.0858	-0.51	86.184	85.885	0.35
8	410.928	3.2373	3.2474	-0.31	86.184	85.970	0.25
8	444.261	2.7645	2.7714	-0.25	86.184	86.001	0.21
8	477.594	2.4431	2.4490	-0.24	86.184	85.996	0.22
8	510.928	2.2028	2.2099	-0.32	86.184	85.925	0.30
8	310.928	11.8116	11.8807	-0.59	103.421	100.977	2.36
8	344.261	8.2287	8.1557	0.89	103.421	104.275	-0.83
8	377.594	5.2776	5.3106	-0.63	103.421	102.959	0.45
8	410.928	4.0686	4.0863	-0.43	103.421	103.067	0.34
8	444.261	3.4145	3.4256	-0.33	103.421	103.133	0.28
8	477.594	2.9861	2.9963	-0.34	103.421	103.105	0.31
8	510.928	2.6754	2.6862	-0.41	103.421	103.031	0.38
8	310.928	12.2182	12.2988	-0.66	120.658	116.984	3.05
8	344.261	9.3676	9.3479	0.21	120.658	121.018	-0.30
8	377.594	6.4713	6.4858	-0.22	120.658	120.431	0.19
8	410.928	4.9220	4.9488	-0.54	120.658	120.119	0.45
8	444.261	4.0781	4.0962	-0.44	120.658	120.194	0.38
8	477.594	3.5369	3.5520	-0.43	120.658	120.193	0.39
8	510.928	3.1538	3.1664	-0.40	120.658	120.207	0.37
8	310.928	12.5479	12.6333	-0.68	137.895	133.171	3.43
8	344.261	10.1360	10.1396	-0.04	137.895	137.802	0.07
8	377.594	7.5147	7.4975	0.23	137.895	138.216	-0.23
8	410.928	5.7575	5.7831	-0.44	137.895	137.349	0.40
8	444.261	4.7394	4.7654	-0.55	137.895	137.217	0.49
8	477.594	4.0884	4.1085	-0.49	137.895	137.268	0.45
8	510.928	3.6322	3.6462	-0.39	137.895	137.389	0.37
8	310.928	12.8333	12.9143	-0.63	155.132	149.886	3.38
8	344.261	10.6669	10.7182	-0.48	155.132	153.407	1.11
8	377.594	8.3540	8.3367	0.21	155.132	155.527	-0.25
8	410.928	6.5294	6.5505	-0.32	155.132	154.632	0.32
8	444.261	5.3796	5.4124	-0.61	155.132	154.236	0.58
8	477.594	4.6299	4.6564	-0.57	155.132	154.288	0.54
8	510.928	4.1041	4.1210	-0.41	155.132	154.516	0.40
8	310.928	13.0738	13.1579	-0.64	172.369	166.162	3.60
8	344.261	11.0985	11.1720	-0.66	172.369	169.320	1.77
8	377.594	9.0258	9.0201	0.06	172.369	172.531	-0.09
8	410.928	7.2289	7.2381	-0.13	172.369	172.124	0.14
8	444.261	5.9919	6.0219	-0.50	172.369	171.493	0.51
8	477.594	5.1560	5.1860	-0.58	172.369	171.370	0.58
8	510.928	4.5658	4.5853	-0.43	172.369	171.633	0.43
8	310.928	13.2869	13.3736	-0.65	189.606	182.447	3.78
8	344.261	11.4646	11.5453	-0.70	189.606	185.617	2.10
8	377.594	9.5652	9.5810	-0.17	189.606	189.074	0.28
8	410.928	7.8461	7.8502	-0.05	189.606	189.482	0.07
8	444.261	6.5583	6.5860	-0.42	189.606	188.723	0.47
8	477.594	5.6568	5.6902	-0.59	189.606	188.432	0.62

Table 12. Experimental and calculated P- ρ -T data- - (Continued)
EQUATION OF STATE VS. PVT DATA

ID	T, K	MOL/L	CALCD	D, PCT	P, BAR	CALCD	P, PCT
8	510.928	5.0133	5.0344	-0.42	189.606	188.781	0.43
8	310.928	13.4768	13.5679	-0.68	206.843	198.548	4.01
8	344.261	11.7810	11.8628	-0.70	206.843	202.151	2.27
8	377.594	10.0144	10.0500	-0.35	206.843	205.433	0.68
8	410.928	8.3875	8.3906	-0.04	206.843	206.735	0.05
8	444.261	7.0812	7.1044	-0.33	206.843	206.039	0.39
8	477.594	6.1325	6.1653	-0.53	206.843	205.617	0.59
8	510.928	5.4446	5.4646	-0.37	206.843	206.024	0.40
8	310.928	13.8169	13.9077	-0.66	241.316	231.536	4.05
8	344.261	12.3150	12.3850	-0.57	241.316	236.205	2.12
8	377.594	10.7385	10.7972	-0.55	241.316	238.239	1.28
8	410.928	9.2546	9.2879	-0.36	241.316	239.874	0.60
8	444.261	8.0043	8.0164	-0.15	241.316	240.816	0.21
8	477.594	6.9989	7.0249	-0.37	241.316	240.204	0.46
8	510.928	6.2432	6.2616	-0.29	241.316	240.475	0.35
8	310.928	14.1021	14.1998	-0.69	275.790	263.723	4.38
8	344.261	12.7400	12.8070	-0.53	275.790	269.878	2.14
8	377.594	11.3044	11.3770	-0.64	275.790	271.038	1.72
8	410.928	9.9483	9.9983	-0.50	275.790	273.107	0.97
8	444.261	8.7521	8.7793	-0.31	275.790	274.453	0.49
8	477.594	7.7541	7.7753	-0.27	275.790	274.748	0.38
8	510.928	6.9554	6.9734	-0.26	275.790	274.871	0.33
8	310.928	14.3527	14.4571	-0.73	310.264	295.792	4.66
8	344.261	13.0835	13.1626	-0.60	310.264	302.128	2.62
8	377.594	11.7680	11.8495	-0.69	310.264	303.853	2.07
8	410.928	10.5117	10.5772	-0.62	310.264	306.030	1.36
8	444.261	9.3799	9.4201	-0.43	310.264	307.927	0.75
8	477.594	8.4052	8.4289	-0.28	310.264	308.925	0.43
8	510.928	7.5930	7.6094	-0.22	310.264	309.327	0.30
8	310.928	14.5677	14.6877	-0.82	344.738	326.363	5.33
8	344.261	13.3764	13.4709	-0.71	344.738	333.679	3.21
8	377.594	12.1604	12.2483	-0.72	344.738	336.676	2.34
8	410.928	10.9866	11.0620	-0.69	344.738	338.997	1.67
8	444.261	9.9098	9.9651	-0.56	344.738	340.987	1.09
8	477.594	8.9742	8.9992	-0.28	344.738	343.124	0.47
8	510.928	8.1552	8.1777	-0.28	344.738	343.297	0.42
8	310.928	14.9359	15.0894	-1.03	413.685	385.936	6.71
8	344.261	13.8663	13.9892	-0.89	413.685	395.994	4.28
8	377.594	12.8094	12.8982	-0.69	413.685	403.217	2.53
8	410.928	11.7577	11.8412	-0.71	413.685	405.383	2.01
8	444.261	10.7824	10.8474	-0.60	413.685	407.951	1.39
8	477.594	9.9049	9.9429	-0.38	413.685	410.568	0.75
8	510.928	9.1371	9.1425	-0.06	413.685	413.258	0.10
8	310.928	15.2790	15.4333	-1.01	482.633	450.484	6.66
8	344.261	14.2981	14.4173	-0.83	482.633	462.241	4.23
8	377.594	13.3124	13.4189	-0.80	482.633	467.419	3.15
8	410.928	12.3491	12.4538	-0.85	482.633	469.784	2.66
8	444.261	11.4576	11.5401	-0.72	482.633	473.608	1.87
8	477.594	10.6337	10.6943	-0.57	482.633	476.512	1.27
8	510.928	9.8992	9.9277	-0.29	482.633	479.885	0.57
8	310.928	15.5877	15.7353	-0.95	551.581	516.844	6.30
8	344.261	14.6722	14.7839	-0.76	551.581	529.535	4.00
8	377.594	13.7271	13.8549	-0.93	551.581	530.226	3.87

Table 12. Experimental and calculated P- ρ -T data- - - (Continued)

EQUATION OF STATE VS. PVT DATA

ID	T, K	MOL/L	CALCD	C, PCT	P, BAR	CALCD	P, PCT
8	410.928	12.8373	12.9589	-0.95	551.581	533.862	3.21
8	444.261	12.0126	12.1079	-0.79	551.581	539.119	2.26
8	477.594	11.2338	11.3126	-0.70	551.581	542.088	1.72
8	510.928	10.5290	10.5812	-0.50	551.581	545.625	1.08
8	310.928	15.8659	16.0055	-0.88	620.528	584.801	5.89
8	344.261	14.9988	15.1058	-0.71	620.528	596.696	3.84
8	377.594	14.1021	14.2311	-0.91	620.528	595.836	3.98
8	410.928	13.2590	13.3892	-0.98	620.528	598.584	3.54
8	444.261	12.4801	12.5883	-0.87	620.528	604.063	2.65
8	477.594	11.7416	11.8356	-0.80	620.528	607.339	2.13
8	510.928	11.0763	11.1369	-0.55	620.528	612.496	1.29
8	310.928	16.1346	16.2505	-0.72	689.476	656.075	4.84
8	344.261	15.2747	15.3933	-0.78	689.476	660.150	4.25
8	377.594	14.4380	14.5628	-0.86	689.476	662.597	3.90
8	410.928	13.6362	13.7647	-0.94	689.476	664.891	3.57
8	444.261	12.8838	13.0047	-0.94	689.476	668.504	3.04
8	477.594	12.1848	12.2880	-0.85	689.476	672.912	2.40
8	510.928	11.5520	11.6184	-0.58	689.476	679.400	1.46

NP = 176, DNRMS PCT = 0.605, PMEAN PCT = 1.222

Table 12. Experimental and calculated P- ρ -T data- - - (Continued)

EQUATION OF STATE VS. PVT DATA

ID	T,K	MOL/L	CALCD	D,PCT	P,BAR	CALCD	P,PCT
9	273.150	0.8538	0.8552	-0.16	15.874	15.854	0.13
9	298.142	0.8538	0.8545	-0.08	17.978	17.967	0.06
9	323.140	0.8538	0.8540	-0.02	20.036	20.032	0.02
9	348.143	0.8538	0.8538	0.00	22.065	22.065	-0.00
9	373.150	0.8538	0.8535	0.04	24.066	24.075	-0.04
9	398.160	0.8538	0.8533	0.06	26.053	26.067	-0.06
9	423.170	0.8538	0.8533	0.06	28.031	28.046	-0.06
9	273.150	1.0672	1.0686	-0.13	18.802	18.784	0.10
9	298.142	1.0672	1.0675	-0.03	21.539	21.534	0.02
9	323.140	1.0672	1.0669	0.03	24.201	24.206	-0.02
9	348.143	1.0672	1.0665	0.06	26.812	26.826	-0.05
9	373.150	1.0672	1.0662	0.10	29.385	29.410	-0.08
9	398.160	1.0672	1.0660	0.12	31.933	31.967	-0.11
9	423.170	1.0672	1.0661	0.11	34.468	34.502	-0.10
9	273.150	1.2812	1.2828	-0.13	21.349	21.331	0.08
9	298.142	1.2812	1.2815	-0.03	24.769	24.764	0.02
9	323.140	1.2812	1.2805	0.05	28.067	28.079	-0.04
9	348.143	1.2812	1.2800	0.09	31.294	31.318	-0.08
9	373.150	1.2812	1.2794	0.13	34.465	34.504	-0.12
9	398.160	1.2812	1.2791	0.16	37.599	37.652	-0.14
9	423.170	1.2812	1.2792	0.15	40.713	40.770	-0.14
9	273.150	1.4870	1.4888	-0.12	23.441	23.424	0.07
9	298.142	1.4870	1.4876	-0.04	27.563	27.555	0.03
9	323.140	1.4870	1.4862	0.05	31.508	31.520	-0.04
9	348.143	1.4870	1.4856	0.09	35.354	35.381	-0.08
9	373.150	1.4870	1.4848	0.14	39.125	39.173	-0.12
9	398.160	1.4870	1.4844	0.17	42.848	42.912	-0.15
9	423.170	1.4870	1.4845	0.17	46.543	46.612	-0.15
9	298.142	1.6354	1.6366	-0.07	29.397	29.384	0.05
9	323.140	1.6354	1.6351	0.02	33.830	33.836	-0.02
9	348.143	1.6354	1.6343	0.07	38.142	38.163	-0.06
9	373.150	1.6354	1.6333	0.13	42.360	42.405	-0.11
9	398.160	1.6354	1.6328	0.16	46.520	46.585	-0.14
9	423.170	1.6354	1.6328	0.16	50.647	50.719	-0.14
9	298.142	1.7032	1.7050	-0.11	30.189	30.169	0.07
9	323.140	1.7032	1.7031	0.01	34.846	34.848	-0.01
9	348.143	1.7032	1.7021	0.07	39.371	39.392	-0.05
9	373.150	1.7032	1.7010	0.13	43.798	43.844	-0.10
9	398.160	1.7032	1.7004	0.17	48.161	48.229	-0.14
9	423.170	1.7032	1.7005	0.16	52.490	52.564	-0.14
9	298.142	1.9165	1.9202	-0.19	32.483	32.446	0.11
9	323.140	1.9165	1.9174	-0.05	37.873	37.861	0.03
9	348.143	1.9165	1.9159	0.03	43.093	43.104	-0.02
9	373.150	1.9165	1.9145	0.10	48.192	48.232	-0.08
9	398.160	1.9165	1.9137	0.14	53.214	53.278	-0.12
9	423.170	1.9165	1.9138	0.14	58.192	58.262	-0.12
9	298.142	1.9754	1.9793	-0.20	33.063	33.025	0.11
9	323.140	1.9754	1.9767	-0.06	38.665	38.648	0.04
9	348.143	1.9754	1.9751	0.01	44.084	44.088	-0.01
9	373.150	1.9754	1.9739	0.08	49.378	49.407	-0.06
9	398.160	1.9754	1.9728	0.13	54.581	54.640	-0.11
9	423.170	1.9754	1.9728	0.13	59.738	59.807	-0.12

Table 12. Experimental and calculated P- ρ -T data- - - (Continued)

EQUATION OF STATE VS. PVT DATA

ID	T,K	MOL/L	CALCD	D,FCT	P,BAR	CALCD	F,PCT
9	298.142	2.1218	2.1279	-0.29	34.428	34.374	0.16
9	323.140	2.1218	2.1243	-0.12	40.556	40.524	0.08
9	348.143	2.1218	2.1222	-0.02	46.470	46.463	0.02
9	373.150	2.1218	2.1204	0.06	52.238	52.264	-0.05
9	398.160	2.1218	2.1194	0.11	57.913	57.967	-0.09
9	423.170	2.1218	2.1195	0.11	63.538	63.596	-0.09
9	298.142	2.3339	2.3428	-0.38	36.183	36.115	0.19
9	323.140	2.3339	2.3383	-0.19	43.101	43.052	0.12
9	348.143	2.3339	2.3356	-0.07	49.758	49.732	0.05
9	373.150	2.3339	2.3334	0.02	56.240	56.251	-0.02
9	398.160	2.3339	2.3321	0.08	62.614	62.655	-0.06
9	423.170	2.3339	2.3319	0.09	68.922	68.972	-0.07
9	298.142	2.4084	2.4175	-0.38	36.734	36.668	0.18
9	323.140	2.4084	2.4130	-0.19	43.938	43.887	0.12
9	348.143	2.4084	2.4103	-0.08	50.862	50.834	0.06
9	373.150	2.4084	2.4081	0.01	57.603	57.609	-0.01
9	398.160	2.4084	2.4066	0.08	64.224	64.263	-0.06
9	423.170	2.4084	2.4063	0.09	70.776	70.828	-0.07
9	298.142	2.9393	2.9535	-0.48	39.901	39.833	0.17
9	323.140	2.9393	2.9485	-0.31	49.228	49.148	0.16
9	348.143	2.9393	2.9443	-0.17	58.126	58.062	0.11
9	373.150	2.9393	2.9410	-0.06	66.768	66.742	0.04
9	398.160	2.9393	2.9390	0.01	75.253	75.260	-0.01
9	423.170	2.9393	2.9385	0.03	83.640	83.659	-0.02
9	323.140	3.5820	3.5966	-0.41	54.204	54.107	0.18
9	348.143	3.5820	3.5907	-0.24	65.647	65.553	0.14
9	373.150	3.5820	3.5867	-0.13	76.769	76.700	0.09
9	398.160	3.5820	3.5841	-0.06	87.686	87.646	0.04
9	423.170	3.5820	3.5836	-0.04	98.481	98.446	0.04
9	323.140	4.4288	4.4544	-0.58	58.974	58.854	0.20
9	348.143	4.4288	4.4450	-0.37	74.001	73.854	0.20
9	373.150	4.4288	4.4392	-0.24	88.656	88.516	0.16
9	398.160	4.4288	4.4367	-0.18	103.099	102.959	0.14
9	423.170	4.4288	4.4361	-0.17	117.402	117.240	0.14
9	323.140	5.4403	5.4572	-0.31	62.995	62.935	0.10
9	348.143	5.4403	5.4494	-0.17	82.596	82.521	0.09
9	373.150	5.4403	5.4478	-0.14	101.932	101.833	0.10
9	398.160	5.4403	5.4476	-0.13	121.098	120.966	0.11
9	423.170	5.4403	5.4492	-0.16	140.168	139.962	0.15
9	323.140	6.6818	6.5878	1.41	66.912	67.250	-0.51
9	348.143	6.6818	6.6341	0.71	92.790	93.230	-0.47
9	373.150	6.6818	6.6551	0.40	118.770	119.173	-0.34
9	398.160	6.6818	6.6654	0.25	144.726	145.073	-0.24
9	423.170	6.6818	6.6739	0.12	170.709	170.924	-0.13
9	323.140	8.2024	8.0128	2.31	72.785	73.780	-1.37
9	348.143	8.2024	8.1079	1.15	108.346	109.548	-1.11
9	373.150	8.2024	8.1498	0.64	144.605	145.681	-0.74
9	398.160	8.2024	8.1707	0.39	181.105	182.004	-0.50
9	423.170	8.2024	8.1813	0.26	217.659	218.423	-0.35

NP = 101, DNRMSPT = 0.353, PMEANPCT = 0.135

Table 12. Experimental and calculated P- ρ -T data- - - (Continued)

EQUATION OF STATE VS. PVT DATA

ID	T,K	MOL/L	CALCD	C,PCT	P,BAR	CALCD	P,PCT
10	248.150	0.7000	0.6999	0.02	11.763	11.764	-0.01
10	273.150	0.7500	0.7508	-0.11	14.298	14.285	0.09
10	298.150	0.7500	0.7506	-0.08	16.116	16.105	0.07
10	303.150	0.7500	0.7506	-0.08	16.475	16.464	0.07
10	323.150	0.7500	0.7504	-0.06	17.897	17.888	0.05
10	348.150	0.7500	0.7503	-0.03	19.652	19.646	0.03
10	373.150	0.7500	0.7502	-0.02	21.391	21.386	0.02
10	398.150	0.7500	0.7501	-0.01	23.116	23.113	0.01
10	423.150	0.7500	0.7500	-0.00	24.830	24.829	0.00
10	448.150	0.7500	0.7500	-0.00	26.538	26.537	0.00
10	473.150	0.7500	0.7500	-0.00	28.239	28.238	0.00
10	498.150	0.7500	0.7500	0.00	29.934	29.934	-0.00
10	523.150	0.7500	0.7500	-0.00	31.627	31.626	0.00
10	548.150	0.7500	0.7501	-0.01	33.315	33.313	0.01
10	573.150	0.7500	0.7501	-0.02	35.003	34.997	0.02
10	598.150	0.7500	0.7502	-0.03	36.689	36.678	0.03
10	623.150	0.7500	0.7504	-0.05	38.375	38.357	0.05
10	273.150	1.0000	1.0003	-0.03	17.908	17.903	0.02
10	298.150	1.0000	1.0000	-0.00	20.450	20.449	0.00
10	303.150	1.0000	0.9999	0.01	20.948	20.949	-0.01
10	323.150	1.0000	0.9996	0.04	22.919	22.926	-0.03
10	348.150	1.0000	0.9994	0.06	25.344	25.358	-0.05
10	373.150	1.0000	0.9992	0.08	27.738	27.757	-0.07
10	398.150	1.0000	0.9991	0.09	30.109	30.133	-0.08
10	423.150	1.0000	0.9991	0.09	32.462	32.489	-0.09
10	448.150	1.0000	0.9991	0.09	34.802	34.832	-0.09
10	473.150	1.0000	0.9991	0.09	37.130	37.162	-0.09
10	498.150	1.0000	0.9991	0.09	39.450	39.483	-0.08
10	523.150	1.0000	0.9992	0.08	41.763	41.796	-0.08
10	548.150	1.0000	0.9993	0.07	44.071	44.102	-0.07
10	573.150	1.0000	0.9994	0.06	46.375	46.402	-0.06
10	598.150	1.0000	0.9995	0.05	48.675	48.697	-0.05
10	623.150	1.0000	0.9999	0.01	50.982	50.988	-0.01
10	273.150	1.5000	1.4984	0.11	23.530	23.545	-0.06
10	298.150	1.5000	1.4997	0.02	27.719	27.723	-0.01
10	303.150	1.5000	1.4994	0.04	28.528	28.535	-0.03
10	323.150	1.5000	1.4987	0.09	31.709	31.730	-0.07
10	348.150	1.5000	1.4979	0.14	35.592	35.632	-0.11
10	373.150	1.5000	1.4975	0.16	39.407	39.461	-0.14
10	398.150	1.5000	1.4974	0.17	43.172	43.237	-0.15
10	423.150	1.5000	1.4973	0.18	46.899	46.973	-0.16
10	448.150	1.5000	1.4975	0.17	50.600	50.678	-0.15
10	473.150	1.5000	1.4975	0.16	54.276	54.358	-0.15
10	498.150	1.5000	1.4977	0.15	57.934	58.017	-0.14
10	523.150	1.5000	1.4979	0.14	61.578	61.659	-0.13
10	548.150	1.5000	1.4983	0.11	65.215	65.287	-0.11
10	573.150	1.5000	1.4983	0.11	68.827	68.902	-0.11
10	598.150	1.5000	1.4987	0.09	72.443	72.506	-0.09
10	623.150	1.5000	1.4993	0.05	76.067	76.101	-0.05
10	298.150	2.0000	2.0027	-0.14	33.289	33.263	0.08
10	303.150	2.0000	2.0023	-0.12	34.448	34.425	0.07
10	323.150	2.0000	2.0003	-0.02	38.978	38.974	0.01

Table 12. Experimental and calculated P-p-T data- - - (Continued)

EQUATION OF STATE VS. PVT DATA

ID	T,K	MOL/L	CALCD	D,PCT	P,BAR	CALCD	P,PCT
10	348.150	2.0000	1.9986	0.07	44.474	44.496	-0.05
10	373.150	2.0000	1.9978	0.11	49.850	49.894	-0.09
10	398.150	2.0000	1.9972	0.14	55.139	55.203	-0.12
10	423.150	2.0000	1.9969	0.15	60.365	60.445	-0.13
10	448.150	2.0000	1.9971	0.15	65.550	65.635	-0.13
10	473.150	2.0000	1.9973	0.13	70.697	70.783	-0.12
10	498.150	2.0000	1.9975	0.13	75.809	75.898	-0.12
10	523.150	2.0000	1.9977	0.11	80.898	80.984	-0.11
10	548.150	2.0000	1.9979	0.11	85.959	86.047	-0.10
10	573.150	2.0000	1.9982	0.09	91.008	91.089	-0.09
10	598.150	2.0000	1.9987	0.06	96.054	96.114	-0.06
10	623.150	2.0000	1.9997	0.02	101.105	101.123	-0.02
10	298.150	2.5000	2.5084	-0.33	37.369	37.313	0.15
10	303.150	2.5000	2.5077	-0.31	38.918	38.860	0.15
10	323.150	2.5000	2.5042	-0.17	44.928	44.883	0.10
10	348.150	2.5000	2.5007	-0.03	52.169	52.159	0.02
10	373.150	2.5000	2.4989	0.04	59.233	59.252	-0.03
10	398.150	2.5000	2.4981	0.07	66.177	66.216	-0.06
10	423.150	2.5000	2.4977	0.09	73.029	73.085	-0.08
10	448.150	2.5000	2.4978	0.09	79.818	79.880	-0.08
10	473.150	2.5000	2.4977	0.09	86.544	86.616	-0.08
10	498.150	2.5000	2.4979	0.09	93.231	93.305	-0.08
10	523.150	2.5000	2.4984	0.06	99.892	99.953	-0.06
10	548.150	2.5000	2.4989	0.04	106.522	106.568	-0.04
10	573.150	2.5000	2.4993	0.03	113.120	113.153	-0.03
10	598.150	2.5000	2.4998	0.01	119.704	119.713	-0.01
10	623.150	2.5000	2.5013	-0.05	126.314	126.251	0.05
10	298.150	3.0000	3.0121	-0.40	40.172	40.118	0.13
10	303.150	3.0000	3.0125	-0.42	42.149	42.082	0.16
10	323.150	3.0000	3.0080	-0.27	49.750	49.681	0.14
10	348.150	3.0000	3.0029	-0.10	58.862	58.826	0.06
10	373.150	3.0000	3.0002	-0.01	67.732	67.729	0.00
10	398.150	3.0000	2.9992	0.03	76.450	76.465	-0.02
10	423.150	3.0000	2.9983	0.06	85.039	85.079	-0.05
10	448.150	3.0000	2.9986	0.05	93.560	93.599	-0.04
10	473.150	3.0000	2.9988	0.04	102.007	102.044	-0.04
10	498.150	3.0000	2.9990	0.03	110.392	110.427	-0.03
10	523.150	3.0000	2.9995	0.02	118.741	118.759	-0.02
10	548.150	3.0000	3.0002	-0.01	127.056	127.048	0.01
10	573.150	3.0000	3.0007	-0.02	135.329	135.299	0.02
10	598.150	3.0000	3.0016	-0.05	143.594	143.517	0.05
10	623.150	3.0000	3.0034	-0.11	151.881	151.705	0.12
10	303.150	3.5000	3.5146	-0.42	44.346	44.294	0.12
10	323.150	3.5000	3.5119	-0.34	53.635	53.553	0.15
10	348.150	3.5000	3.5051	-0.15	64.723	64.667	0.09
10	373.150	3.5000	3.5017	-0.05	75.512	75.486	0.03
10	398.150	3.5000	3.5007	-0.02	86.122	86.108	0.02
10	423.150	3.5000	3.5000	0.00	96.586	96.586	-0.00
10	448.150	3.5000	3.5003	-0.01	106.961	106.953	0.01
10	473.150	3.5000	3.5008	-0.02	117.256	117.232	0.02
10	498.150	3.5000	3.5010	-0.03	127.471	127.438	0.03
10	523.150	3.5000	3.5015	-0.04	137.642	137.583	0.04
10	548.150	3.5000	3.5021	-0.06	147.765	147.676	0.06

Table 12. Experimental and calculated P- ρ -T data- - - (Continued)

EQUATION OF STATE VS. PVT DATA

ID	T, K	MOL/L	CALCD	C, PCT	P, BAR	CALCD	P, PCT
10	573.150	3.5000	3.5029	-0.08	157.853	157.724	0.08
10	598.150	3.5000	3.5039	-0.11	167.924	167.731	0.11
10	623.150	3.5000	3.5061	-0.17	178.025	177.702	0.18
10	303.150	4.0000	4.0149	-0.37	45.714	45.684	0.07
10	323.150	4.0000	4.0182	-0.45	56.768	56.667	0.18
10	348.150	4.0000	4.0086	-0.21	69.920	69.836	0.12
10	373.150	4.0000	4.0044	-0.11	82.737	82.675	0.07
10	398.150	4.0000	4.0030	-0.07	95.353	95.299	0.06
10	423.150	4.0000	4.0025	-0.06	107.820	107.764	0.05
10	448.150	4.0000	4.0031	-0.08	120.189	120.108	0.07
10	473.150	4.0000	4.0035	-0.09	132.460	132.355	0.08
10	498.150	4.0000	4.0038	-0.10	144.652	144.521	0.09
10	523.150	4.0000	4.0046	-0.11	156.793	156.618	0.11
10	548.150	4.0000	4.0048	-0.12	168.860	168.656	0.12
10	573.150	4.0000	4.0055	-0.14	180.897	180.643	0.14
10	598.150	4.0000	4.0067	-0.17	192.920	192.583	0.17
10	623.150	4.0000	4.0093	-0.23	204.991	204.481	0.25
10	303.150	4.5000	4.5112	-0.25	46.448	46.437	0.02
10	323.150	4.5000	4.5245	-0.54	59.302	59.191	0.19
10	348.150	4.5000	4.5115	-0.25	74.601	74.498	0.14
10	373.150	4.5000	4.5068	-0.15	89.556	89.466	0.10
10	398.150	4.5000	4.5058	-0.13	104.316	104.213	0.10
10	423.150	4.5000	4.5055	-0.12	118.922	118.800	0.10
10	448.150	4.5000	4.5065	-0.15	133.434	133.261	0.13
10	473.150	4.5000	4.5065	-0.15	147.823	147.621	0.14
10	498.150	4.5000	4.5072	-0.16	162.148	161.896	0.16
10	523.150	4.5000	4.5076	-0.17	176.399	176.098	0.17
10	548.150	4.5000	4.5076	-0.17	190.571	190.236	0.18
10	573.150	4.5000	4.5080	-0.18	204.706	204.318	0.19
10	598.150	4.5000	4.5093	-0.21	218.837	218.348	0.22
10	623.150	4.5000	4.5123	-0.27	233.031	232.331	0.30
10	323.150	5.0000	5.0242	-0.48	61.395	61.300	0.15
10	348.150	5.0000	5.0099	-0.20	78.919	78.835	0.11
10	373.150	5.0000	5.0065	-0.13	96.135	96.050	0.09
10	398.150	5.0000	5.0068	-0.14	113.178	113.057	0.11
10	423.150	5.0000	5.0073	-0.15	130.076	129.912	0.13
10	448.150	5.0000	5.0083	-0.17	146.871	146.646	0.15
10	473.150	5.0000	5.0086	-0.17	163.555	163.281	0.17
10	498.150	5.0000	5.0089	-0.18	180.155	179.830	0.18
10	523.150	5.0000	5.0087	-0.17	196.667	196.306	0.18
10	548.150	5.0000	5.0088	-0.18	213.119	212.715	0.19
10	573.150	5.0000	5.0094	-0.19	229.543	229.063	0.21
10	598.150	5.0000	5.0107	-0.21	245.951	245.357	0.24
10	623.150	5.0000	5.0140	-0.28	262.444	261.600	0.32
10	323.150	5.5000	5.5078	-0.14	63.184	63.156	0.04
10	348.150	5.5000	5.4995	0.01	83.020	83.024	-0.01
10	373.150	5.5000	5.5009	-0.02	102.635	102.623	0.01
10	398.150	5.5000	5.5036	-0.06	122.111	122.046	0.05
10	423.150	5.5000	5.5056	-0.10	141.466	141.335	0.09
10	448.150	5.5000	5.5070	-0.13	160.716	160.516	0.12
10	473.150	5.5000	5.5075	-0.14	179.857	179.604	0.14
10	498.150	5.5000	5.5083	-0.15	198.931	198.612	0.16
10	523.150	5.5000	5.5081	-0.15	217.901	217.547	0.16

Table 12. Experimental and calculated P-P-T data- - - (Continued)

EQUATION OF STATE VS. PVT DATA

ID	T, K	MOL/L	CALCD	D, PCT	P, BAR	CALCD	P, PCT
10	548.150	5.5000	5.5080	-0.15	236.807	236.415	0.17
10	573.150	5.5000	5.5087	-0.16	255.693	255.221	0.18
10	598.150	5.5000	5.5099	-0.18	274.554	273.970	0.21
10	623.150	5.5000	5.5135	-0.25	293.532	292.665	0.30
10	323.150	6.0000	5.9723	0.46	64.792	64.887	-0.15
10	348.150	6.0000	5.9798	0.34	87.049	87.221	-0.20
10	373.150	6.0000	5.9890	0.18	109.215	109.367	-0.14
10	398.150	6.0000	5.9962	0.06	131.309	131.383	-0.06
10	423.150	6.0000	5.9999	0.00	153.294	153.295	-0.00
10	448.150	6.0000	6.0026	-0.04	175.196	175.118	0.04
10	473.150	6.0000	6.0042	-0.07	197.010	196.861	0.08
10	498.150	6.0000	6.0053	-0.09	218.751	218.531	0.10
10	523.150	6.0000	6.0049	-0.08	240.359	240.132	0.09
10	548.150	6.0000	6.0051	-0.09	261.935	261.668	0.10
10	573.150	6.0000	6.0056	-0.09	283.465	283.143	0.11
10	598.150	6.0000	6.0070	-0.12	304.998	304.557	0.14
10	623.150	6.0000	6.0109	-0.18	326.668	325.914	0.23
10	323.150	6.5000	6.4217	1.20	66.335	66.610	-0.41
10	348.150	6.5000	6.4533	0.72	91.161	91.579	-0.46
10	373.150	6.5000	6.4720	0.43	116.055	116.465	-0.35
10	398.150	6.5000	6.4843	0.24	140.958	141.281	-0.23
10	423.150	6.5000	6.4913	0.13	165.800	166.031	-0.14
10	448.150	6.5000	6.4957	0.07	190.579	190.717	-0.07
10	473.150	6.5000	6.4981	0.03	215.266	215.340	-0.03
10	498.150	6.5000	6.4997	0.00	239.886	239.900	-0.01
10	523.150	6.5000	6.4995	0.01	264.373	264.398	-0.01
10	548.150	6.5000	6.5003	-0.00	288.851	288.833	0.01
10	573.150	6.5000	6.5005	-0.01	313.236	313.207	0.01
10	598.150	6.5000	6.5023	-0.04	337.677	337.520	0.05
10	623.150	6.5000	6.5059	-0.09	362.215	361.772	0.12
10	323.150	7.0000	6.8616	1.98	67.920	68.441	-0.77
10	348.150	7.0000	6.9238	1.09	95.515	96.251	-0.77
10	373.150	7.0000	6.9537	0.66	123.367	124.100	-0.59
10	398.150	7.0000	6.9727	0.39	151.344	151.950	-0.40
10	423.150	7.0000	6.9822	0.25	179.269	179.778	-0.28
10	448.150	7.0000	6.9890	0.16	207.185	207.572	-0.19
10	473.150	7.0000	6.9918	0.12	234.982	235.323	-0.15
10	498.150	7.0000	6.9933	0.10	262.698	263.022	-0.12
10	523.150	7.0000	6.9939	0.09	290.334	290.667	-0.11
10	548.150	7.0000	6.9943	0.08	317.906	318.253	-0.11
10	573.150	7.0000	6.9948	0.07	345.424	345.778	-0.10
10	598.150	7.0000	6.9967	0.05	372.994	373.241	-0.07
10	623.150	7.0000	7.0011	-0.02	400.729	400.640	0.02
10	323.150	7.5000	7.3181	2.43	69.687	70.439	-1.08
10	348.150	7.5000	7.4020	1.31	100.302	101.338	-1.03
10	373.150	7.5000	7.4407	0.79	131.381	132.409	-0.78
10	398.150	7.5000	7.4644	0.48	162.693	163.557	-0.53
10	423.150	7.5000	7.4762	0.32	193.990	194.733	-0.38
10	448.150	7.5000	7.4843	0.21	225.305	225.906	-0.27
10	473.150	7.5000	7.4879	0.16	256.509	257.056	-0.21
10	498.150	7.5000	7.4900	0.13	287.646	288.170	-0.18
10	523.150	7.5000	7.4901	0.13	318.646	319.235	-0.18
10	548.150	7.5000	7.4899	0.14	349.569	350.246	-0.19

Table 12. Experimental and calculated P- ρ -T data- - - (Continued)

EQUATION OF STATE VS. PVT DATA

ID	T,K	MOL/L	CALCD	D,PCT	P,BAR	CALCD	F,PCT
10	573.150	7.5000	7.4900	0.13	380.454	381.196	-0.20
10	323.150	8.0000	7.8017	2.48	71.775	72.734	-1.34
10	348.150	8.0000	7.8935	1.33	105.750	107.024	-1.20
10	373.150	8.0000	7.9379	0.78	140.417	141.621	-0.86
10	398.150	8.0000	7.9617	0.48	175.341	176.373	-0.59
10	423.150	8.0000	7.9749	0.31	210.334	211.202	-0.41
10	448.150	8.0000	7.9832	0.21	245.348	246.061	-0.29
10	473.150	8.0000	7.9884	0.14	280.338	280.917	-0.21
10	498.150	8.0000	7.9888	0.14	315.099	315.748	-0.21
10	523.150	8.0000	7.9884	0.14	349.779	350.538	-0.22
10	548.150	8.0000	7.9882	0.15	384.407	385.276	-0.23
10	323.150	8.5000	8.3116	2.22	74.407	75.542	-1.52
10	348.150	8.5000	8.3967	1.22	112.147	113.592	-1.29
10	373.150	8.5000	8.4411	0.69	150.763	152.072	-0.87
10	398.150	8.5000	8.4648	0.41	189.705	190.779	-0.57
10	423.150	8.5000	8.4774	0.27	228.728	229.609	-0.39
10	448.150	8.5000	8.4858	0.17	267.823	268.497	-0.25
10	473.150	8.5000	8.4903	0.11	306.859	307.399	-0.18
10	498.150	8.5000	8.4898	0.12	345.630	346.287	-0.19
10	523.150	8.5000	8.4886	0.13	384.306	385.139	-0.22
10	323.150	9.0000	8.8361	1.82	77.856	79.144	-1.65
10	348.150	9.0000	8.9087	1.01	119.857	121.393	-1.28
10	373.150	9.0000	8.9493	0.56	162.857	164.171	-0.81
10	398.150	9.0000	8.9723	0.31	206.258	207.234	-0.47
10	423.150	9.0000	8.9836	0.18	249.728	250.455	-0.29
10	448.150	9.0000	8.9901	0.11	293.226	293.756	-0.18
10	473.150	9.0000	8.9943	0.06	336.726	337.085	-0.11
10	498.150	9.0000	8.9924	0.08	379.850	380.403	-0.15
10	323.150	9.5000	9.3667	1.40	82.499	83.907	-1.71
10	348.150	9.5000	9.4253	0.79	129.325	130.868	-1.19
10	373.150	9.5000	9.4606	0.41	177.203	178.418	-0.69
10	398.150	9.5000	9.4811	0.20	225.515	226.290	-0.34
10	423.150	9.5000	9.4913	0.09	273.897	274.343	-0.16
10	448.150	9.5000	9.4975	0.03	322.334	322.486	-0.05
10	473.150	9.5000	9.4993	0.01	370.609	370.659	-0.01
10	323.150	10.0000	9.8976	1.02	88.838	90.311	-1.66
10	348.150	10.0000	9.9423	0.58	141.085	142.568	-1.05
10	373.150	10.0000	9.9730	0.27	194.424	195.427	-0.52
10	398.150	10.0000	9.9915	0.08	248.207	248.618	-0.17
10	423.150	10.0000	9.9998	0.00	301.977	301.991	-0.00
10	448.150	10.0000	10.0037	-0.04	355.715	355.450	0.07
10	323.150	10.5000	10.4239	0.73	97.478	98.972	-1.53
10	348.150	10.5000	10.4587	0.39	155.840	157.176	-0.86
10	373.150	10.5000	10.4843	0.15	215.238	215.943	-0.33
10	398.150	10.5000	10.4999	0.00	275.014	275.018	-0.00
10	423.150	10.5000	10.5069	-0.07	334.734	334.252	0.14
10	448.150	10.5000	10.5097	-0.09	394.346	393.551	0.20
10	298.150	11.0000	10.9727	0.25	46.397	46.734	-0.73
10	323.150	11.0000	10.9450	0.50	109.201	110.664	-1.34
10	348.150	11.0000	10.9729	0.25	174.420	175.525	-0.63
10	373.150	11.0000	10.9952	0.04	240.596	240.858	-0.11
10	398.150	11.0000	11.0079	-0.07	306.980	306.438	0.18
10	423.150	11.0000	11.0133	-0.12	373.226	372.128	0.29

Table 12. Experimental and calculated P- ρ -T data- - - (Continued)

EQUATION OF STATE VS. PVT DATA

ID	T,K	MOL/L	CALCD	D,PCT	P,BAR	CALCD	P,PCT
10	298.150	11.5000	11.4689	0.27	54.120	54.730	-1.13
10	323.150	11.5000	11.4619	0.33	124.979	126.340	-1.09
10	348.150	11.5000	11.4841	0.14	197.803	198.620	-0.41
10	373.150	11.5000	11.5036	-0.03	271.474	271.232	0.09
10	398.150	11.5000	11.5151	-0.13	345.236	343.992	0.36
10	298.150	12.0000	11.9705	0.25	66.139	67.006	-1.31
10	323.150	12.0000	11.9763	0.20	146.022	147.141	-0.77
10	348.150	12.0000	11.9934	0.05	227.224	227.651	-0.19
10	373.150	12.0000	12.0104	-0.09	309.160	308.307	0.28
10	398.150	12.0000	12.0220	-0.18	391.141	388.973	0.55
10	298.150	12.5000	12.4738	0.21	83.768	84.868	-1.31
10	323.150	12.5000	12.4854	0.12	173.516	174.419	-0.52
10	348.150	12.5000	12.5006	-0.01	264.063	264.011	0.02
10	373.150	12.5000	12.5155	-0.12	355.074	353.521	0.44
10	298.150	13.0000	12.9782	0.17	108.587	109.845	-1.16
10	323.150	13.0000	12.9890	0.08	208.863	209.738	-0.42
10	348.150	13.0000	13.0057	-0.04	309.878	309.305	0.18
10	273.150	13.5000	13.4989	0.01	31.583	31.642	-0.19
10	298.150	13.5000	13.4821	0.13	142.310	143.698	-0.98
10	323.150	13.5000	13.4926	0.05	254.146	254.893	-0.29
10	348.150	13.5000	13.5083	-0.06	366.398	365.364	0.28
10	273.150	14.0000	13.9904	0.07	62.783	63.504	-1.15
10	298.150	14.0000	13.9863	0.10	187.036	188.425	-0.74
10	323.150	14.0000	13.9986	0.01	311.735	311.915	-0.06
10	273.150	14.5000	14.4880	0.08	106.237	107.449	-1.14
10	298.150	14.5000	14.4911	0.06	245.114	246.273	-0.47
10	323.150	14.5000	14.5033	-0.02	383.607	383.080	0.14
10	273.150	15.0000	14.9872	0.09	164.251	165.958	-1.04
10	298.150	15.0000	14.9928	0.05	318.560	319.750	-0.37
10	248.150	15.5000	15.4982	0.01	67.393	67.644	-0.37
10	273.150	15.5000	15.4916	0.05	240.347	241.786	-0.60
10	298.150	15.5000	15.4932	0.04	410.257	411.635	-0.34
10	248.150	16.0000	15.9930	0.04	144.656	145.900	-0.86
10	273.150	16.0000	15.9950	0.03	336.908	337.977	-0.32

NP = 298, DNRMSPT = 0.401, PMEANPCT = 0.256

Table 12. Experimental and calculated P- ρ -T data- - - (Continued)

EQUATION OF STATE VS. PVT DATA

ID	T,K	MOL/L	CALCD	D,PCT	P,BAR	CALCD	P,PCT
101	263.847	1.1061	1.0901	1.45	17.993	18.174	-1.01
102	267.267	1.1058	1.0955	0.92	18.458	18.578	-0.65
103	270.457	1.1054	1.0970	0.76	18.849	18.951	-0.54
104	273.094	1.1054	1.0977	0.69	19.165	19.261	-0.50
105	276.946	1.1051	1.0987	0.58	19.623	19.706	-0.42
106	281.362	1.1048	1.0995	0.48	20.142	20.213	-0.35
107	288.868	1.1044	1.1000	0.40	21.006	21.069	-0.30
108	293.954	1.1038	1.0998	0.36	22.139	22.202	-0.28
109	306.232	1.1034	1.0999	0.32	22.953	23.012	-0.25
110	315.928	1.1028	1.0994	0.31	24.016	24.077	-0.25
111	326.185	1.1021	1.0990	0.28	25.135	25.192	-0.23
112	332.655	1.1018	1.0989	0.26	25.836	25.892	-0.22
113	343.612	1.1011	1.0984	0.25	27.010	27.067	-0.21
201	290.936	2.5966	2.5821	0.56	35.479	35.553	-0.21
202	292.700	2.5963	2.5957	0.02	36.139	36.142	-0.01
203	294.967	2.5959	2.5983	-0.09	36.907	36.894	0.04
204	297.293	2.5956	2.5988	-0.12	37.678	37.658	0.05
205	299.402	2.5953	2.6006	-0.20	38.380	38.346	0.09
206	300.717	2.5953	2.5987	-0.13	38.797	38.773	0.06
207	306.169	2.5943	2.5983	-0.16	40.554	40.524	0.08
208	311.528	2.5936	2.5974	-0.14	42.255	42.223	0.07
209	317.621	2.5926	2.5957	-0.12	44.159	44.130	0.07
210	325.244	2.5916	2.5935	-0.07	46.507	46.487	0.04
211	333.158	2.5903	2.5911	-0.03	48.909	48.900	0.02
212	343.446	2.5890	2.5883	0.03	51.991	52.000	-0.02
301	305.270	4.5943	4.5190	1.64	47.863	47.962	-0.21
302	306.575	4.5939	4.5368	1.24	48.748	48.836	-0.18
303	306.998	4.5939	4.5454	1.06	49.040	49.118	-0.16
304	308.355	4.5936	4.5483	0.99	49.934	50.018	-0.17
305	309.475	4.5933	4.5514	0.91	50.671	50.757	-0.17
306	310.226	4.5929	4.5547	0.83	51.168	51.251	-0.16
307	311.461	4.5926	4.5562	0.79	51.973	52.060	-0.17
308	314.528	4.5920	4.5585	0.73	53.959	54.058	-0.18
309	316.957	4.5913	4.5587	0.71	55.518	55.628	-0.20
310	326.208	4.5890	4.5558	0.72	61.371	61.537	-0.27
311	329.914	4.5880	4.5471	0.89	63.647	63.878	-0.36
312	333.690	4.5870	4.5821	0.11	66.220	66.251	-0.05
401	305.232	5.3595	4.9727	7.22	48.302	48.507	-0.42
402	306.165	5.3595	5.1961	3.05	49.168	49.266	-0.20
403	307.343	5.3588	5.2688	1.68	50.145	50.216	-0.14
404	308.378	5.3585	5.2844	1.38	50.973	51.045	-0.14
405	310.753	5.3578	5.3268	0.58	52.892	52.935	-0.08
406	315.523	5.3565	5.3429	0.25	56.662	56.693	-0.05
407	320.133	5.3552	5.3418	0.25	60.250	60.291	-0.07
408	324.789	5.3535	5.3397	0.26	63.845	63.900	-0.09
409	329.529	5.3522	5.3387	0.25	67.488	67.553	-0.10
410	334.774	5.3505	5.3379	0.24	71.501	71.574	-0.10
411	342.584	5.3482	5.3379	0.19	77.450	77.525	-0.10

Table 12. Experimental and calculated P-ρ-T data- - - (Continued)

EQUATION OF STATE VS. PVT DATA

ID	T,K	MOL/L	CALCD	D,PCT	P,BAR	CALCD	P,PCT
501	304.721	6.1373	5.2442	14.55	48.051	48.166	-0.24
502	305.380	6.1370	5.5227	10.01	48.682	48.763	-0.17
503	305.932	6.1367	5.6833	7.39	49.202	49.289	-0.18
504	306.528	6.1367	5.7928	5.60	49.760	49.854	-0.19
505	307.927	6.1360	5.9612	2.85	51.087	51.173	-0.17
506	309.803	6.1354	6.0301	1.71	52.846	52.933	-0.16
507	314.618	6.1337	6.0789	0.89	57.330	57.425	-0.17
508	320.295	6.1317	6.0814	0.82	62.550	62.692	-0.23
509	325.427	6.1300	6.0801	0.82	67.241	67.434	-0.29
510	330.799	6.1280	6.0821	0.75	72.153	72.381	-0.32
511	336.699	6.1260	6.0860	0.65	77.549	77.797	-0.32
512	343.543	6.1237	6.0873	0.59	83.782	84.059	-0.33
601	305.423	6.7892	5.9149	12.88	48.790	48.811	-0.04
602	305.743	6.7888	5.6716	16.46	49.034	49.151	-0.24
603	306.184	6.7888	5.8169	14.32	49.461	49.619	-0.32
604	306.693	6.7885	6.0142	11.41	49.978	50.159	-0.36
605	307.188	6.7885	6.2012	8.65	50.499	50.685	-0.37
606	309.162	6.7875	6.4936	4.33	52.576	52.781	-0.39
607	312.231	6.7865	6.5013	4.20	55.667	56.040	-0.67
608	317.552	6.7845	6.5778	3.05	61.188	61.688	-0.82
609	322.347	6.7825	6.6161	2.45	66.200	66.775	-0.87
610	327.148	6.7805	6.6398	2.08	71.229	71.864	-0.89
611	333.270	6.7782	6.6639	1.69	77.676	78.349	-0.87
612	343.351	6.7745	6.6836	1.34	88.268	89.013	-0.84
701	305.633	8.1021	5.9810	26.18	48.991	49.211	-0.45
702	306.319	8.1018	7.1329	11.96	49.819	50.129	-0.62
703	307.031	8.1014	7.6433	5.65	50.808	51.087	-0.55
704	308.123	8.1008	7.6411	5.67	52.160	52.564	-0.77
705	311.913	8.0991	7.6884	5.07	56.966	57.728	-1.34
706	316.998	8.0968	7.7679	4.06	63.649	64.713	-1.67
707	322.404	8.0941	7.8239	3.34	70.899	72.181	-1.81
708	327.708	8.0918	7.8583	2.89	78.080	79.537	-1.87
709	333.451	8.0891	7.8875	2.49	85.935	87.525	-1.85
710	339.014	8.0865	7.9157	2.11	93.653	95.278	-1.73
711	343.093	8.0845	7.9315	1.89	99.332	100.969	-1.65
801	305.015	8.8104	8.2090	6.83	48.426	48.920	-1.02
802	306.220	8.8096	8.2922	5.87	50.132	50.785	-1.30
803	307.783	8.8088	8.3015	5.76	52.332	53.219	-1.70
804	309.310	8.8081	8.4607	3.94	54.784	55.611	-1.51
805	310.839	8.8074	8.4754	3.77	57.061	58.016	-1.67
806	314.681	8.8055	8.4776	3.72	62.751	64.091	-2.14
807	319.840	8.8028	8.5218	3.19	70.675	72.302	-2.30
808	325.591	8.7998	8.5685	2.63	79.720	81.507	-2.24
809	331.302	8.7971	8.6010	2.23	88.794	90.690	-2.13
810	337.309	8.7938	8.6277	1.89	98.429	100.374	-1.98
811	342.720	8.7912	8.6448	1.67	107.138	109.122	-1.85
901	303.430	9.6887	9.5875	1.04	48.035	48.413	-0.79
902	303.752	9.6887	9.5850	1.07	48.615	49.016	-0.82
903	303.962	9.6887	9.5803	1.12	48.982	49.410	-0.87

Table 12. Experimental and calculated P- ρ -T data- - - (Continued)

EQUATION OF STATE VS. PVT DATA

ID	T,K	MOL/L	CALCD	D,PCT	P,BAR	CALCD	P,PCT
904	304.336	9.6884	9.5310	1.62	49.484	50.110	-1.27
905	305.899	9.6874	9.5180	1.75	52.267	53.046	-1.49
906	308.437	9.6861	9.5031	1.89	56.812	57.839	-1.81
907	313.081	9.6834	9.5096	1.80	65.354	66.663	-2.00
908	318.048	9.6807	9.5318	1.54	74.730	76.163	-1.92
909	322.924	9.6781	9.5421	1.40	83.951	85.534	-1.89
910	327.991	9.6751	9.5515	1.28	93.608	95.306	-1.81
911	334.413	9.6714	9.5540	1.21	105.811	107.733	-1.82
912	342.647	9.6668	9.5814	0.88	122.022	123.717	-1.39
1001	293.336	11.3761	11.3655	0.09	38.979	39.135	-0.40
1002	293.674	11.3761	11.3634	0.11	39.876	40.064	-0.47
1003	294.103	11.3758	11.3587	0.15	40.981	41.238	-0.63
1004	294.883	11.3751	11.3534	0.19	43.036	43.374	-0.78
1005	295.416	11.3748	11.3495	0.22	44.436	44.835	-0.90
1006	295.792	11.3745	11.3470	0.24	45.424	45.865	-0.97
1007	296.034	11.3745	11.3452	0.26	46.058	46.532	-1.03
1008	298.624	11.3728	11.3334	0.35	52.946	53.646	-1.32
1009	301.993	11.3705	11.3220	0.43	61.951	62.912	-1.55
1010	304.995	11.3685	11.3180	0.44	70.089	71.183	-1.56
1011	309.657	11.3651	11.3151	0.44	82.812	84.041	-1.48
1012	314.468	11.3622	11.3130	0.43	95.989	97.341	-1.41
1013	319.264	11.3588	11.3170	0.37	109.329	110.604	-1.17
1014	324.667	11.3552	11.3213	0.30	124.415	125.561	-0.92
1015	328.588	11.3525	11.3216	0.27	135.300	136.420	-0.83
1016	335.200	11.3482	11.3225	0.23	153.711	154.743	-0.67
1017	341.335	11.3442	11.3099	0.30	170.251	171.747	-0.88
1101	277.504	12.9867	13.0057	-0.13	27.349	26.677	2.46
1102	277.925	12.9884	13.0037	-0.12	28.958	28.348	2.11
1103	273.136	12.9884	13.0006	-0.09	29.682	29.192	1.65
1104	278.777	12.9877	12.9994	-0.09	32.203	31.730	1.47
1105	279.387	12.9874	12.9966	-0.07	34.536	34.156	1.10
1106	279.902	12.9870	12.9955	-0.07	36.554	36.202	0.96
1107	282.317	12.9850	12.9838	0.01	45.716	45.770	-0.12
1108	284.543	12.9834	12.9823	0.01	54.539	54.588	-0.09
1109	286.727	12.9814	12.9784	0.02	63.074	63.214	-0.22
1110	290.618	12.9784	12.9727	0.04	78.298	78.585	-0.37
1111	297.190	12.9734	12.9664	0.05	104.097	104.490	-0.36
1112	304.683	12.9674	12.9640	0.03	133.702	133.914	-0.16
1113	312.625	12.9614	12.9601	0.01	164.925	165.016	-0.06
1114	320.632	12.9548	12.9581	-0.03	197.261	197.007	0.13
1115	329.753	12.9478	12.9589	-0.09	232.594	231.663	0.40
1116	339.989	12.9401	12.9531	-0.10	272.480	271.290	0.44
1201	263.389	13.7157	13.7212	-0.04	21.840	21.525	1.44
1202	263.613	13.7153	13.7206	-0.04	22.869	22.567	1.32
1203	268.944	13.7150	13.7198	-0.04	24.394	24.115	1.14
1204	269.313	13.7150	13.7180	-0.02	26.037	25.862	0.67
1205	269.861	13.7143	13.7169	-0.02	28.565	28.418	0.52
1206	270.539	13.7137	13.7146	-0.01	31.644	31.586	0.18
1207	271.359	13.7130	13.7128	0.00	35.412	35.424	-0.03
1208	272.788	13.7120	13.7094	0.02	41.957	42.115	-0.38

Table 12. Experimental and calculated P- ρ -T data- - - (Continued)

EQUATION OF STATE VS. PVT DATA

ID	T,K	MOL/L	CALCD	D,PCT	P,BAR	CALCD	P,PCT
1209	277.695	13.7080	13.7001	0.06	64.048	64.572	-0.82
1210	281.789	13.7044	13.6957	0.06	83.378	83.991	-0.74
1211	286.317	13.7007	13.6911	0.07	104.232	104.953	-0.69
1212	290.328	13.6974	13.6879	0.07	122.712	123.454	-0.61
1213	296.212	13.6924	13.6851	0.05	149.868	150.484	-0.41
1214	302.145	13.6874	13.6819	0.04	177.132	177.624	-0.28
1215	310.715	13.6804	13.6790	0.01	216.504	216.647	-0.07
1216	313.093	13.6734	13.6783	-0.04	255.083	254.561	0.20
1217	334.225	13.6608	13.6723	-0.08	323.892	322.512	0.43
1301	256.613	14.5544	14.5584	-0.03	19.044	18.702	1.80
1302	257.326	14.5537	14.5556	-0.01	22.901	22.743	0.69
1303	257.911	14.5534	14.5538	-0.00	26.113	26.073	0.15
1304	259.065	14.5524	14.5519	0.00	32.560	32.607	-0.15
1305	263.450	14.5484	14.5440	0.03	56.915	57.324	-0.72
1306	268.631	14.5437	14.5353	0.06	85.525	86.354	-0.97
1307	273.496	14.5391	14.5321	0.05	112.695	113.417	-0.64
1308	283.116	14.5304	14.5247	0.04	165.879	166.542	-0.40
1309	291.287	14.5231	14.5194	0.03	210.784	211.238	-0.22
1310	293.372	14.5168	14.5160	0.01	249.591	249.700	-0.04
1311	307.254	14.5088	14.5117	-0.02	297.945	297.542	0.14
1312	319.529	14.4978	14.5045	-0.05	364.059	363.039	0.28
1401	248.290	15.0496	15.0457	0.03	14.224	14.625	-2.82
1402	249.192	15.0486	15.0456	0.02	20.022	20.331	-1.54
1403	250.248	15.0476	15.0433	0.03	26.564	27.018	-1.71
1404	253.374	15.0446	15.0378	0.05	45.992	46.742	-1.63
1405	259.654	15.0396	15.0300	0.06	78.728	79.845	-1.42
1406	265.858	15.0329	15.0229	0.07	123.345	124.612	-1.03
1407	272.972	15.0263	15.0163	0.07	167.038	168.374	-0.80
1408	279.035	15.0206	15.0116	0.06	204.080	205.354	-0.62
1409	285.189	15.0146	15.0074	0.05	241.489	242.571	-0.45
1410	294.840	15.0057	15.0025	0.02	299.962	300.461	-0.17
1411	304.470	14.9967	14.9963	0.00	357.549	357.617	-0.02
1412	316.744	14.9850	14.9999	-0.10	432.383	429.618	0.64
1501	240.733	15.4546	15.4609	-0.04	10.100	9.335	7.57
1502	243.885	15.4546	15.4603	-0.04	11.065	10.369	6.28
1503	241.249	15.4543	15.4602	-0.04	13.638	12.905	5.37
1504	241.891	15.4536	15.4590	-0.03	18.027	17.364	3.68
1505	243.148	15.4523	15.4565	-0.03	26.600	26.074	1.98
1506	246.601	15.4490	15.4481	0.01	49.822	49.933	-0.23
1507	251.930	15.4436	15.4423	0.01	86.273	86.453	-0.21
1508	257.186	15.4386	15.4375	0.01	122.011	122.182	-0.14
1509	261.745	15.4343	15.4335	0.01	152.813	152.930	-0.08
1510	267.242	15.4287	15.4300	-0.01	189.860	189.655	0.11
1511	273.834	15.4223	15.4245	-0.01	233.738	233.380	0.15
1512	282.799	15.4137	15.4187	-0.03	293.088	292.212	0.30
1513	290.022	15.4067	15.4131	-0.04	340.314	339.120	0.35
1514	298.219	15.3987	15.4081	-0.06	393.682	391.850	0.47
1515	309.559	15.3878	15.4010	-0.09	466.789	464.006	0.60
1601	230.051	16.0366	16.0361	0.00	8.060	8.126	-0.82

Table 12. Experimental and calculated P- ρ -T data- - - (Continued)

EQUATION OF STATE VS. PVT DATA

ID	T,K	MOL/L	CALCD	D,PCT	P,BAR	CALCD	P,PCT
1602	230.294	16.0362	16.0357	0.00	9.965	10.043	-0.78
1603	230.807	16.0359	16.0348	0.01	13.973	14.142	-1.21
1604	232.572	16.0339	16.0324	0.01	27.840	28.078	-0.85
1605	234.160	16.0323	16.0286	0.02	40.005	40.590	-1.46
1606	235.255	16.0313	16.0268	0.03	48.499	49.217	-1.48
1607	242.791	16.0236	16.0158	0.05	106.582	107.928	-1.26
1608	249.107	16.0170	16.0093	0.05	155.042	156.422	-0.89
1609	254.888	16.0110	16.0029	0.05	198.800	200.331	-0.77
1610	262.164	16.0037	15.9976	0.04	253.808	255.017	-0.48
1611	271.236	15.9943	15.9880	0.04	320.920	322.271	-0.42
1612	279.282	15.9860	15.9829	0.02	380.442	381.144	-0.18
1613	286.940	15.9781	15.9779	0.00	436.516	436.544	-0.01
1614	294.543	15.9704	15.9734	-0.02	491.788	491.055	0.15
1615	301.025	15.9638	15.9651	-0.01	537.420	537.087	0.06
1701	222.875	16.4230	16.4030	0.12	7.625	11.158	-46.34
1702	223.264	16.4227	16.4017	0.13	10.831	14.539	-34.24
1703	223.573	16.4223	16.4012	0.13	13.464	17.210	-27.83
1704	225.014	16.4210	16.3994	0.13	25.785	29.680	-15.10
1705	230.291	16.4154	16.3902	0.15	70.101	74.832	-6.75
1706	237.396	16.4077	16.3812	0.16	129.495	134.758	-4.06
1707	252.785	16.3911	16.3647	0.16	255.712	261.545	-2.28
1708	259.848	16.3838	16.3580	0.16	312.610	318.592	-1.91
1709	267.602	16.3755	16.3512	0.15	374.481	380.373	-1.57
1710	275.649	16.3668	16.3480	0.11	438.898	443.679	-1.09
1711	282.466	16.3598	16.3429	0.10	492.335	495.803	-0.91
1712	293.185	16.3485	16.3360	0.08	575.740	579.231	-0.61
1801	215.247	16.7539	16.7727	-0.11	6.823	3.084	54.80
1802	215.504	16.7536	16.7728	-0.11	9.325	5.477	41.27
1803	215.892	16.7532	16.7715	-0.11	12.777	9.119	28.62
1804	216.369	16.7526	16.7710	-0.11	17.256	13.541	21.53
1805	216.832	16.7522	16.7702	-0.11	21.511	17.890	16.83
1806	217.058	16.7519	16.7692	-0.10	23.470	19.977	14.88
1807	220.809	16.7476	16.7629	-0.09	57.842	54.663	5.50
1808	226.802	16.7409	16.7551	-0.08	112.523	109.438	2.74
1809	234.917	16.7323	16.7458	-0.08	185.542	182.440	1.67
1810	243.045	16.7233	16.7365	-0.08	257.383	254.185	1.24
1811	250.885	16.7147	16.7300	-0.09	326.185	322.276	1.20
1812	260.378	16.7044	16.7226	-0.11	408.368	403.438	1.21
1813	269.927	16.6937	16.7176	-0.14	490.451	483.674	1.38
1814	279.130	16.6847	16.7118	-0.16	559.695	551.671	1.43
1815	284.744	16.6778	16.7078	-0.18	615.144	605.967	1.49
1816	293.608	16.6681	16.7025	-0.21	688.810	677.857	1.59
1901	208.453	17.1250	17.0977	0.16	8.116	14.300	-76.19
1902	209.053	17.1244	17.0967	0.16	14.087	20.385	-44.71
1903	213.403	17.1194	17.0891	0.18	57.037	64.142	-12.46
1904	218.566	17.1134	17.0812	0.19	107.538	115.363	-7.28
1905	227.034	17.1038	17.0713	0.19	189.571	197.916	-4.40
1906	233.700	17.0961	17.0636	0.19	252.998	261.697	-3.44
1907	241.770	17.0871	17.0560	0.18	328.989	337.725	-2.66
1908	251.549	17.0762	17.0496	0.16	420.278	428.155	-1.87

Table 12. Experimental and calculated P- ρ -T data- - - (Continued)

EQUATION OF STATE VS. PVT DATA

ID	T,K	MOL/L	CALCD	D,PCT	P,BAR	CALCD	P,PCT
1909	260.957	17.0655	17.0446	0.12	507.048	513.568	-1.29
1910	268.486	17.0569	17.0368	0.12	574.398	580.876	-1.13
1911	280.494	17.0436	17.0328	0.06	683.038	686.701	-0.54
2001	198.356	17.5291	17.5476	-0.11	7.130	2.315	67.53
2002	199.230	17.5281	17.5454	-0.10	16.592	12.067	27.27
2003	200.946	17.5261	17.5424	-0.09	35.439	31.123	12.18
2004	204.756	17.5214	17.5355	-0.08	76.814	72.991	4.98
2005	210.931	17.5141	17.5267	-0.07	143.419	139.863	2.48
2006	220.998	17.5022	17.5152	-0.07	250.280	246.369	1.56
2007	227.537	17.4945	17.5071	-0.07	318.013	314.102	1.23
2008	235.067	17.4859	17.5015	-0.09	395.918	390.856	1.28
2009	242.758	17.4769	17.4948	-0.10	473.940	467.901	1.27
2010	249.071	17.4692	17.4903	-0.12	537.459	530.140	1.36
2011	256.389	17.4609	17.4875	-0.15	611.081	601.535	1.56
2012	263.603	17.4523	17.4829	-0.18	682.214	670.834	1.67
2101	183.907	17.9415	17.9532	-0.07	6.728	3.226	52.05
2102	189.331	17.9411	17.9521	-0.06	11.762	8.484	27.87
2103	189.746	17.9405	17.9515	-0.06	16.843	13.521	19.72
2104	192.590	17.9368	17.9459	-0.05	50.874	48.097	5.46
2105	198.660	17.9295	17.9362	-0.04	123.000	120.883	1.72
2106	205.509	17.9209	17.9254	-0.03	202.640	201.149	0.74
2107	213.217	17.9115	17.9159	-0.02	291.132	289.643	0.51
2108	220.733	17.9022	17.9096	-0.04	376.667	374.052	0.69
2109	228.543	17.8929	17.9040	-0.06	464.311	460.202	0.89
2110	238.949	17.8799	17.9001	-0.11	580.193	572.381	1.35
2201	176.719	18.4456	18.4480	-0.01	3.471	2.652	23.59
2202	177.382	18.4450	18.4462	-0.01	12.310	11.869	3.58
2203	178.429	18.4433	18.4445	-0.01	26.585	26.156	1.61
2204	179.691	18.4416	18.4416	-0.00	43.417	43.413	0.01
2205	182.793	18.4376	18.4358	0.01	84.808	85.485	-0.80
2206	188.263	18.4307	18.4260	0.03	156.732	158.461	-1.10
2207	195.148	18.4217	18.4155	0.03	245.802	248.198	-0.97
2208	201.949	18.4130	18.4077	0.03	332.786	334.917	-0.64
2209	208.686	18.4044	18.4024	0.01	418.212	419.023	-0.19
2210	215.452	18.3957	18.3979	-0.01	502.825	501.907	0.18
2211	222.008	18.3871	18.3956	-0.05	584.427	580.711	0.64
2212	227.030	18.3808	18.3942	-0.07	646.312	640.353	0.92
2213	229.121	18.3781	18.3946	-0.09	672.368	664.967	1.10
2301	168.032	18.8234	18.8126	0.06	10.003	14.303	-42.99
2302	168.479	18.8227	18.8117	0.06	16.593	21.008	-26.61
2303	169.437	18.8214	18.8093	0.06	30.514	35.366	-15.90
2304	171.067	18.8194	18.8057	0.07	54.233	59.753	-10.19
2305	173.679	18.8158	18.8008	0.08	92.210	98.292	-6.60
2306	177.673	18.8104	18.7931	0.09	149.285	156.488	-4.83
2307	183.136	18.8031	18.7831	0.11	226.036	234.559	-3.77
2308	188.844	18.7955	18.7749	0.11	305.443	314.423	-2.94
2309	195.448	18.7865	18.7688	0.09	396.836	404.799	-2.01
2310	201.251	18.7788	18.7661	0.07	476.851	482.746	-1.24
2311	206.784	18.7715	18.7606	0.06	550.626	555.805	-0.94

Table 12. Experimental and calculated P- ρ -T data - - (Continued)
EQUATION OF STATE VS. PVT DATA

ID	T,K	MOL/L	CALCD	D,PCT	P,BAR	CALCD	P,PCT
2312	212.460	18.7639	18.7618	0.01	628.513	629.515	-0.16
2313	217.337	18.7576	18.7591	-0.01	692.835	692.094	0.11
2401	157.201	19.2261	19.2220	0.02	5.219	7.098	-36.01
2402	158.496	19.2241	19.2189	0.03	26.162	28.516	-9.00
2403	159.577	19.2225	19.2149	0.04	42.827	46.284	-8.07
2404	160.786	19.2208	19.2138	0.04	62.930	66.128	-5.08
2405	163.656	19.2168	19.2080	0.05	108.664	112.741	-3.75
2406	167.103	19.2122	19.1981	0.07	161.353	167.949	-4.09
2407	172.270	19.2049	19.1897	0.08	241.688	248.959	-3.01
2408	177.321	19.1979	19.1815	0.09	318.533	326.541	-2.51
2409	183.160	19.1896	19.1764	0.07	407.622	414.225	-1.62
2410	188.652	19.1819	19.1726	0.05	490.353	495.107	-0.97
2411	194.552	19.1739	19.1703	0.02	578.543	580.480	-0.33
2412	199.115	19.1673	19.1720	-0.02	647.704	645.181	0.39
2413	202.417	19.1630	19.1682	-0.03	694.537	691.718	0.41
2501	134.069	20.4300	20.1037	1.60	14.291	221.481	-1449.79
2502	134.656	20.4293	20.1019	1.60	25.882	234.170	-804.77
2503	136.071	20.4270	20.0975	1.61	53.739	264.078	-391.41
2504	137.536	20.4247	20.0931	1.62	82.345	294.824	-258.04
2505	140.791	20.4194	20.0842	1.64	145.396	362.087	-149.04
2506	144.763	20.4134	20.0753	1.66	221.796	442.862	-99.67
2507	149.679	20.4054	20.0673	1.66	315.714	540.141	-71.09
2508	154.382	20.3981	20.0628	1.64	405.313	631.278	-55.75
2509	159.399	20.3904	20.0607	1.62	500.568	726.521	-45.14
2510	164.174	20.3828	20.0598	1.58	590.104	815.074	-38.12
2511	168.954	20.3755	20.0614	1.54	679.933	902.343	-32.71

NP = 321, DNRMS PCT = 2.853, PMEANPCT = 14.092

Table 13. Experimental and calculated ideal gas functions

IDEAL GAS FUNCTIONS FOR ETHANE, IN JOULES, MOLES, KELVINS

T, K	HZ	CALC	PCNT	SZ	CALC	FCNT	CPZ	CALC	FCNT
50.00	1663.77	1063.77	0.00	160.12	160.18	0.04	33.39	33.09	-0.90
100.00	3381.51	3381.50	-0.00	183.84	183.88	0.02	35.65	35.73	0.24
150.00	5233.20	5239.29	0.00	193.67	198.91	0.02	38.66	38.64	-0.96
200.00	7257.57	7257.41	-0.00	219.50	219.50	0.00	42.26	42.26	0.00
273.15	10601.17	10600.97	-0.00	224.68	224.69	0.00	49.54	49.53	-0.01
298.15	11675.82	11675.64	-0.00	223.12	229.15	0.01	52.47	52.47	0.01
300.00	11972.10	11972.91	0.01	223.45	229.47	0.01	52.72	52.69	-0.04
400.00	17875.72	17875.11	-0.00	246.35	246.37	0.00	65.48	65.48	0.00
500.00	25057.96	25058.40	0.00	262.34	262.34	0.00	77.99	78.00	0.02
600.00	33431.00	33431.55	0.00	277.57	277.58	0.00	89.24	89.23	-0.02
700.00	42862.99	42862.23	-0.00	292.09	292.10	0.00	99.20	99.19	-0.01
800.00	53230.52	53231.87	0.00	305.89	305.93	0.01	107.99	108.01	0.02
900.00	64425.65	64426.01	0.00	313.07	319.10	0.01	115.77	115.70	-0.06
1000.00	76353.82	76354.94	0.00	331.62	331.67	0.01	122.59	122.97	0.31

Table 14. Interpolated ideal gas functions

ETHANE IDEAL GAS FUNCTIONS, JOULES, MOLES, KELVINS

T, K	EZ	HZ	SZ	CVZ	CPZ
90	2279.7	3027.0	180.150	26.86	35.17
100	2550.1	3381.5	183.884	27.42	35.73
110	2827.0	3741.6	187.316	27.98	36.29
120	3109.6	4107.4	190.498	28.54	36.86
130	3397.9	4478.3	193.471	29.12	37.43
140	3692.0	4856.0	196.266	29.71	38.02
150	3992.1	5239.3	198.910	30.32	38.64
160	4298.6	5628.9	201.424	30.97	39.28
170	4611.6	6025.1	203.826	31.65	39.96
180	4931.7	6428.3	206.131	32.37	40.69
190	5259.2	6838.9	208.351	33.14	41.45
200	5594.0	7257.4	210.497	33.95	42.25
210	5938.2	7684.3	212.579	34.80	43.12
220	6290.7	8119.9	214.606	35.70	44.02
230	6652.5	8564.5	216.583	36.65	44.97
240	7023.9	9019.4	218.513	37.64	45.96
250	7405.5	9484.1	220.415	38.68	46.99
260	7797.6	9959.3	222.279	39.75	48.07
270	8200.6	10445.5	224.113	40.86	49.18
280	8614.9	10943.0	225.922	42.01	50.32
290	9040.7	11452.0	227.708	43.18	51.49
300	9478.6	11972.9	229.474	44.38	52.69
310	9928.5	12506.0	231.222	45.61	53.92
320	10390.8	13051.4	232.954	46.85	55.17
330	10865.6	13609.3	234.670	48.11	56.43
340	11353.1	14180.0	236.374	49.39	57.70
350	11853.4	14763.4	238.065	50.68	58.99
360	12366.6	15359.6	239.745	51.97	60.28
370	12892.8	15969.1	241.414	53.27	61.58
380	13432.0	16591.4	243.074	54.57	62.83
390	13984.2	17226.8	244.724	55.87	64.13
400	14549.4	17875.1	246.366	57.17	65.48
410	15127.5	18536.4	247.998	58.46	66.79
420	15718.6	19210.5	249.623	59.75	68.07
430	16322.5	19897.7	251.240	61.03	69.35
440	16939.2	20597.5	252.849	62.30	70.62
450	17568.5	21310.0	254.450	63.56	71.88
460	18210.5	22035.0	256.043	64.81	73.13
470	18864.8	22772.5	257.629	66.05	74.37
480	19531.5	23522.3	259.208	67.28	75.59
490	20210.3	24284.4	260.779	68.49	76.81
500	20901.3	25058.4	262.343	69.69	78.00
510	21604.1	25844.4	263.899	70.87	79.19
520	22318.7	26642.1	265.448	72.05	80.36
530	23045.0	27451.5	266.990	73.20	81.52
540	23782.7	28272.4	268.524	74.35	82.66
550	24531.5	29104.7	270.051	75.47	83.79
560	25292.2	29948.2	271.571	76.59	84.90
570	26063.8	30802.7	273.084	77.69	86.01
580	26845.9	31668.2	274.589	78.78	87.09
590	27639.1	32544.5	276.087	79.85	88.17
600	28443.6	33431.5	277.578	80.92	89.23

Table 15. Experimental and calculated heats of vaporization

ID: (10) Douslin; (11) Wiebe; (13) Riedel via Furtado; (20) Furtado

1.21027302+001		1.11655879+001	1.65332652+001	
-7.18546945+001		8.21662387+001	-3.26105136+001	
ID	T,K	KJ/MOL	CALCD	PCNT
10	248.15	11.239	11.235	0.57
10	253.15	10.925	10.862	0.58
10	263.15	10.072	10.039	0.33
10	273.15	9.073	9.072	0.01
10	283.15	7.844	7.878	-0.44
10	293.15	6.170	6.253	-1.34
10	298.15	5.034	5.090	-1.09
10	302.15	3.677	3.708	-0.85
10	303.15	3.207	3.208	-0.02
10	304.15	2.548	2.547	0.04
13	100.00	17.154	17.312	-0.91
13	111.11	16.928	17.068	-0.82
13	133.33	16.455	16.492	-0.22
13	155.56	15.853	15.797	0.35
13	166.67	15.430	15.403	0.50
13	180.00	14.957	14.886	0.48
12	184.11	14.712	14.717	-0.07
13	184.11	14.802	14.716	0.58
13	190.00	14.526	14.465	0.43
13	200.00	14.049	14.012	0.26
13	210.00	13.530	13.525	0.04
13	220.00	12.939	12.998	0.01
13	230.00	12.338	12.425	-0.30
13	240.00	11.743	11.797	-0.46
13	250.00	11.044	11.099	-0.50
13	260.00	10.237	10.311	-0.24
13	270.00	9.416	9.396	0.22
13	280.00	8.333	8.287	0.80
13	290.00	6.853	6.836	0.40
13	300.00	4.557	4.531	0.57
20	100.00	17.544	17.312	1.34
20	111.11	17.117	17.068	0.28
20	133.33	16.437	16.492	0.03
20	155.56	15.761	15.797	-0.23
20	166.67	15.351	15.403	-0.34
20	180.00	14.832	14.886	-0.36
20	184.11	14.677	14.716	-0.27
20	190.00	14.422	14.465	-0.30
20	200.00	13.953	14.012	-0.42
20	210.00	13.438	13.525	-0.27
20	220.00	12.939	12.998	0.01
20	230.00	12.434	12.425	0.07
20	240.00	11.814	11.797	0.15
20	250.00	11.065	11.099	-0.31
20	260.00	10.237	10.311	-0.24
20	270.00	9.416	9.396	0.22
20	280.00	8.249	8.287	-0.46
20	290.00	6.863	6.836	0.40
20	300.00	4.612	4.531	1.78
11	190.00	13.777	14.465	-4.75
11	195.00	13.635	14.242	-4.27
11	200.00	13.511	14.012	-3.65
11	205.00	13.338	13.773	-3.16
11	210.00	13.179	13.525	-2.56
11	215.00	12.939	13.266	-2.02
11	220.00	12.806	12.998	-1.47
11	225.00	12.534	12.718	-1.05
11	230.00	12.362	12.425	-0.50
11	235.00	12.111	12.119	-0.06
11	240.00	11.844	11.797	0.40
11	245.00	11.551	11.458	0.81
11	250.00	11.233	11.099	1.20
11	255.00	10.831	10.718	1.52
11	260.00	10.432	10.311	1.75
11	265.00	10.036	9.872	1.65
11	270.00	9.534	9.396	2.00
11	275.00	9.032	8.872	1.47
11	280.00	8.429	8.287	1.71
11	285.00	7.700	7.620	1.05
11	290.00	6.834	6.836	-0.03
11	295.00	5.779	5.865	-1.46
11	300.00	4.234	4.531	-5.24

NP = 43, RMSPCT = 0.56

Table 16. Experimental and calculated specific heats for saturated liquid

ID: (11) Wiebe; (12) Witt		$T_c = 305.37\text{ K}$		
6.73153+001		-1.65876+001	1.63526+001	$\epsilon = 0.5$
ID	T, K	J/MOL/K	CALCD	PCNT
12	90.00	68.22	68.17	0.07
11	96.77	68.42	68.33	0.14
11	96.82	68.72	68.33	0.57
11	98.06	68.51	68.36	0.21
12	100.00	68.55	68.41	0.20
11	101.54	68.68	68.46	0.32
11	107.08	68.59	68.61	-0.03
11	108.65	68.51	68.66	-0.22
12	110.00	68.93	68.70	0.32
11	115.74	68.63	68.89	-0.38
11	116.19	68.42	68.91	-0.70
12	120.00	69.26	69.04	0.31
11	122.70	69.51	69.15	0.53
11	123.60	69.14	69.18	-0.06
11	128.08	69.51	69.36	0.22
11	128.49	69.47	69.38	0.14
12	130.00	69.51	69.44	0.10
11	132.65	69.81	69.55	0.36
11	138.05	69.85	69.80	0.06
11	138.18	69.97	69.81	0.23
11	138.31	69.81	69.82	-0.01
12	140.00	69.85	69.90	-0.07
11	142.43	70.06	70.02	-0.05
11	143.36	70.02	70.07	-0.08
12	150.00	70.27	70.43	-0.23
11	151.75	69.93	70.53	-0.85
11	152.60	70.10	70.58	-0.68
11	154.99	70.22	70.72	-0.71
11	156.98	70.22	70.85	-0.88
11	157.42	70.06	70.88	-1.15
12	160.00	70.85	71.04	-0.27
11	160.10	71.06	71.05	0.02
11	162.65	71.14	71.22	-0.11
11	164.49	71.69	71.35	0.48
11	168.09	71.56	71.61	-0.06
12	170.00	71.48	71.75	-0.38
11	170.18	71.73	71.77	-0.05
11	172.05	71.73	71.91	-0.25
11	172.69	72.11	71.96	0.20
11	178.17	72.78	72.42	0.49
12	180.00	72.23	72.58	-0.48
11	181.50	73.03	72.72	0.43
11	182.03	73.28	72.77	0.71
11	190.00	73.49	73.55	-0.08
11	199.86	74.33	74.67	-0.46
11	208.88	75.62	75.87	-0.32
11	212.80	75.92	76.45	-0.70
11	220.48	77.76	77.73	0.03
11	228.76	80.56	79.35	1.53
11	236.21	82.28	81.06	1.50
11	244.61	83.91	83.39	0.62
11	252.53	87.09	86.11	1.14
11	258.22	88.39	88.48	-0.10
11	265.25	92.28	92.09	0.20
11	273.06	98.05	97.44	0.63
11	278.07	101.28	102.01	-0.72
11	284.07	109.06	109.48	-0.39
11	291.27	122.62	124.08	-1.18
11	294.85	135.72	136.37	-0.47
NP = 59, RMSPCT = 0.54				

Table 17. Experimental and calculated specific heats $C_p(T)$ on isobar P_b

$T_M = 354.0$, $CM = 117.333$

3.89154 -0.15442 -0.14149 -0.50644 0.27699

T,K	J/MOL/K	CALC	PCT
110.928	68.19	68.45	-0.39
118.372	68.45	68.55	-0.15
122.039	68.56	68.62	-0.08
133.150	68.94	68.87	0.10
144.261	69.44	69.23	0.31
155.372	70.08	69.70	0.55
166.483	70.59	70.29	0.42
177.594	71.09	71.03	0.09
186.872	71.58	71.75	-0.24
188.706	71.71	71.91	-0.27
199.817	72.72	72.94	-0.30
210.928	73.98	74.15	-0.23
222.039	75.37	75.54	-0.23
233.150	77.13	77.14	-0.01
241.761	78.63	78.53	0.13
244.261	79.00	78.96	0.06
255.372	81.14	81.03	0.13
266.483	83.41	83.42	-0.01
277.594	86.31	86.17	0.17
282.706	87.70	87.58	0.13
288.706	89.71	89.39	0.36
299.817	92.97	93.22	-0.27
305.261	94.86	95.38	-0.55
310.928	97.88	97.88	0.00
322.039	103.80	103.63	0.17
324.817	105.43	105.26	0.16
333.150	110.45	110.54	-0.08
344.261	116.62	116.62	0.00

NP = 28, RMS = 0.25

Table 18. Calculated $P(\rho)$ critical isotherm

The following page gives a high-resolution examination of the critical isotherm of ethane as computed by equation of state (5). Column headings have the following interpretations--

$D/DC \equiv d/d_c$, density reduced at the critical point.

$P/PC \equiv P/P_c$, pressure reduced at the critical point.

$DP/DD \equiv \partial P/\partial d$, slope of the critical isotherm, bar/(mol/l).

The last five columns give the density-dependence of functions used in the equation of state, where $R \equiv \rho \equiv d/d_t$ is density reduced at the liquid triple point--

$DTS/DR \equiv dT_\sigma(\rho)/d\rho$, K.

$DTH/DR \equiv d\theta(\rho)/d\rho$, K.

$DPS/DR \equiv dP_\sigma(\rho)/d\rho$, bar.

$DXB/DR \equiv \partial\Phi(\rho, T)/\partial\rho$.

$DXC/DR \equiv \partial\Psi(\rho, T)/\partial\rho$.

Table 18. Calculated P(p) critical isotherm.

TC = 305.370, DC = 6.740, PC = 48.7550

D/DC	P/PC	DP/DD	DTS/DR	DTH/DR	DPS/DR	DXB/DR	DXC/DR
0.75	0.993995341	0.658819307	40.90712	74.38357	40.77208	-0.13448	0.40412
0.76	0.994858823	0.591217592	38.34226	69.22775	38.32854	-0.12600	0.38616
0.77	0.995632133	0.528321099	35.89818	64.29211	35.98713	-0.11792	0.36888
0.78	0.996321595	0.469866251	33.56442	59.56723	33.73933	-0.11021	0.35219
0.79	0.996933166	0.415589108	31.32866	55.04173	31.57456	-0.10284	0.33599
0.80	0.997472439	0.365229997	29.17651	50.70206	29.47982	-0.09575	0.32014
0.81	0.997944660	0.318539129	27.09132	46.53235	27.43963	-0.08888	0.30447
0.82	0.998354733	0.275283463	25.05409	42.51428	25.43582	-0.08217	0.28875
0.83	0.998707261	0.235255248	23.04356	38.62722	23.44768	-0.07556	0.27271
0.84	0.999006584	0.198282488	21.03666	34.84865	21.45237	-0.06896	0.25603
0.85	0.999256832	0.164241474	19.00951	31.15516	19.42597	-0.06230	0.23833
0.86	0.999462008	0.133071105	16.93942	27.52453	17.34554	-0.05551	0.21919
0.87	0.999626082	0.104787529	14.80834	23.93907	15.19272	-0.04852	0.19819
0.88	0.999753105	0.079495860	12.60834	20.39122	12.95942	-0.04130	0.17498
0.89	0.999847343	0.057392249	10.34968	16.89154	10.65629	-0.03390	0.14936
0.90	0.999913379	0.038744754	8.07130	13.47924	8.32377	-0.02644	0.12153
0.91	0.999956191	0.023836181	5.85191	10.23329	6.04377	-0.01917	0.09228
0.92	0.999981094	0.012851315	3.81596	7.27835	3.94613	-0.01250	0.06328
0.93	0.999993499	0.005707396	2.12263	4.77383	2.19740	-0.00695	0.03716
0.94	0.999998411	0.001881248	0.92089	2.86884	0.95413	-0.00302	0.01707
0.95	0.999999775	0.000380131	0.26456	1.61736	0.27427	-0.00087	0.00521
0.96	0.999999987	0.000031585	0.03611	0.90191	0.03745	-0.00012	0.00076
0.97	0.999999999	0.000000382	0.00107	0.48808	0.00111	-0.00000	0.00002
0.98	1.000000000	0.000000001	0.00000	0.21645	0.00000	-0.00000	0.00000
0.99	1.000000000	0.000000000	0.00000	0.05411	0.00000	-0.00000	0.00000
1.00	1.000000000	0.000000001	0.00000	0.00000	0.00000	0.00000	0.00000
1.01	1.000000000	0.000000001	-0.00000	-0.05411	-0.00000	0.00000	-0.00000
1.02	1.000000000	0.000000000	-0.00000	-0.21645	-0.00000	0.00000	-0.00000
1.03	0.999999999	0.000000307	-0.00017	-0.48719	-0.00018	0.00000	-0.00000
1.04	1.000000006	0.000015499	-0.00658	-0.87239	-0.00683	0.00002	-0.00014
1.05	1.000000099	0.000163143	-0.05510	-1.40790	-0.05714	0.00018	-0.00109
1.06	1.000000673	0.000790788	-0.21774	-2.16574	-0.22573	0.00071	-0.00408
1.07	1.000002769	0.002471622	-0.56601	-3.21735	-0.58651	0.00185	-0.01010
1.08	1.000008306	0.005884685	-1.13956	-4.60234	-1.18018	0.00373	-0.01943
1.09	1.000020147	0.011698168	-1.94303	-6.32524	-2.01086	0.00636	-0.03171
1.10	1.000042032	0.020506538	-2.95766	-8.36717	-3.05834	0.00969	-0.04633
1.11	1.000078458	0.032814787	-4.15409	-10.69861	-4.29137	0.01360	-0.06259
1.12	1.000134569	0.049048904	-5.50116	-13.28819	-5.67682	0.01802	-0.07991
1.13	1.000216050	0.069575997	-6.97053	-16.10734	-7.18454	0.02283	-0.09782
1.14	1.000329066	0.094724915	-8.53860	-19.13220	-8.78935	0.02797	-0.11598
1.15	1.000480221	0.124803633	-10.18679	-22.34387	-10.47126	0.03337	-0.13414
1.16	1.000676539	0.160112464	-11.90101	-25.72791	-12.21500	0.03899	-0.15216
1.17	1.000925457	0.200953526	-13.67097	-29.27363	-14.00923	0.04480	-0.16995
1.18	1.001234836	0.247637223	-15.48936	-32.97332	-15.84571	0.05076	-0.18744
1.19	1.001612976	0.300486478	-17.35121	-36.82149	-17.71862	0.05687	-0.20483
1.20	1.002068631	0.359839428	-19.25328	-40.81437	-19.62388	0.06312	-0.22150
1.21	1.002611035	0.426051033	-21.19357	-44.94941	-21.55873	0.06950	-0.23807
1.22	1.003249928	0.499493948	-23.17105	-49.22492	-23.52133	0.07600	-0.25436
1.23	1.003995570	0.580558929	-25.18528	-53.63980	-25.51048	0.08262	-0.27039
1.24	1.004858783	0.669654959	-27.23630	-58.19332	-27.52539	0.08938	-0.28618
1.25	1.005850959	0.767209159	-29.32441	-62.88500	-29.56554	0.09626	-0.30175

Table 19. Loop closure computations for saturated liquid.
 ENTHALPY, H, VIA FURTDAC CP(T). HC VIA CLAPEYRON EQN.

T,K	H	HC	PCT	S	SC	PCT
90	5306	5382	1.45	76.57	77.16	0.77
95	5648	5677	0.51	80.28	80.44	0.21
100	5991	5978	-0.22	83.80	83.55	-0.29
105	6335	6296	-0.61	87.15	86.65	-0.57
110	6678	6633	-0.68	90.35	89.79	-0.62
115	7023	6987	-0.52	93.41	92.93	-0.51
120	7368	7352	-0.21	96.35	96.05	-0.31
125	7714	7724	0.13	99.17	99.09	-0.08
130	8061	8098	0.46	101.89	102.04	0.14
135	8409	8470	0.73	104.52	104.86	0.32
140	8758	8837	0.90	107.06	107.54	0.45
145	9108	9197	0.98	109.51	110.08	0.52
150	9460	9552	0.97	111.90	112.50	0.54
155	9814	9901	0.89	114.22	114.80	0.51
160	10169	10246	0.76	116.47	117.00	0.45
165	10527	10589	0.60	118.67	119.11	0.38
170	10886	10932	0.42	120.81	121.16	0.29
175	11248	11277	0.26	122.91	123.16	0.20
180	11613	11626	0.11	124.96	125.11	0.13
185	11981	11979	-0.02	126.96	127.04	0.06
190	12352	12340	-0.10	128.93	128.95	0.02
195	12727	12707	-0.15	130.87	130.85	-0.01
200	13106	13083	-0.17	132.77	132.73	-0.03
205	13488	13466	-0.16	134.65	134.61	-0.03
210	13876	13857	-0.14	136.50	136.47	-0.02
215	14268	14255	-0.09	138.32	138.32	-0.00
220	14666	14660	-0.04	140.13	140.15	0.02
225	15070	15071	0.00	141.92	141.97	0.04
230	15480	15486	0.04	143.69	143.77	0.05
235	15898	15908	0.06	145.45	145.54	0.06
240	16323	16336	0.08	147.21	147.30	0.06
245	16758	16768	0.07	148.96	149.04	0.06
250	17202	17210	0.05	150.70	150.77	0.05
255	17657	17660	0.02	152.45	152.50	0.03
260	18125	18123	-0.01	154.21	154.24	0.02
265	18607	18601	-0.03	155.99	156.00	0.01
270	19107	19098	-0.05	157.78	157.78	0.00
275	19628	19619	-0.04	159.62	159.62	0.00
280	20175	20169	-0.03	161.50	161.51	0.01
285	20756	20754	-0.01	163.46	163.48	0.01
290	21386	21383	-0.02	165.55	165.56	0.01
295	22093	22080	-0.06	167.84	167.82	-0.01
300	22950	22915	-0.16	170.58	170.49	-0.06

Table 20. Experimental and calculated specific heats, $C_p(\rho, T)$.

THE CP ISOBAR AT P = 0.000 BAR				
T, K	MOL/L	J/MOL/K	CALCD	PCNT
99.817	0.000	35.86	35.72	0.37
110.928	0.000	36.49	36.34	0.41
118.372	0.000	36.98	36.76	0.59
122.039	0.000	37.24	36.97	0.73
133.150	0.000	37.99	37.61	1.00
144.261	0.000	38.74	38.28	1.19
155.372	0.000	39.25	38.98	0.69
166.483	0.000	40.02	39.72	0.74
177.594	0.000	40.77	40.51	0.64
186.872	0.000	41.39	41.21	0.43
188.706	0.000	41.65	41.35	0.72
199.817	0.000	42.53	42.24	0.67
210.928	0.000	43.52	43.20	0.74
222.039	0.000	44.53	44.21	0.73
233.150	0.000	45.55	45.27	0.60
241.761	0.000	46.43	46.14	0.62
244.261	0.000	46.67	46.39	0.59
255.372	0.000	47.93	47.56	0.76
266.483	0.000	49.20	48.78	0.85
277.594	0.000	50.46	50.04	0.82
282.706	0.000	50.96	50.63	0.65
288.706	0.000	51.71	51.34	0.72
299.817	0.000	52.84	52.67	0.31
305.261	0.000	53.21	53.34	-0.23
310.928	0.000	53.85	54.03	-0.34
322.039	0.000	55.24	55.42	-0.33
324.817	0.000	55.61	55.77	-0.29
333.150	0.000	56.62	56.83	-0.36
344.261	0.000	58.12	58.25	-0.22
355.372	0.000	60.15	59.68	0.77
366.483	0.000	61.65	61.12	0.85
366.817	0.000	61.78	61.17	0.99
377.594	0.000	63.17	62.57	0.94
388.706	0.000	64.53	64.02	0.80
399.817	0.000	65.81	65.46	0.53
410.928	0.000	66.56	66.90	-0.51
422.039	0.000	67.81	68.33	-0.76
THE CP ISOBAR AT P = 17.237 BAR				
T, K	MOL/L	J/MOL/K	CALCD	PCNT
99.817	21.340	68.45	68.59	-0.21
110.928	20.943	68.69	68.80	-0.15
118.372	20.676	68.83	68.98	-0.23
122.039	20.544	68.94	69.09	-0.22
133.150	20.142	69.20	69.50	-0.43
144.261	19.734	69.82	70.03	-0.30
155.372	19.318	70.70	70.70	-0.00
166.483	18.891	71.47	71.55	-0.11
177.594	18.452	72.46	72.59	-0.18
186.872	18.073	73.34	73.63	-0.39
188.706	17.936	73.47	73.86	-0.53
199.817	17.522	74.99	75.41	-0.55
210.928	17.025	76.75	77.31	-0.72
222.039	16.438	78.89	79.66	-0.98
233.150	15.933	82.02	82.67	-0.80
241.761	15.460	85.30	85.68	-0.44
244.261	15.315	85.94	86.70	-0.89
249.817	14.990	89.33	89.31	0.02
252.594	14.804	91.34	90.84	0.55
255.372	14.621	94.11	92.54	1.67
258.150	14.431	98.76	94.48	4.33
260.928	1.053	74.35	71.68	3.59
262.594	1.037	72.72	70.51	3.04
265.372	1.012	70.21	68.88	1.90
266.483	1.002	69.44	68.32	1.62
277.594	0.921	65.17	64.56	0.94
282.706	0.890	64.05	63.57	0.75
288.706	0.858	63.28	62.77	0.80
299.817	0.805	62.40	62.01	0.62
305.261	0.783	62.15	61.87	0.45
310.928	0.761	62.02	61.86	0.27
322.039	0.723	62.28	62.10	0.30
324.817	0.714	62.40	62.20	0.31
333.150	0.589	62.77	62.61	0.26
344.261	0.659	63.65	63.31	0.53
355.372	0.632	64.53	64.17	0.57
366.483	0.608	65.30	65.12	0.27
366.817	0.607	65.41	65.15	0.40
377.594	0.596	66.18	66.17	0.03

Table 20. Experimental and calculated specific heats, $C_p(\rho, T)$, (continued).

THE CP ISOBAR AT P = 28.269 BAR				
T, K	MOL/L	J/MOL/K	CALCD	PCNT
277.594	13.020	115.37	113.73	1.42
278.706	12.906	116.13	116.21	-0.07
279.817	12.788	118.65	119.01	-0.31
THE CP ISOBAR AT P = 34.474 BAR				
T, K	MOL/L	J/MOL/K	CALCD	PCNT
233.150	16.045	81.78	81.55	0.28
241.761	15.594	84.42	84.13	0.35
244.261	15.457	85.30	84.99	0.37
255.372	14.807	89.20	89.67	-0.53
266.483	14.066	96.86	96.69	0.20
277.594	13.185	109.70	109.28	0.39
282.706	12.652	119.26	119.93	-0.56
285.928	12.272	128.82	130.62	-1.40
287.594	12.049	136.88	138.50	-1.18
288.706	11.886	142.81	145.26	-1.72
290.372	2.432	131.60	132.60	-0.77
291.483	2.377	122.28	124.59	-1.89
292.594	2.327	115.63	118.25	-2.27
294.261	2.261	107.19	110.84	-3.40
297.039	2.166	98.52	101.99	-3.53
299.817	2.087	98.38	95.77	2.66
305.261	1.959	87.06	87.69	-0.72
310.928	1.853	82.28	82.43	-0.18
322.039	1.631	76.25	76.54	-0.39
324.817	1.658	75.61	75.60	0.02
333.150	1.569	73.72	73.53	0.26
344.261	1.470	72.22	71.96	0.36
355.372	1.338	71.47	71.23	0.33
366.483	1.318	71.47	71.04	0.60
366.817	1.316	71.47	71.04	0.60
THE CP ISOBAR AT P = 41.369 BAR				
T, K	MOL/L	J/MOL/K	CALCD	PCNT
282.706	12.842	111.60	113.45	-1.66
288.706	12.131	129.59	129.39	0.16
294.261	11.356	161.66	163.98	-1.43
295.928	11.021	179.28	187.10	-4.36
297.039	10.752	195.01	212.72	-9.08
298.706	3.252	220.80	208.18	5.71
299.817	3.131	189.98	179.61	5.46
299.817	3.131	189.85	179.61	5.39
300.650	3.055	168.60	165.17	2.03
301.206	3.009	157.76	157.51	0.16
302.594	2.909	137.89	142.85	-3.59
305.261	2.754	122.41	124.78	-1.94
310.928	2.516	104.68	104.74	-0.06
322.039	2.214	89.20	89.19	1.13
324.817	2.157	86.93	85.89	1.20
THE CP ISOBAR AT P = 46.678 BAR				
T, K	MOL/L	J/MOL/K	CALCD	PCNT
298.428	10.938	174.88	180.66	-3.31
299.817	10.619	198.79	206.55	-3.90
300.650	10.332	221.43	230.76	-4.21
301.206	10.219	240.31	253.87	-5.64
302.039	9.906	279.31	310.02	-10.99
302.594	9.639	320.83	381.40	-18.88
302.872	9.474	352.28	443.36	-25.85
303.150	9.270	401.35	549.78	-36.98
303.983	4.273	425.25	457.03	-7.47
304.261	4.176	352.28	394.11	-11.87
305.261	3.922	299.44	281.47	6.00
305.372	3.900	293.15	274.01	6.53
305.928	3.739	261.69	243.90	6.80
306.761	3.673	223.05	213.18	4.81
308.150	3.505	184.94	181.23	2.00
309.539	3.371	162.30	151.11	0.73
310.928	3.259	146.47	147.11	0.92
310.928	3.259	148.84	147.11	1.17
313.706	3.078	130.85	128.66	1.67
316.483	2.934	120.28	116.93	2.78
322.039	2.712	119.02	102.71	13.71
324.817	2.623	97.88	98.06	-0.18

Table 20. Experimental and calculated specific heats, $C_p(\rho, T)$, (continued).

THE CP ISOBAR AT P = 49.160 BAR				
T, K	MOL/L	J/MOL/K	CALCD	PCNT
232.706	13.026	106.07	108.18	-1.99
283.150	12.986	106.69	103.82	-2.00
288.706	12.443	119.15	119.03	0.10
294.261	11.778	135.50	136.93	-1.06
297.039	11.366	149.08	152.75	-2.46
298.261	11.158	156.64	162.78	-3.92
299.817	10.858	177.89	180.52	-1.47
300.928	10.610	193.13	199.02	-3.05
302.039	10.320	217.40	226.77	-4.31
302.594	10.152	231.24	246.82	-6.74
303.150	9.963	246.48	274.21	-11.25
303.706	9.743	274.40	314.24	-14.52
304.261	9.476	566.16	379.44	32.98
304.817	9.125	691.97	510.24	26.26
305.261	8.707	1006.50	795.16	21.00
305.261	8.707	1132.32	795.16	29.79
306.483	4.904	553.58	709.02	-28.08
307.039	4.603	488.15	474.72	2.75
307.594	4.401	375.56	371.78	1.01
308.150	4.247	332.39	312.59	5.96
309.261	4.016	261.83	246.21	5.97
310.928	3.769	200.05	196.12	1.96
313.706	3.435	158.14	155.87	1.44
316.483	3.281	135.50	134.78	0.53
322.039	2.987	108.82	112.55	-3.42
324.817	2.875	101.91	105.91	-3.92
327.594	2.777	102.54	100.83	1.67
333.150	2.613	95.37	93.61	1.84
THE CP ISOBAR AT P = 51.711 BAR				
T, K	MOL/L	J/MOL/K	CALCD	PCNT
322.039	3.310	125.81	126.12	-0.25
324.817	3.164	116.88	116.22	0.57
333.150	2.841	99.26	99.23	0.04
344.261	2.549	88.82	88.60	0.26
355.372	2.339	83.03	83.19	-0.19
366.483	2.176	79.27	80.19	-1.16
366.817	2.171	79.13	80.12	-1.25
377.594	2.043	76.75	78.50	-2.28
THE CP ISOBAR AT P = 56.468 BAR				
T, K	MOL/L	J/MOL/K	CALCD	PCNT
310.372	8.515	408.89	442.02	-8.10
310.650	8.338	444.12	479.25	-7.91
310.928	8.146	483.13	519.80	-7.59
311.206	7.938	530.92	560.87	-5.64
311.483	7.718	577.48	596.74	-3.33
311.761	7.488	626.55	619.71	1.09
312.039	7.256	666.81	623.91	6.43
312.150	7.165	680.65	620.86	8.78
312.261	7.076	689.46	616.16	10.63
312.428	6.944	693.22	607.65	12.34
312.594	6.817	694.48	598.49	13.82
312.706	6.733	693.22	598.20	13.71
312.817	6.652	691.97	591.75	14.48
312.928	6.572	679.39	585.18	13.87
313.150	6.419	644.15	571.49	11.28
313.428	6.235	595.10	549.95	7.59
313.706	6.054	552.31	520.95	5.68
313.983	5.909	514.58	489.20	4.93
314.261	5.766	485.64	458.39	5.61

Table 20. Experimental and calculated specific heats, $C_p(\rho, T)$, (continued).

THE CP ISOBAR AT P = 63.948 BAR				
T, K	MOL/L	J/MOL/K	CALCD	PCNT
110.928	21.009	68.56	63.64	-0.11
118.372	20.748	68.69	63.79	-0.13
122.039	20.619	68.83	63.87	-0.07
133.150	20.227	69.07	63.21	-0.20
144.261	19.830	69.71	63.66	0.07
155.372	19.426	70.46	70.23	0.32
166.483	19.015	71.21	70.96	0.35
177.594	18.533	71.84	71.84	-0.00
186.872	18.232	72.46	72.73	-0.36
188.706	18.159	73.23	72.92	0.43
199.817	17.711	73.98	74.20	-0.29
210.928	17.246	75.37	75.72	-0.47
222.039	16.760	77.00	77.54	-0.70
233.150	16.250	79.27	79.71	-0.57
241.761	15.833	81.14	81.72	-0.72
244.261	15.708	82.41	82.37	0.06
255.372	15.126	85.68	85.68	-0.01
266.483	14.489	89.46	90.00	-0.60
277.594	13.773	95.74	96.01	-0.28
282.706	13.407	98.89	99.72	-0.83
288.706	12.937	104.93	105.30	-0.36
299.817	11.886	111.84	122.47	-9.50
305.261	11.228	137.15	138.02	-0.64
310.928	10.353	158.53	166.91	-5.29
314.261	9.637	176.39	196.21	-11.23
316.483	9.148	200.16	223.37	-11.59
317.594	8.844	222.69	238.79	-7.23
319.261	8.349	254.27	260.98	-2.64
320.372	7.998	270.62	271.62	-0.37
320.928	7.820	277.80	274.61	1.15
322.039	7.468	284.97	274.66	3.62
322.706	7.264	285.59	271.01	5.11
323.706	6.972	285.22	262.63	7.92
324.817	6.670	281.83	256.13	9.12
324.817	6.670	282.20	256.13	9.24
325.372	6.528	277.16	251.11	9.40
326.483	6.261	258.30	240.78	6.73
327.594	6.017	240.93	229.87	5.01
330.372	5.503	200.55	193.26	0.64
333.150	5.103	176.51	175.40	0.62
335.928	4.734	158.91	157.02	1.19
338.706	4.525	143.69	142.97	0.50
344.261	4.126	123.29	123.74	-0.36
355.372	3.534	104.42	103.65	0.73
366.483	3.241	94.49	93.94	0.58
366.817	3.232	94.24	93.73	0.55
THE CP ISOBAR AT P = 85.184 BAR				
T, K	MOL/L	J/MOL/K	CALCD	PCNT
282.706	13.675	94.86	95.17	-0.33
288.706	13.260	98.89	98.94	-0.05
299.817	12.339	108.21	108.67	-0.42
305.261	11.894	114.82	115.53	-0.80
310.928	11.310	123.42	125.07	-1.33
316.483	10.647	134.61	137.82	-2.38
322.039	9.867	149.97	154.63	-3.11
324.817	9.428	160.16	164.03	-2.41
327.594	8.957	168.20	172.82	-2.75
330.372	8.467	176.13	179.23	-1.76
333.150	7.973	180.54	181.35	-0.45
334.817	7.684	181.17	180.18	0.55
337.039	7.317	180.29	176.04	2.36
338.706	7.060	177.65	171.68	3.36
341.483	6.665	170.23	165.13	2.99
344.261	6.311	161.79	157.81	2.46
349.817	5.713	148.47	142.89	3.75
355.372	5.241	134.00	130.08	2.92
366.483	4.557	114.24	112.09	1.88
366.817	4.540	113.98	111.68	2.01
377.594	4.086	101.66	101.36	0.30

Table 20 Experimental and calculated specific heats, $C_p(\rho, T)$, (continued).

THE CP ISOBAR AT P = 103.421 BAR				
T, K	MOL/L	J/MOL/K	CALCD	PCNT
241.761	16.045	79.64	79.93	-0.36
244.261	15.929	80.15	80.44	-0.37
255.372	15.394	82.79	82.99	-0.25
266.483	14.824	85.94	86.07	-0.15
277.594	14.207	89.84	89.86	-0.03
282.706	13.903	91.84	91.94	-0.11
288.706	13.528	94.73	94.74	-0.01
299.817	12.765	101.66	101.29	0.37
305.261	12.349	105.68	105.41	0.25
310.928	11.881	110.34	110.57	-0.21
316.483	11.378	115.63	116.70	-0.92
322.039	10.825	122.17	124.00	-1.50
324.817	10.528	126.44	128.06	-1.28
327.594	10.217	129.97	132.29	-1.79
333.150	9.555	137.89	140.60	-1.96
338.706	8.855	144.81	146.68	-1.29
344.261	8.156	150.85	148.60	1.49
344.928	8.074	151.73	148.33	2.24
345.928	7.953	151.48	147.78	2.44
348.150	7.691	151.11	146.01	3.37
349.817	7.501	149.22	144.25	3.33
352.594	7.202	144.81	140.73	2.82
355.372	6.923	140.91	136.97	2.80
360.928	6.425	132.35	130.00	1.77
366.483	5.336	126.82	123.53	2.60
366.817	5.972	126.44	123.14	2.61
377.594	5.311	116.75	112.23	3.87
THE CP ISOBAR AT P = 120.658 BAR				
T, K	MOL/L	J/MOL/K	CALCD	PCNT
324.817	11.192	113.73	113.36	0.33
333.150	10.439	120.28	120.95	-0.56
338.706	9.903	124.68	125.75	-0.86
344.261	9.348	129.70	130.03	-0.25
347.039	9.068	131.60	130.98	0.47
349.817	8.790	132.74	131.44	0.98
351.761	8.598	133.12	131.44	1.26
352.317	8.543	133.23	131.39	1.38
355.372	8.248	132.35	130.74	1.21
358.150	7.938	130.34	129.64	0.54
360.928	7.738	128.34	128.13	0.16
366.483	7.274	124.04	124.21	-0.13
366.817	7.247	123.80	123.95	-0.12
377.594	6.486	117.26	116.09	1.00
THE CP ISOBAR AT P = 137.895 BAR				
T, K	MOL/L	J/MOL/K	CALCD	PCNT
110.928	21.095	68.19	68.45	-0.39
118.372	20.941	68.45	68.55	-0.15
122.039	20.716	68.56	68.62	-0.08
133.150	20.335	68.94	68.87	0.10
144.261	19.952	69.44	69.23	0.31
155.372	19.564	70.08	69.70	0.55
166.483	19.170	70.59	70.29	0.41
177.594	18.768	71.09	71.03	0.09
186.872	18.427	71.58	71.75	-0.24
188.706	18.358	71.71	71.91	-0.27
199.817	17.938	72.72	72.94	-0.30
210.928	17.507	73.98	74.15	-0.23
222.039	17.063	75.37	75.54	-0.23
233.150	16.603	77.13	77.14	-0.01
241.761	16.235	78.63	78.53	0.13
244.261	16.126	79.00	78.96	0.06
255.372	15.628	81.14	81.03	0.13
266.483	15.105	83.41	83.42	-0.01
277.594	14.552	86.31	86.17	0.17
282.706	14.285	87.70	87.58	0.13
288.706	13.961	89.71	89.39	0.36
299.817	13.325	92.97	93.22	-0.27
305.261	12.994	94.86	95.38	-0.55
310.928	12.633	97.88	97.88	0.00
322.039	11.875	103.80	103.63	0.17
324.817	11.673	105.43	105.26	0.16
333.150	11.041	110.45	110.54	-0.08
344.261	10.140	116.62	117.70	-0.93
355.372	9.204	120.28	120.81	-0.44
366.483	6.302	120.65	120.01	0.53
366.817	8.276	118.38	119.93	-1.30
377.594	7.497	112.61	115.84	-2.87

Table 21. Comparison of Enthalpies for Saturated Liquid, J/mol

<u>T, K</u>	<u>Tester [70]</u>	<u>This Report</u>	<u>Difference</u>
100	6 075	5 991	84
120	7 447	7 368	79
140	8 833	8 758	75
160	10 243	10 169	74
180	11 682	11 613	69
200	13 156	13 106	50
220	14 678	14 666	12
240	16 281	16 323	-42
260	18 006	18 125	-119
280	19 940	20 175	-235
300	22 720	22 950	-230

Table 22. Comparison of Enthalpies, J/mol[†]

T, K	H ^o	P = 20 atm			P = 100 atm		
		HT	TE	RG [*]	HT	TE	RG ^{**}
280	31 228	29 493	29 457	29 535	--	--	--
320	33 348	32 169	32 169	32 137	24 122	23 774	24 019
360	35 666	34 781	34 799	34 708	29 715	29 733	29 720
400	38 188	37 493	37 515	37 391	34 185	34 270	34 134
460	42 353	41 837	41 862	41 718	39 680	39 771	39 564

† HT = Tester [70], TE = Eubank et al. [18], RG = This Report,

* Pressure of 20 bar; ** Pressure of 100 bar.

Table 23. Calculated $P(T)$ isochores

The following pages give $P(T)$ along isochores, as computed by the equation of state. The third column DP/DD is the isotherm slope $(\partial P/\partial \rho)$ in units of the bar and mol/l. The last two columns give the isochore slopes and curvatures $\partial P/\partial T$, $\partial^2 P/\partial T^2$, in units of the bar and K.

These tables show that the isochore curvatures are qualitatively consistent with a maximum in the specific heat $C_V(\rho, T)$ at the critical point.

Table 23. Calculated P(T) isochores.
THE ISOCHORE AT. 1.00 MOL/L

T,K	P,BAR	DP/DD	DP/DT	D2P/DT2
266.0	17.157	12.481	0.1051	-0.00021
274.0	17.992	13.495	0.1035	-0.00017
282.0	18.815	14.482	0.1023	-0.00015
290.0	19.628	15.448	0.1012	-0.00012
298.0	20.434	16.395	0.1003	-0.00011
306.0	21.233	17.328	0.0995	-0.00009
314.0	22.026	18.248	0.0988	-0.00008
322.0	22.814	19.156	0.0982	-0.00007
330.0	23.597	20.055	0.0976	-0.00007
338.0	24.375	20.946	0.0971	-0.00006
346.0	25.150	21.828	0.0967	-0.00005
354.0	25.922	22.704	0.0963	-0.00005
362.0	26.691	23.574	0.0959	-0.00004
370.0	27.457	24.438	0.0956	-0.00004
378.0	28.220	25.298	0.0953	-0.00004
386.0	28.981	26.152	0.0950	-0.00003
394.0	29.740	27.003	0.0947	-0.00003
402.0	30.497	27.849	0.0945	-0.00003
410.0	31.252	28.692	0.0943	-0.00003
418.0	32.005	29.532	0.0941	-0.00002
426.0	32.757	30.369	0.0939	-0.00002
434.0	33.508	31.203	0.0937	-0.00002
442.0	34.257	32.034	0.0936	-0.00002
450.0	35.004	32.863	0.0934	-0.00002
458.0	35.751	33.690	0.0933	-0.00002
466.0	36.497	34.514	0.0931	-0.00002
474.0	37.241	35.337	0.0930	-0.00002
482.0	37.985	36.157	0.0929	-0.00001
490.0	38.727	36.976	0.0928	-0.00001
498.0	39.469	37.793	0.0927	-0.00001
506.0	40.210	38.609	0.0926	-0.00001
514.0	40.950	39.423	0.0925	-0.00001
522.0	41.690	40.235	0.0924	-0.00001
530.0	42.428	41.047	0.0923	-0.00001
538.0	43.166	41.857	0.0922	-0.00001
546.0	43.904	42.666	0.0921	-0.00001
554.0	44.641	43.473	0.0921	-0.00001
562.0	45.377	44.280	0.0920	-0.00001
570.0	46.113	45.085	0.0919	-0.00001
578.0	46.848	45.890	0.0919	-0.00001
586.0	47.583	46.694	0.0918	-0.00001
594.0	48.317	47.496	0.0917	-0.00001

Table 23. Calculated P(T) isochores- - - (Continued)
THE ISOCHORE AT 2.00 MOL/L

T, K	P, BAR	DP/DD	DP/DT	D ² P/DT ²
290.0	31.339	8.269	0.2384	-0.00066
298.0	33.227	9.482	0.2338	-0.00051
306.0	35.082	10.654	0.2301	-0.00042
314.0	36.910	11.796	0.2270	-0.00035
322.0	38.716	12.915	0.2244	-0.00030
330.0	40.502	14.015	0.2222	-0.00026
338.0	42.272	15.099	0.2202	-0.00023
346.0	44.027	16.169	0.2185	-0.00020
354.0	45.769	17.228	0.2170	-0.00018
362.0	47.499	18.276	0.2156	-0.00016
370.0	49.219	19.315	0.2144	-0.00015
378.0	50.930	20.346	0.2133	-0.00013
386.0	52.632	21.370	0.2123	-0.00012
394.0	54.327	22.387	0.2113	-0.00011
402.0	56.014	23.399	0.2105	-0.00010
410.0	57.695	24.404	0.2097	-0.00009
418.0	59.369	25.405	0.2090	-0.00009
426.0	61.039	26.401	0.2083	-0.00008
434.0	62.703	27.393	0.2077	-0.00007
442.0	64.362	28.380	0.2071	-0.00007
450.0	66.017	29.365	0.2066	-0.00006
458.0	67.668	30.345	0.2061	-0.00006
466.0	69.314	31.323	0.2056	-0.00006
474.0	70.958	32.297	0.2052	-0.00005
482.0	72.597	33.269	0.2048	-0.00005
490.0	74.234	34.238	0.2044	-0.00005
498.0	75.867	35.204	0.2040	-0.00004
506.0	77.498	36.168	0.2036	-0.00004
514.0	79.126	37.130	0.2033	-0.00004
522.0	80.751	38.090	0.2030	-0.00004
530.0	82.374	39.047	0.2027	-0.00004
538.0	83.994	40.003	0.2024	-0.00003
546.0	85.613	40.957	0.2021	-0.00003
554.0	87.229	41.909	0.2019	-0.00003
562.0	88.843	42.860	0.2016	-0.00003
570.0	90.455	43.808	0.2014	-0.00003
578.0	92.065	44.756	0.2012	-0.00003
586.0	93.674	45.701	0.2010	-0.00003
594.0	95.281	46.646	0.2008	-0.00003

Table 23. Calculated P(T) isochores- - - (Continued)
THE ISOCHORE AT 3.00 MOL/L

T,K	P,BAR	DP/DD	DP/DT	D ² P/DT ²
298.0	40.058	4.480	0.3967	-0.00163
306.0	43.187	5.849	0.3862	-0.00107
314.0	46.246	7.159	0.3788	-0.00080
322.0	49.252	8.432	0.3731	-0.00064
330.0	52.218	9.682	0.3684	-0.00053
338.0	55.149	10.913	0.3645	-0.00045
346.0	58.051	12.131	0.3611	-0.00039
354.0	60.928	13.336	0.3582	-0.00034
362.0	63.782	14.532	0.3556	-0.00031
370.0	66.617	15.719	0.3532	-0.00027
378.0	69.435	16.898	0.3512	-0.00025
386.0	72.237	18.071	0.3493	-0.00022
394.0	75.024	19.239	0.3476	-0.00020
402.0	77.799	20.401	0.3460	-0.00019
410.0	80.561	21.558	0.3446	-0.00017
418.0	83.313	22.710	0.3433	-0.00016
426.0	86.054	23.859	0.3421	-0.00015
434.0	88.787	25.004	0.3410	-0.00014
442.0	91.510	26.146	0.3399	-0.00013
450.0	94.226	27.284	0.3390	-0.00012
458.0	96.934	28.419	0.3381	-0.00011
466.0	99.635	29.552	0.3372	-0.00010
474.0	102.330	30.681	0.3364	-0.00010
482.0	105.018	31.808	0.3357	-0.00009
490.0	107.700	32.933	0.3349	-0.00009
498.0	110.377	34.056	0.3343	-0.00008
506.0	113.049	35.176	0.3336	-0.00008
514.0	115.715	36.294	0.3330	-0.00007
522.0	118.377	37.410	0.3325	-0.00007
530.0	121.034	38.524	0.3319	-0.00007
538.0	123.688	39.637	0.3314	-0.00006
546.0	126.337	40.748	0.3309	-0.00006
554.0	128.982	41.856	0.3304	-0.00006
562.0	131.623	42.964	0.3300	-0.00006
570.0	134.261	44.070	0.3295	-0.00005
578.0	136.895	45.174	0.3291	-0.00005
586.0	139.527	46.276	0.3287	-0.00005
594.0	142.155	47.378	0.3283	-0.00005

Table 23. Calculated P(T) isochores- - - (Continued)
THE ISOCHORE AT 4.00 MOL/L

T, K	P, BAR	DP/DD	DP/DT	D ² P/D ² T
306.0	47.293	2.606	0.5608	-0.00241
314.0	51.716	4.014	0.5465	-0.00137
322.0	56.049	5.384	0.5373	-0.00098
330.0	60.319	6.736	0.5304	-0.00076
338.0	64.539	8.079	0.5248	-0.00063
346.0	68.719	9.415	0.5202	-0.00053
354.0	72.864	10.746	0.5163	-0.00046
362.0	76.981	12.074	0.5129	-0.00040
370.0	81.071	13.398	0.5098	-0.00036
378.0	85.139	14.720	0.5072	-0.00032
386.0	89.186	16.040	0.5047	-0.00029
394.0	93.215	17.358	0.5025	-0.00026
402.0	97.228	18.674	0.5005	-0.00024
410.0	101.224	19.988	0.4987	-0.00022
418.0	105.207	21.301	0.4970	-0.00020
426.0	109.177	22.612	0.4955	-0.00019
434.0	113.135	23.922	0.4940	-0.00017
442.0	117.082	25.230	0.4927	-0.00016
450.0	121.018	26.537	0.4914	-0.00015
458.0	124.944	27.843	0.4902	-0.00014
466.0	128.861	29.147	0.4891	-0.00014
474.0	132.770	30.450	0.4880	-0.00013
482.0	136.670	31.752	0.4870	-0.00012
490.0	140.563	33.052	0.4861	-0.00011
498.0	144.448	34.351	0.4852	-0.00011
506.0	148.326	35.649	0.4844	-0.00010
514.0	152.198	36.946	0.4835	-0.00010
522.0	156.063	38.242	0.4828	-0.00009
530.0	159.922	39.536	0.4820	-0.00009
538.0	163.775	40.829	0.4813	-0.00009
546.0	167.623	42.121	0.4806	-0.00008
554.0	171.466	43.412	0.4800	-0.00008
562.0	175.303	44.702	0.4793	-0.00008
570.0	179.135	45.990	0.4787	-0.00007
578.0	182.962	47.278	0.4781	-0.00007
586.0	186.785	48.564	0.4776	-0.00007
594.0	190.604	49.849	0.4770	-0.00007

Table 23. Calculated P(T) isochores- - - (Continued)

THE ISOCHORE AT 5.00 MOL/L

T, K	P, BAR	DP/DD	DP/DT	D ² P/DT ²
306.0	48.895	0.835	0.7449	-0.00551
314.0	54.747	2.274	0.7225	-0.00167
322.0	60.482	3.709	0.7120	-0.00104
330.0	66.148	5.155	0.7049	-0.00077
338.0	71.765	6.610	0.6994	-0.00061
346.0	77.342	8.074	0.6950	-0.00051
354.0	82.886	9.546	0.6912	-0.00044
362.0	88.402	11.024	0.6879	-0.00038
370.0	93.894	12.508	0.6850	-0.00034
378.0	99.363	13.996	0.6824	-0.00031
386.0	104.813	15.489	0.6801	-0.00028
394.0	110.246	16.985	0.6780	-0.00025
402.0	115.662	18.484	0.6761	-0.00023
410.0	121.063	19.985	0.6743	-0.00022
418.0	126.451	21.489	0.6726	-0.00020
426.0	131.826	22.994	0.6711	-0.00019
434.0	137.188	24.502	0.6696	-0.00018
442.0	142.540	26.010	0.6683	-0.00017
450.0	147.881	27.520	0.6670	-0.00016
458.0	153.211	29.030	0.6657	-0.00015
466.0	158.533	30.542	0.6646	-0.00014
474.0	163.845	32.053	0.6635	-0.00013
482.0	169.149	33.565	0.6624	-0.00013
490.0	174.444	35.078	0.6614	-0.00012
498.0	179.731	36.590	0.6605	-0.00012
506.0	185.011	38.103	0.6595	-0.00011
514.0	190.284	39.615	0.6586	-0.00011
522.0	195.549	41.128	0.6578	-0.00011
530.0	200.808	42.640	0.6569	-0.00010
538.0	206.060	44.151	0.6561	-0.00010
546.0	211.306	45.663	0.6553	-0.00010
554.0	216.545	47.173	0.6546	-0.00009
562.0	221.779	48.684	0.6538	-0.00009
570.0	227.007	50.193	0.6531	-0.00009
578.0	232.229	51.702	0.6524	-0.00009
586.0	237.445	53.211	0.6517	-0.00008
594.0	242.656	54.718	0.6510	-0.00008

Table 23. Calculated P(T) isochores- - - (Continued)

THE ISOCHORE AT 6.00 MOL/L

T, K	P, BAR	DP/DD	DP/DT	D2P/DT2
306.0	49.334	0.167	0.9259	-0.00990
314.0	56.633	1.634	0.9058	-0.00105
322.0	63.853	3.183	0.8995	-0.00061
330.0	71.031	4.777	0.8954	-0.00044
338.0	78.182	6.402	0.8922	-0.00036
346.0	85.309	8.052	0.8896	-0.00030
354.0	92.417	9.720	0.8874	-0.00026
362.0	99.508	11.404	0.8854	-0.00023
370.0	106.584	13.102	0.8837	-0.00021
378.0	113.647	14.811	0.8820	-0.00019
386.0	120.697	16.530	0.8805	-0.00018
394.0	127.736	18.257	0.8791	-0.00017
402.0	134.763	19.992	0.8778	-0.00016
410.0	141.781	21.734	0.8766	-0.00015
418.0	148.789	23.481	0.8754	-0.00015
426.0	155.787	25.233	0.8742	-0.00014
434.0	162.776	26.989	0.8731	-0.00013
442.0	169.757	28.750	0.8721	-0.00013
450.0	176.729	30.513	0.8710	-0.00013
458.0	183.694	32.280	0.8700	-0.00012
466.0	190.650	34.048	0.8691	-0.00012
474.0	197.599	35.819	0.8681	-0.00012
482.0	204.540	37.592	0.8672	-0.00011
490.0	211.474	39.367	0.8663	-0.00011
498.0	218.401	41.142	0.8654	-0.00011
506.0	225.321	42.919	0.8645	-0.00011
514.0	232.234	44.697	0.8637	-0.00011
522.0	239.140	46.475	0.8628	-0.00010
530.0	246.039	48.254	0.8620	-0.00010
538.0	252.932	50.033	0.8612	-0.00010
546.0	259.819	51.812	0.8604	-0.00010
554.0	266.699	53.591	0.8596	-0.00010
562.0	273.573	55.371	0.8588	-0.00010
570.0	280.440	57.150	0.8581	-0.00010
578.0	287.302	58.928	0.8573	-0.00009
586.0	294.157	60.707	0.8565	-0.00009
594.0	301.006	62.485	0.8558	-0.00009

Table 23. Calculated P(T) isochores- - - (Continued)
THE ISOCHORE AT 6.74 MOL/L

T, K	P, BAR	DP/DD	DP/DT	D2P/DT2
306.0	49.418	0.104	1.0528	-0.00000
314.0	57.840	1.691	1.0527	-0.00001
322.0	66.261	3.401	1.0526	-0.00002
330.0	74.681	5.171	1.0524	-0.00003
338.0	83.100	6.981	1.0521	-0.00004
346.0	91.515	8.823	1.0518	-0.00004
354.0	99.929	10.690	1.0515	-0.00005
362.0	108.339	12.578	1.0511	-0.00005
370.0	116.746	14.483	1.0506	-0.00006
378.0	125.149	16.403	1.0501	-0.00006
386.0	133.548	18.336	1.0496	-0.00007
394.0	141.943	20.279	1.0491	-0.00007
402.0	150.333	22.233	1.0485	-0.00007
410.0	158.719	24.195	1.0479	-0.00008
418.0	167.100	26.165	1.0473	-0.00008
426.0	175.476	28.141	1.0466	-0.00008
434.0	183.846	30.122	1.0460	-0.00008
442.0	192.211	32.109	1.0453	-0.00009
450.0	200.571	34.100	1.0446	-0.00009
458.0	208.925	36.095	1.0439	-0.00009
466.0	217.273	38.093	1.0432	-0.00009
474.0	225.616	40.094	1.0425	-0.00009
482.0	233.953	42.098	1.0417	-0.00009
490.0	242.284	44.103	1.0410	-0.00009
498.0	250.609	46.111	1.0402	-0.00009
506.0	258.927	48.119	1.0395	-0.00010
514.0	267.240	50.130	1.0387	-0.00010
522.0	275.547	52.141	1.0379	-0.00010
530.0	283.847	54.152	1.0372	-0.00010
538.0	292.141	56.165	1.0364	-0.00010
546.0	300.429	58.178	1.0356	-0.00010
554.0	308.710	60.191	1.0348	-0.00010
562.0	316.986	62.204	1.0340	-0.00010
570.0	325.255	64.216	1.0332	-0.00010
578.0	333.517	66.229	1.0324	-0.00010
586.0	341.774	68.241	1.0317	-0.00010
594.0	350.024	70.253	1.0309	-0.00010

Table 23. Calculated P(T) isochores- - - (Continued)
THE ISOCHORE AT 8.00 MOL/L

T, K	P, BAR	DP/DD	DP/DT	D ² P/DT ²
306.0	49.651	0.447	1.3126	0.01309
314.0	60.333	2.529	1.3477	0.00208
322.0	71.169	4.704	1.3601	0.00119
330.0	82.083	6.937	1.3680	0.00083
338.0	93.051	9.214	1.3738	0.00063
346.0	104.060	11.524	1.3782	0.00049
354.0	115.100	13.861	1.3817	0.00039
362.0	126.165	16.221	1.3846	0.00032
370.0	137.251	18.600	1.3869	0.00026
378.0	148.354	20.994	1.3887	0.00021
386.0	159.470	23.403	1.3903	0.00017
394.0	170.597	25.824	1.3915	0.00014
402.0	181.733	28.255	1.3924	0.00011
410.0	192.876	30.696	1.3932	0.00008
418.0	204.024	33.144	1.3937	0.00006
426.0	215.175	35.599	1.3941	0.00004
434.0	226.329	38.060	1.3944	0.00002
442.0	237.485	40.526	1.3945	0.00001
450.0	248.640	42.997	1.3945	-0.00001
458.0	259.796	45.471	1.3943	-0.00002
466.0	270.950	47.949	1.3941	-0.00003
474.0	282.101	50.429	1.3938	-0.00004
482.0	293.251	52.911	1.3935	-0.00005
490.0	304.397	55.396	1.3930	-0.00006
498.0	315.539	57.882	1.3925	-0.00007
506.0	326.677	60.369	1.3920	-0.00007
514.0	337.811	62.857	1.3914	-0.00008
522.0	348.939	65.345	1.3907	-0.00008
530.0	360.062	67.834	1.3900	-0.00009
538.0	371.180	70.323	1.3893	-0.00009
546.0	382.291	72.812	1.3886	-0.00010
554.0	393.397	75.301	1.3878	-0.00010
562.0	404.495	77.789	1.3869	-0.00010
570.0	415.588	80.276	1.3861	-0.00011
578.0	426.673	82.763	1.3852	-0.00011
586.0	437.751	85.249	1.3843	-0.00011
594.0	448.823	87.733	1.3834	-0.00011

Table 23. Calculated P(T) isochores- - - (Continued)

THE ISOCHORE AT 9.00 MOL/L

T,K	P,BAR	DP/DD	DP/DT	C2P/DT2
306.0	50.818	2.236	1.6175	0.00728
314.0	63.920	5.028	1.6527	0.00291
322.0	77.221	7.822	1.6712	0.00186
330.0	90.644	10.640	1.6839	0.00136
338.0	104.155	13.480	1.6935	0.00106
346.0	117.734	16.341	1.7011	0.00085
354.0	131.368	19.218	1.7072	0.00069
362.0	145.046	22.110	1.7123	0.00057
370.0	158.762	25.014	1.7164	0.00048
378.0	172.508	27.929	1.7199	0.00040
386.0	186.279	30.853	1.7228	0.00033
394.0	200.072	33.784	1.7252	0.00027
402.0	213.882	36.723	1.7272	0.00023
410.0	227.707	39.666	1.7289	0.00018
418.0	241.543	42.614	1.7302	0.00015
426.0	255.389	45.566	1.7312	0.00011
434.0	269.242	48.522	1.7320	0.00008
442.0	283.100	51.479	1.7326	0.00006
450.0	296.962	54.439	1.7330	0.00004
458.0	310.827	57.400	1.7332	0.00002
466.0	324.692	60.363	1.7332	-0.00000
474.0	338.558	63.326	1.7331	-0.00002
482.0	352.422	66.289	1.7329	-0.00003
490.0	366.284	69.252	1.7326	-0.00005
498.0	380.143	72.215	1.7322	-0.00006
506.0	393.998	75.178	1.7316	-0.00007
514.0	407.849	78.139	1.7310	-0.00008
522.0	421.695	81.100	1.7304	-0.00009
530.0	435.535	84.059	1.7296	-0.00010
538.0	449.369	87.017	1.7288	-0.00010
546.0	463.196	89.973	1.7279	-0.00011
554.0	477.015	92.928	1.7270	-0.00012
562.0	490.828	95.880	1.7261	-0.00012
570.0	504.632	98.831	1.7250	-0.00013
578.0	518.428	101.779	1.7240	-0.00013
586.0	532.216	104.725	1.7229	-0.00014
594.0	545.995	107.669	1.7218	-0.00014

Table 23. Calculated P(T) isochores- - - (Continued)

THE ISOCHORE AT 10.00 MOL/L

T, K	P, BAR	DF/DD	DF/DT	D ² P/DT ²
306.0	55.121	7.041	2.0254	0.00422
314.0	71.438	10.701	2.0519	0.00265
322.0	87.929	14.316	2.0699	0.00192
330.0	104.545	17.915	2.0834	0.00149
338.0	121.257	21.505	2.0941	0.00119
346.0	138.045	25.092	2.1027	0.00097
354.0	154.896	28.677	2.1098	0.00080
362.0	171.799	32.261	2.1157	0.00067
370.0	188.745	35.843	2.1206	0.00056
378.0	205.726	39.424	2.1246	0.00046
386.0	222.737	43.004	2.1280	0.00038
394.0	239.772	46.582	2.1308	0.00032
402.0	256.828	50.158	2.1331	0.00026
410.0	273.901	53.732	2.1349	0.00021
418.0	290.986	57.304	2.1364	0.00016
426.0	308.082	60.873	2.1375	0.00012
434.0	325.186	64.440	2.1383	0.00009
442.0	342.295	68.004	2.1389	0.00005
450.0	359.407	71.564	2.1392	0.00003
458.0	376.522	75.122	2.1393	0.00000
466.0	393.636	78.676	2.1392	-0.00002
474.0	410.749	82.226	2.1390	-0.00004
482.0	427.859	85.773	2.1386	-0.00006
490.0	444.966	89.316	2.1380	-0.00008
498.0	462.067	92.856	2.1373	-0.00009
506.0	479.162	96.391	2.1365	-0.00011
514.0	496.251	99.922	2.1356	-0.00012
522.0	513.332	103.449	2.1346	-0.00013
530.0	530.405	106.972	2.1335	-0.00014
538.0	547.469	110.491	2.1324	-0.00015
546.0	564.523	114.005	2.1312	-0.00016
554.0	581.567	117.515	2.1299	-0.00017
562.0	598.600	121.021	2.1285	-0.00017
570.0	615.623	124.522	2.1271	-0.00018
578.0	632.634	128.018	2.1256	-0.00018
586.0	649.633	131.510	2.1241	-0.00019
594.0	666.620	134.998	2.1226	-0.00020

Table 23. Calculated P(T) isochores- - - (Continued)

THE ISOCHORE AT 11.00 MOL/L

T, K	P, BAR	DP/DD	DP/DT	C2P/DT2
298.0	46.355	12.389	2.5254	0.00353
306.0	66.658	17.137	2.5488	0.00244
314.0	87.118	21.783	2.5657	0.00184
322.0	107.698	26.365	2.5787	0.00144
330.0	128.370	30.903	2.5890	0.00116
338.0	149.117	35.406	2.5974	0.00094
346.0	169.924	39.881	2.6042	0.00077
354.0	190.781	44.332	2.6098	0.00063
362.0	211.678	48.763	2.6144	0.00052
370.0	232.609	53.175	2.6181	0.00042
378.0	253.567	57.570	2.6211	0.00033
386.0	274.546	61.950	2.6235	0.00026
394.0	295.541	66.316	2.6254	0.00020
402.0	316.550	70.668	2.6267	0.00014
410.0	337.568	75.007	2.6277	0.00010
418.0	358.592	79.334	2.6283	0.00005
426.0	379.620	83.650	2.6286	0.00002
434.0	400.648	87.954	2.6285	-0.00002
442.0	421.675	92.248	2.6283	-0.00005
450.0	442.700	96.531	2.6278	-0.00008
458.0	463.719	100.804	2.6270	-0.00010
466.0	484.732	105.067	2.6261	-0.00012
474.0	505.737	109.320	2.6251	-0.00014
482.0	526.733	113.564	2.6239	-0.00016
490.0	547.718	117.798	2.6225	-0.00018
498.0	568.693	122.024	2.6210	-0.00019
506.0	589.655	126.240	2.6194	-0.00020
514.0	610.603	130.448	2.6178	-0.00022
522.0	631.538	134.647	2.6160	-0.00023
530.0	652.459	138.838	2.6141	-0.00024
538.0	673.364	143.020	2.6122	-0.00025
546.0	694.254	147.194	2.6102	-0.00025

Table 23. Calculated P(T) isochores- - - (Continued)

THE ISOCHORE AT 12.00 MOL/L

T, K	P, BAR	DP/DO	DP/DT	D2P/DT2
290.0	41.028	23.606	3.1812	0.00170
294.0	53.766	26.598	3.1875	0.00146
298.0	66.527	29.555	3.1929	0.00127
302.0	79.308	32.483	3.1977	0.00112
306.0	92.108	35.385	3.2019	0.00098
310.0	104.923	38.264	3.2056	0.00087
314.0	117.751	41.123	3.2088	0.00076
318.0	130.593	43.963	3.2117	0.00067
322.0	143.445	46.785	3.2142	0.00059
326.0	156.306	49.592	3.2165	0.00052
330.0	169.176	52.384	3.2184	0.00046
334.0	182.053	55.162	3.2201	0.00040
338.0	194.937	57.928	3.2216	0.00034
342.0	207.826	60.681	3.2229	0.00029
346.0	220.719	63.423	3.2239	0.00025
350.0	233.617	66.154	3.2248	0.00020
354.0	246.518	68.875	3.2256	0.00016
358.0	259.421	71.587	3.2261	0.00013
362.0	272.327	74.289	3.2266	0.00009
366.0	285.234	76.982	3.2269	0.00006
370.0	298.142	79.666	3.2271	0.00003
374.0	311.050	82.342	3.2271	0.00000
378.0	323.959	85.011	3.2271	-0.00002
382.0	336.867	87.672	3.2270	-0.00005
386.0	349.774	90.325	3.2267	-0.00007
390.0	362.681	92.972	3.2264	-0.00009
394.0	375.586	95.612	3.2260	-0.00011
398.0	388.489	98.245	3.2255	-0.00013
402.0	401.390	100.872	3.2250	-0.00015
406.0	414.288	103.492	3.2243	-0.00017
410.0	427.184	106.107	3.2237	-0.00018
414.0	440.077	108.715	3.2229	-0.00020
418.0	452.967	111.318	3.2221	-0.00021
422.0	465.854	113.915	3.2212	-0.00022
426.0	478.737	116.507	3.2203	-0.00024
430.0	491.616	119.094	3.2193	-0.00025
434.0	504.492	121.676	3.2183	-0.00026
438.0	517.363	124.252	3.2172	-0.00027
442.0	530.229	126.823	3.2161	-0.00028
446.0	543.092	129.390	3.2150	-0.00029
450.0	555.949	131.952	3.2138	-0.00030
454.0	568.802	134.509	3.2126	-0.00031
458.0	581.650	137.062	3.2113	-0.00032
462.0	594.493	139.610	3.2101	-0.00032
466.0	607.331	142.154	3.2087	-0.00033
470.0	620.163	144.694	3.2074	-0.00034
474.0	632.990	147.229	3.2060	-0.00035
478.0	645.811	149.761	3.2046	-0.00035
482.0	658.627	152.288	3.2032	-0.00036
486.0	671.437	154.811	3.2018	-0.00036
490.0	684.241	157.330	3.2003	-0.00037
494.0	697.039	159.846	3.1988	-0.00037

Table 23. Calculated P(T) isochores- - (Continued)

THE ISOCHORE AT 13.00 MOL/L

T, K	P, BAR	DP/DD	DP/DT	D ² P/DT ²
278.0	29.111	39.986	4.0115	-0.00049
282.0	45.153	43.672	4.0095	-0.00048
286.0	61.188	47.321	4.0076	-0.00048
290.0	77.215	50.936	4.0057	-0.00048
294.0	93.234	54.518	4.0038	-0.00048
298.0	109.245	58.072	4.0019	-0.00048
302.0	125.249	61.597	4.0000	-0.00048
306.0	141.245	65.096	3.9980	-0.00049
310.0	157.233	68.571	3.9961	-0.00050
314.0	173.213	72.022	3.9941	-0.00050
318.0	189.186	75.452	3.9920	-0.00051
322.0	205.150	78.861	3.9900	-0.00052
326.0	221.105	82.251	3.9879	-0.00052
330.0	237.053	85.621	3.9858	-0.00053
334.0	252.992	88.974	3.9836	-0.00054
338.0	268.922	92.310	3.9815	-0.00055
342.0	284.843	95.630	3.9793	-0.00055
346.0	300.756	98.935	3.9771	-0.00056
350.0	316.660	102.224	3.9748	-0.00057
354.0	332.554	105.499	3.9725	-0.00057
358.0	348.440	108.761	3.9702	-0.00058
362.0	364.316	112.009	3.9679	-0.00058
366.0	380.183	115.245	3.9655	-0.00059
370.0	396.041	118.468	3.9632	-0.00060
374.0	411.889	121.680	3.9608	-0.00060
378.0	427.727	124.880	3.9584	-0.00061
382.0	443.556	128.070	3.9559	-0.00061
386.0	459.374	131.248	3.9535	-0.00061
390.0	475.183	134.417	3.9510	-0.00062
394.0	490.983	137.575	3.9486	-0.00062
398.0	506.772	140.724	3.9461	-0.00063
402.0	522.551	143.863	3.9435	-0.00063
406.0	538.320	146.993	3.9410	-0.00063
410.0	554.079	150.114	3.9385	-0.00064
414.0	569.828	153.227	3.9359	-0.00064
418.0	585.567	156.331	3.9334	-0.00064
422.0	601.295	159.427	3.9308	-0.00064
426.0	617.013	162.514	3.9282	-0.00065
430.0	632.721	165.594	3.9256	-0.00065
434.0	648.418	168.667	3.9230	-0.00065
438.0	664.105	171.732	3.9204	-0.00065
442.0	679.781	174.790	3.9178	-0.00065
446.0	695.447	177.840	3.9152	-0.00066

Table 23. Calculated P(T) isochores- - - (Continued)

THE ISOCHORE AT 14.00 MOL/L

T, K	P, BAR	DP/DD	DF/DT	D ² F/D ² T
266.0	27.449	67.107	5.0545	-0.00345
270.0	47.640	71.553	5.0412	-0.00323
274.0	67.779	75.957	5.0286	-0.00304
278.0	87.870	80.323	5.0168	-0.00287
282.0	107.915	84.651	5.0057	-0.00272
286.0	127.916	88.944	4.9951	-0.00258
290.0	147.876	93.204	4.9850	-0.00246
294.0	167.797	97.431	4.9754	-0.00236
298.0	187.680	101.627	4.9661	-0.00226
302.0	207.526	105.794	4.9572	-0.00217
306.0	227.338	109.932	4.9487	-0.00210
310.0	247.116	114.044	4.9405	-0.00202
314.0	266.862	118.130	4.9325	-0.00196
318.0	286.577	122.191	4.9248	-0.00190
322.0	306.261	126.229	4.9173	-0.00184
326.0	325.916	130.244	4.9100	-0.00179
330.0	345.541	134.238	4.9030	-0.00175
334.0	365.139	138.210	4.8961	-0.00170
338.0	384.710	142.162	4.8893	-0.00166
342.0	404.254	146.095	4.8827	-0.00163
346.0	423.772	150.009	4.8763	-0.00159
350.0	443.265	153.905	4.8700	-0.00156
354.0	462.733	157.783	4.8638	-0.00153
358.0	482.176	161.645	4.8578	-0.00150
362.0	501.595	165.491	4.8518	-0.00148
366.0	520.990	169.320	4.8460	-0.00145
370.0	540.362	173.135	4.8402	-0.00143
374.0	559.712	176.935	4.8345	-0.00141
378.0	579.039	180.720	4.8289	-0.00139
382.0	598.343	184.492	4.8234	-0.00137
386.0	617.626	188.250	4.8180	-0.00135
390.0	636.888	191.995	4.8126	-0.00133
394.0	656.128	195.727	4.8074	-0.00131
398.0	675.347	199.448	4.8021	-0.00130
402.0	694.545	203.156	4.7970	-0.00128

Table 23. Calculated P(T) isochores- - - (Continued)

THE ISOCHORE AT 15.00 MOL/L

T, K	P, BAR	DP/DD	DP/DT	D ² P/DT ²
250.0	20.439	103.276	6.3663	-0.00782
254.0	45.843	108.584	6.3360	-0.00732
258.0	71.129	113.846	6.3077	-0.00687
262.0	96.306	119.061	6.2810	-0.00647
266.0	121.379	124.232	6.2559	-0.00610
270.0	146.355	129.361	6.2321	-0.00578
274.0	171.238	134.449	6.2096	-0.00548
278.0	196.034	139.498	6.1883	-0.00520
282.0	220.746	144.509	6.1680	-0.00496
286.0	245.379	149.484	6.1486	-0.00473
290.0	269.936	154.425	6.1301	-0.00452
294.0	294.421	159.331	6.1124	-0.00433
298.0	318.836	164.206	6.0955	-0.00415
302.0	343.185	169.050	6.0792	-0.00399
306.0	367.471	173.865	6.0636	-0.00384
310.0	391.694	178.650	6.0485	-0.00369
314.0	415.859	183.408	6.0340	-0.00356
318.0	439.967	188.140	6.0200	-0.00344
322.0	464.020	192.846	6.0064	-0.00333
326.0	488.019	197.528	5.9933	-0.00323
330.0	511.967	202.185	5.9806	-0.00313
334.0	535.865	206.820	5.9683	-0.00304
338.0	559.714	211.432	5.9563	-0.00295
342.0	583.516	216.023	5.9447	-0.00287
346.0	607.272	220.593	5.9334	-0.00279
350.0	630.983	225.143	5.9224	-0.00272
354.0	654.651	229.674	5.9116	-0.00265
358.0	678.276	234.185	5.9011	-0.00259

Table 23. Calculated P(T) isochores- - - (Continued)

THE ISOCHORE AT 16.00 MOL/L

T, K	P, BAR	DP/DD	DP/DT	D ² P/D ² T
232.0	18.224	153.066	8.0124	-0.01443
234.0	34.221	156.194	7.9840	-0.01395
236.0	50.161	159.307	7.9566	-0.01349
238.0	66.048	162.407	7.9301	-0.01306
240.0	81.882	165.494	7.9043	-0.01265
242.0	97.666	168.568	7.8794	-0.01226
244.0	113.400	171.629	7.8553	-0.01188
246.0	129.087	174.677	7.8319	-0.01153
248.0	144.728	177.713	7.8092	-0.01119
250.0	160.325	180.737	7.7872	-0.01086
252.0	175.877	183.750	7.7657	-0.01055
254.0	191.388	186.750	7.7449	-0.01025
256.0	206.858	189.739	7.7247	-0.00997
258.0	222.287	192.717	7.7050	-0.00970
260.0	237.678	195.683	7.6859	-0.00944
262.0	253.031	198.639	7.6673	-0.00919
264.0	268.348	201.585	7.6491	-0.00895
266.0	283.628	204.519	7.6315	-0.00873
268.0	298.874	207.444	7.6142	-0.00851
270.0	314.085	210.359	7.5974	-0.00830
272.0	329.264	213.263	7.5810	-0.00810
274.0	344.410	216.158	7.5650	-0.00790
276.0	359.524	219.044	7.5494	-0.00772
278.0	374.608	221.920	7.5342	-0.00754
280.0	389.661	224.787	7.5193	-0.00737
282.0	404.685	227.645	7.5047	-0.00720
284.0	419.680	230.494	7.4904	-0.00704
286.0	434.647	233.335	7.4765	-0.00689
288.0	449.586	236.167	7.4629	-0.00674
290.0	464.499	238.991	7.4495	-0.00660
292.0	479.385	241.806	7.4365	-0.00646
294.0	494.245	244.614	7.4237	-0.00633
296.0	509.080	247.413	7.4112	-0.00620
298.0	523.890	250.205	7.3989	-0.00608
300.0	538.675	252.989	7.3868	-0.00596
302.0	553.437	255.766	7.3750	-0.00585
304.0	568.175	258.535	7.3634	-0.00574
306.0	582.891	261.298	7.3521	-0.00563
308.0	597.584	264.052	7.3409	-0.00553
310.0	612.255	266.800	7.3300	-0.00543
312.0	626.904	269.541	7.3192	-0.00533
314.0	641.532	272.276	7.3086	-0.00524
316.0	656.139	275.003	7.2983	-0.00515
318.0	670.725	277.724	7.2880	-0.00506
320.0	685.291	280.439	7.2780	-0.00498
322.0	699.837	283.147	7.2681	-0.00489

Table 23. Calculated P(T) isochores- - - (Continued)
THE ISOCHORE AT 17.00 MOL/L

T, K	P, BAR	DP/DO	DP/DT	D ² P/D ² T
212.0	22.625	219.957	10.0847	-0.02469
214.0	42.745	223.563	10.0362	-0.02383
216.0	62.771	227.155	9.9893	-0.02301
218.0	82.704	230.735	9.9441	-0.02223
220.0	102.548	234.300	9.9004	-0.02148
222.0	122.307	237.853	9.8582	-0.02077
224.0	141.982	241.393	9.8173	-0.02010
226.0	161.577	244.920	9.7777	-0.01946
228.0	181.094	248.434	9.7394	-0.01884
230.0	200.535	251.936	9.7023	-0.01826
232.0	219.904	255.426	9.6664	-0.01770
234.0	239.202	258.904	9.6315	-0.01717
236.0	258.431	262.370	9.5977	-0.01666
238.0	277.593	265.825	9.5649	-0.01617
240.0	296.691	269.268	9.5330	-0.01571
242.0	315.726	272.700	9.5020	-0.01526
244.0	334.699	276.121	9.4719	-0.01483
246.0	353.614	279.532	9.4427	-0.01442
248.0	372.471	282.931	9.4142	-0.01403
250.0	391.271	286.321	9.3866	-0.01366
252.0	410.017	289.700	9.3596	-0.01330
254.0	428.710	293.069	9.3334	-0.01295
256.0	447.351	296.428	9.3078	-0.01262
258.0	465.942	299.777	9.2829	-0.01230
260.0	484.483	303.117	9.2586	-0.01199
262.0	502.977	306.448	9.2349	-0.01170
264.0	521.423	309.769	9.2118	-0.01142
266.0	539.824	313.081	9.1892	-0.01114
268.0	558.181	316.384	9.1672	-0.01088
270.0	576.493	319.679	9.1457	-0.01063
272.0	594.764	322.964	9.1247	-0.01039
274.0	612.992	326.242	9.1041	-0.01015
276.0	631.181	329.510	9.0841	-0.00993
278.0	649.329	332.771	9.0644	-0.00971
280.0	667.438	336.024	9.0452	-0.00950
282.0	685.510	339.268	9.0264	-0.00930

Table 23. Calculated P(T) isochores- - - (Continued)

THE ISOCHORE AT 18.00 MOL/L

T, K	P, BAR	DP/DD	DP/DT	D ² P/D ² T
188.0	9.323	304.719	12.8014	-0.04276
190.0	34.841	308.783	12.7175	-0.04110
192.0	60.195	312.839	12.6369	-0.03953
194.0	85.391	316.885	12.5594	-0.03804
196.0	110.435	320.923	12.4847	-0.03662
198.0	135.332	324.952	12.4128	-0.03528
200.0	160.088	328.972	12.3436	-0.03401
202.0	184.708	332.983	12.2768	-0.03280
204.0	209.196	336.985	12.2123	-0.03165
206.0	233.558	340.977	12.1501	-0.03056
208.0	257.798	344.961	12.0900	-0.02952
210.0	281.920	348.936	12.0320	-0.02853
212.0	305.928	352.903	11.9759	-0.02759
214.0	329.825	356.860	11.9216	-0.02669
216.0	353.615	360.809	11.8691	-0.02584
218.0	377.302	364.749	11.8182	-0.02502
220.0	400.889	368.680	11.7690	-0.02424
222.0	424.379	372.603	11.7213	-0.02349
224.0	447.775	376.517	11.6750	-0.02278
226.0	471.080	380.423	11.6301	-0.02210
228.0	494.297	384.321	11.5866	-0.02145
230.0	517.427	388.211	11.5443	-0.02083
232.0	540.474	392.092	11.5032	-0.02024
234.0	563.441	395.965	11.4633	-0.01967
236.0	586.328	399.831	11.4245	-0.01912
238.0	609.140	403.688	11.3868	-0.01860
240.0	631.876	407.537	11.3501	-0.01810
242.0	654.541	411.379	11.3144	-0.01762
244.0	677.135	415.213	11.2797	-0.01715
246.0	699.660	419.040	11.2458	-0.01671

Table 23. Calculated P(T) isochores- - - (Continued)
THE ISOCHORE AT 19.00 MOL/L

T,K	P,BAR	DP/CD	DP/DT	D2P/DT2
163.0	6.143	419.883	16.3415	-0.07340
164.0	22.448	422.072	16.2689	-0.07174
165.0	38.681	424.264	16.1980	-0.07014
166.0	54.844	426.458	16.1286	-0.06858
167.0	70.939	428.655	16.0608	-0.06707
168.0	86.966	430.854	15.9945	-0.06560
169.0	102.928	433.056	15.9296	-0.06418
170.0	118.826	435.259	15.8661	-0.06280
171.0	134.661	437.465	15.8040	-0.06146
172.0	150.434	439.672	15.7432	-0.06016
173.0	166.148	441.881	15.6836	-0.05889
174.0	181.802	444.092	15.6254	-0.05767
175.0	197.399	446.304	15.5683	-0.05647
176.0	212.939	448.517	15.5124	-0.05531
177.0	228.424	450.732	15.4576	-0.05419
178.0	243.855	452.949	15.4040	-0.05309
179.0	259.232	455.166	15.3515	-0.05203
180.0	274.558	457.385	15.2999	-0.05099
181.0	289.833	459.604	15.2495	-0.04999
182.0	305.057	461.825	15.2000	-0.04901
183.0	320.233	464.046	15.1514	-0.04806
184.0	335.360	466.268	15.1038	-0.04713
185.0	350.441	468.491	15.0572	-0.04623
186.0	365.475	470.715	15.0114	-0.04535
187.0	380.464	472.939	14.9665	-0.04450
188.0	395.408	475.164	14.9224	-0.04367
189.0	410.309	477.389	14.8791	-0.04286
190.0	425.167	479.615	14.8367	-0.04207
191.0	439.982	481.840	14.7950	-0.04130
192.0	454.757	484.067	14.7541	-0.04055
193.0	469.491	486.293	14.7139	-0.03982
194.0	484.185	488.520	14.6744	-0.03911
195.0	498.840	490.747	14.6356	-0.03842
196.0	513.456	492.974	14.5976	-0.03774
197.0	528.035	495.201	14.5602	-0.03708
198.0	542.577	497.428	14.5234	-0.03644
199.0	557.082	499.655	14.4873	-0.03582
200.0	571.552	501.882	14.4518	-0.03521
201.0	585.986	504.109	14.4168	-0.03461
202.0	600.385	506.336	14.3825	-0.03403
203.0	614.751	508.562	14.3488	-0.03346
204.0	629.083	510.789	14.3156	-0.03291
205.0	643.382	513.015	14.2830	-0.03237
206.0	657.649	515.241	14.2508	-0.03184
207.0	671.884	517.466	14.2193	-0.03133
208.0	686.088	519.692	14.1882	-0.03083

Table 23. Calculated P(T) isochores- - - (Continued)

THE ISOCORE AT 20.00 MOL/L

T, K	P, BAR	DP/DD	DP/DT	D2P/DT2
137.0	16.308	575.795	21.0926	-0.12851
138.0	37.337	577.966	20.9658	-0.12506
139.0	58.241	580.153	20.8424	-0.12174
140.0	79.023	582.358	20.7223	-0.11853
141.0	99.687	584.579	20.6053	-0.11543
142.0	120.235	586.816	20.4914	-0.11245
143.0	140.670	589.068	20.3804	-0.10956
144.0	160.997	591.335	20.2722	-0.10678
145.0	181.216	593.616	20.1668	-0.10408
146.0	201.331	595.911	20.0640	-0.10148
147.0	221.345	598.219	19.9638	-0.09897
148.0	241.260	600.540	19.8661	-0.09654
149.0	261.078	602.873	19.7707	-0.09419
150.0	280.802	605.219	19.6777	-0.09192
151.0	300.434	607.575	19.5869	-0.08972
152.0	319.976	609.943	19.4982	-0.08760
153.0	339.431	612.322	19.4116	-0.08554
154.0	358.800	614.711	19.3271	-0.08354
155.0	378.086	617.110	19.2445	-0.08162
156.0	397.290	619.519	19.1639	-0.07975
157.0	416.414	621.937	19.0850	-0.07794
158.0	435.460	624.364	19.0080	-0.07618
159.0	454.431	626.800	18.9326	-0.07448
160.0	473.326	629.245	18.8590	-0.07284
161.0	492.149	631.697	18.7869	-0.07124
162.0	510.901	634.158	18.7165	-0.06969
163.0	529.583	636.626	18.6475	-0.06819
164.0	548.196	639.101	18.5801	-0.06673
165.0	566.743	641.584	18.5141	-0.06532
166.0	585.225	644.073	18.4494	-0.06395
167.0	603.643	646.569	18.3862	-0.06262
168.0	621.998	649.072	18.3242	-0.06132
169.0	640.291	651.581	18.2635	-0.06007
170.0	658.525	654.095	18.2040	-0.05885
171.0	676.700	656.615	18.1458	-0.05767
172.0	694.817	659.141	18.0887	-0.05652

Table 23. Calculated P(T) isochores- - - (Continued)

THE ISOCHORE AT 21.00 MOL/L

T,K	P,BAR	DP/DD	DP/DT	D2P/DT2
109.0	8.092	782.786	28.1089	-0.24813
110.0	36.078	784.450	27.8650	-0.23973
111.0	63.825	786.177	27.6294	-0.23170
112.0	91.340	787.964	27.4015	-0.22402
113.0	118.631	789.810	27.1812	-0.21668
114.0	145.705	791.713	26.9681	-0.20965
115.0	172.569	793.669	26.7618	-0.20292
116.0	199.230	795.677	26.5621	-0.19647
117.0	225.695	797.735	26.3688	-0.19030
118.0	251.970	799.841	26.1814	-0.18438
119.0	278.060	801.994	25.9999	-0.17871
120.0	303.972	804.191	25.8240	-0.17326
121.0	329.710	806.431	25.6533	-0.16804
122.0	355.280	808.712	25.4878	-0.16303
123.0	380.687	811.034	25.3272	-0.15822
124.0	405.936	813.394	25.1713	-0.15359
125.0	431.031	815.790	25.0200	-0.14915
126.0	455.977	818.223	24.8730	-0.14488
127.0	480.779	820.690	24.7301	-0.14078
128.0	505.439	823.190	24.5913	-0.13683
129.0	529.962	825.722	24.4564	-0.13303
130.0	554.353	828.285	24.3252	-0.12938
131.0	578.614	830.878	24.1976	-0.12586
132.0	602.749	833.500	24.0735	-0.12247
133.0	626.762	836.149	23.9526	-0.11921
134.0	650.656	838.825	23.8350	-0.11606
135.0	674.433	841.526	23.7205	-0.11303
136.0	698.098	844.253	23.6089	-0.11011

THE ISOCHORE AT 22.00 MOL/L

T,K	P,BAR	DP/DD	DP/DT	D2P/DT2
96.0	533.498	1074.777	33.3642	-0.28865
97.0	566.720	1076.862	33.0810	-0.27785
98.0	599.663	1079.053	32.8083	-0.26758
99.0	632.339	1081.344	32.5456	-0.25782
100.0	664.758	1083.732	32.2925	-0.24854
101.0	696.927	1086.211	32.0484	-0.23971

Table 24. Calculated $P(\rho)$ isotherms

The following pages give $P(\rho)$ isotherms, as computed by the equation of state (5). The third column DP/DD is the isotherm slope $(\partial P/\partial \rho)$ in units of the bar and mol/l. The last two columns give the isochore slopes and curvatures, $DP/DT \equiv (\partial P/\partial T)$, $D^2P/DT^2 \equiv (\partial^2 P/\partial T^2)$ in units of the bar and Kelvins.

These tables show that $\partial P/\partial \rho$ is non-negative, and that it increases monotonically with density to pressures about twice those for adjusting the equation of state.

Table 24. Calculated $P(\rho)$ isotherms.
THE ISOTHERM AT 95.00 DEG. K

MOL/L	P,BAR	DP/DD	DP/DT	D2P/DT2
21.50	4.806	911.484	32.9615	-0.359363
21.55	50.760	926.705	33.0105	-0.353331
21.60	97.480	942.107	33.0636	-0.347309
21.65	144.974	957.697	33.1208	-0.341302
21.70	193.253	973.484	33.1826	-0.335313
21.75	242.326	989.475	33.2489	-0.329348
21.80	292.204	1005.679	33.3202	-0.323411
21.85	342.897	1022.104	33.3966	-0.317505
21.90	394.418	1038.760	33.4782	-0.311636
21.95	446.777	1055.656	33.5655	-0.305809

THE ISOTHERM AT 100.00 DEG. K

MOL/L	P,BAR	DP/DD	DP/DT	D2P/DT2
21.35	31.210	871.909	31.1230	-0.310639
21.40	75.180	886.956	31.1884	-0.305784
21.45	119.908	902.184	31.2572	-0.300928
21.50	165.402	917.599	31.3296	-0.296076
21.55	211.671	933.208	31.4057	-0.291231
21.60	258.726	949.019	31.4858	-0.286396
21.65	306.577	965.038	31.5700	-0.281575
21.70	355.234	981.274	31.6586	-0.276773
21.75	404.708	997.736	31.7517	-0.271991
21.80	455.011	1014.432	31.8495	-0.267236
21.85	506.155	1031.370	31.9523	-0.262509
21.90	558.152	1048.559	32.0603	-0.257815
21.95	611.015	1066.010	32.1736	-0.253157
22.00	664.758	1083.732	32.2925	-0.248540
22.05	719.393	1101.735	32.4171	-0.243968

THE ISOTHERM AT 110.00 DEG. K

MOL/L	P,BAR	DP/DD	DP/DT	D2P/DT2
21.00	36.078	784.450	27.8650	-0.239728
21.05	75.660	798.827	27.9509	-0.236564
21.10	115.964	813.376	28.0391	-0.233386
21.15	157.000	828.104	28.1297	-0.230198
21.20	198.777	843.014	28.2230	-0.227000
21.25	241.305	858.114	28.3189	-0.223795
21.30	284.592	873.409	28.4177	-0.220586
21.35	328.649	888.906	28.5196	-0.217375
21.40	373.486	904.610	28.6247	-0.214164
21.45	419.114	920.530	28.7332	-0.210957
21.50	465.543	936.672	28.8451	-0.207755
21.55	512.785	953.043	28.9608	-0.204561
21.60	560.851	969.652	29.0803	-0.201377
21.65	609.754	986.506	29.2038	-0.198208
21.70	659.506	1003.613	29.3315	-0.195054
21.75	710.120	1020.982	29.4635	-0.191920

Table 24. Calculated P(ρ) isotherms (Continued)

THE ISOTHERM AT 120.00 DEG. K

MOL/L	P, BAR	DP/DD	DP/DT	D ² P/DT ²
20.60	5.090	692.070	24.9991	-0.190010
20.65	40.029	705.492	25.0963	-0.187977
20.70	75.642	719.075	25.1949	-0.185923
20.75	111.939	732.823	25.2952	-0.183852
20.80	148.927	746.739	25.3971	-0.181763
20.85	186.616	760.830	25.5008	-0.179658
20.90	225.013	775.099	25.6065	-0.177539
20.95	264.129	789.550	25.7141	-0.175407
21.00	303.972	804.191	25.8240	-0.173264
21.05	344.551	819.025	25.9361	-0.171111
21.10	385.877	834.058	26.0506	-0.168951
21.15	427.960	849.296	26.1676	-0.166784
21.20	470.811	864.746	26.2873	-0.164612
21.25	514.439	880.413	26.4097	-0.162438
21.30	558.856	896.303	26.5351	-0.160263
21.35	604.073	912.424	26.6636	-0.158089
21.40	650.102	928.783	26.7952	-0.155918
21.45	696.955	945.386	26.9301	-0.153751
21.50	744.645	962.241	27.0685	-0.151592

THE ISOTHERM AT 140.00 DEG. K

MOL/L	P, BAR	DP/DD	DP/DT	D ² P/DT ²
19.90	21.970	558.809	20.5026	-0.120130
19.95	50.202	570.510	20.6121	-0.119339
20.00	79.023	582.358	20.7223	-0.118529
20.05	108.440	594.355	20.8334	-0.117703
20.10	138.461	606.504	20.9453	-0.116859
20.15	169.093	618.808	21.0582	-0.115998
20.20	200.345	631.271	21.1721	-0.115121
20.25	232.223	643.894	21.2870	-0.114229
20.30	264.737	656.683	21.4031	-0.113321
20.35	297.894	669.641	21.5204	-0.112399
20.40	331.704	682.771	21.6390	-0.111463
20.45	366.174	696.078	21.7589	-0.110514
20.50	401.315	709.565	21.8802	-0.109552
20.55	437.134	723.237	22.0031	-0.108579
20.60	473.641	737.098	22.1275	-0.107594
20.65	510.847	751.153	22.2536	-0.106600
20.70	548.760	765.407	22.3815	-0.105595
20.75	587.391	779.864	22.5112	-0.104583
20.80	626.750	794.530	22.6428	-0.103563
20.85	666.848	809.410	22.7764	-0.102536
20.90	707.695	824.510	22.9122	-0.101504
20.95	749.302	839.835	23.0501	-0.100466

Table 24. Calculated $P(\rho)$ isotherms (Continued)

THE ISOTHERM AT 160.00 DEG. K

MOL/L	P,BAR	DP/DD	DP/DI	D2P/DI2
19.15	20.934	442.231	16.8979	-0.078123
19.20	43.292	452.114	17.0083	-0.077910
19.25	66.148	462.126	17.1191	-0.077685
19.30	89.507	472.268	17.2304	-0.077447
19.35	113.377	482.543	17.3422	-0.077196
19.40	137.763	492.952	17.4545	-0.076933
19.45	162.674	503.498	17.5675	-0.076657
19.50	188.115	514.182	17.6810	-0.076369
19.55	214.095	525.008	17.7953	-0.076068
19.60	240.619	535.978	17.9102	-0.075755
19.65	267.695	547.094	18.0258	-0.075431
19.70	295.331	558.359	18.1422	-0.075094
19.75	323.533	569.776	18.2594	-0.074746
19.80	352.311	581.348	18.3774	-0.074386
19.85	381.671	593.078	18.4963	-0.074015
19.90	411.621	604.968	18.6162	-0.073633
19.95	442.170	617.023	18.7371	-0.073240
20.00	473.326	629.245	18.8590	-0.072837
20.05	505.098	641.638	18.9820	-0.072424
20.10	537.493	654.205	19.1061	-0.072001
20.15	570.521	666.952	19.2314	-0.071568
20.20	604.191	679.880	19.3579	-0.071127
20.25	638.512	692.995	19.4858	-0.070677
20.30	673.494	706.301	19.6150	-0.070219
20.35	709.146	719.801	19.7456	-0.069753
20.40	745.477	733.501	19.8778	-0.069281

Table 24. Calculated P(ρ) isotherms (Continued)

THE ISOTHERM AT 180.00 DEG. K

MOL/L	P,BAR	DP/DD	DP/DT	D ² P/DT ²
0.05	0.729	14.231	0.0043	-0.000002
18.35	15.706	342.424	13.8992	-0.050964
18.40	33.031	350.573	14.0043	-0.051014
18.45	50.765	358.831	14.1099	-0.051056
18.50	68.916	367.202	14.2158	-0.051090
18.55	87.487	375.685	14.3222	-0.051117
18.60	106.486	384.283	14.4290	-0.051136
18.65	125.918	392.998	14.5362	-0.051147
18.70	145.788	401.829	14.6438	-0.051149
18.75	166.103	410.780	14.7519	-0.051144
18.80	186.868	419.852	14.8605	-0.051131
18.85	208.090	429.047	14.9696	-0.051109
18.90	229.775	438.366	15.0792	-0.051079
18.95	251.929	447.811	15.1893	-0.051041
19.00	274.558	457.385	15.2999	-0.050994
19.05	297.669	467.089	15.4112	-0.050939
19.10	321.269	476.925	15.5230	-0.050876
19.15	345.364	486.896	15.6355	-0.050804
19.20	369.961	497.003	15.7486	-0.050724
19.25	395.067	507.250	15.8624	-0.050636
19.30	420.688	517.638	15.9768	-0.050539
19.35	446.833	528.170	16.0920	-0.050435
19.40	473.508	538.849	16.2080	-0.050322
19.45	500.720	549.678	16.3247	-0.050202
19.50	528.478	560.658	16.4422	-0.050074
19.55	556.789	571.794	16.5606	-0.049938
19.60	585.660	583.088	16.6799	-0.049795
19.65	615.100	594.542	16.8001	-0.049644
19.70	645.117	606.162	16.9212	-0.049486
19.75	675.719	617.949	17.0434	-0.049321
19.80	706.915	629.907	17.1665	-0.049149
19.85	738.713	642.041	17.2908	-0.048971

Table 24. Calculated $P(\rho)$ isotherms (Continued)

THE ISOTHERM AT 200.00 DEG. K

MOL/L	P,BAR	DP/DD	DP/DT	D2P/DT2
0.05	0.814	15.975	0.0042	-0.000001
0.10	1.596	15.285	0.0087	-0.000005
17.50	13.541	258.847	11.3605	-0.032662
17.55	26.647	265.425	11.4570	-0.032815
17.60	40.085	272.097	11.5539	-0.032964
17.65	53.859	278.864	11.6512	-0.033110
17.70	67.973	285.727	11.7489	-0.033251
17.75	82.433	292.686	11.8469	-0.033389
17.80	97.243	299.743	11.9454	-0.033522
17.85	112.409	306.899	12.0443	-0.033651
17.90	127.935	314.155	12.1437	-0.033775
17.95	143.826	321.512	12.2434	-0.033895
18.00	160.088	328.972	12.3436	-0.034009
18.05	176.725	336.535	12.4442	-0.034120
18.10	193.743	344.203	12.5452	-0.034225
18.15	211.147	351.977	12.6467	-0.034325
18.20	228.943	359.859	12.7486	-0.034420
18.25	247.135	367.849	12.8511	-0.034510
18.30	265.729	375.950	12.9540	-0.034595
18.35	284.732	384.163	13.0573	-0.034674
18.40	304.147	392.489	13.1612	-0.034748
18.45	323.982	400.930	13.2656	-0.034817
18.50	344.242	409.487	13.3705	-0.034880
18.55	364.933	418.163	13.4760	-0.034938
18.60	386.061	426.959	13.5820	-0.034990
18.65	407.631	435.877	13.6886	-0.035036
18.70	429.650	444.919	13.7957	-0.035077
18.75	452.125	454.086	13.9035	-0.035113
18.80	475.061	463.381	14.0118	-0.035143
18.85	498.465	472.806	14.1208	-0.035167
18.90	522.344	482.363	14.2304	-0.035186
18.95	546.704	492.054	14.3408	-0.035199
19.00	571.552	501.882	14.4518	-0.035207
19.05	596.894	511.849	14.5635	-0.035209
19.10	622.739	521.957	14.6759	-0.035205
19.15	649.092	532.209	14.7891	-0.035197
19.20	675.962	542.608	14.9031	-0.035183
19.25	703.356	553.156	15.0178	-0.035163
19.30	731.280	563.856	15.1334	-0.035139

Table 24. Calculated $P(\rho)$ isotherms (Continued)
THE ISOTHERM AT 220.00 DEG. K

MOL/L	P,BAR	DP/DD	DP/DT	D2P/DT2
0.10	1.768	17.082	0.0086	-0.000003
0.20	3.411	15.770	0.0178	-0.000014
16.60	17.768	190.467	9.2021	-0.020109
16.70	37.336	200.940	9.3742	-0.020462
16.80	57.967	211.733	9.5479	-0.020809
16.90	79.693	222.851	9.7233	-0.021149
17.00	102.548	234.300	9.9004	-0.021482
17.10	126.565	246.088	10.0792	-0.021806
17.20	151.777	258.222	10.2598	-0.022121
17.30	178.221	270.708	10.4420	-0.022427
17.40	205.931	283.554	10.6260	-0.022722
17.50	234.944	296.769	10.8119	-0.023005
17.60	265.297	310.360	10.9995	-0.023278
17.70	297.029	324.337	11.1890	-0.023537
17.80	330.178	338.710	11.3803	-0.023785
17.90	364.784	353.487	11.5737	-0.024018
18.00	400.889	368.680	11.7690	-0.024239
18.10	438.535	384.300	11.9664	-0.024445
18.20	477.764	400.359	12.1659	-0.024637
18.30	518.621	416.870	12.3677	-0.024814
18.40	561.153	433.846	12.5718	-0.024976
18.50	605.407	451.302	12.7783	-0.025124
18.60	651.430	469.253	12.9873	-0.025256
18.70	699.274	487.716	13.1989	-0.025373
18.80	748.991	506.709	13.4133	-0.025475

Table 24. Calculated $P(\rho)$ isotherms (Continued)
THE ISOTHERM AT 240.00 DEG. K

MOL/L	P,BAR	DP/DD	DP/DT	02P/DT2
0.10	1.940	18.852	0.0085	-0.000002
0.20	3.766	17.661	0.0176	-0.000009
0.30	5.473	16.494	0.0272	-0.000022
0.40	7.066	15.364	0.0374	-0.000044
0.50	8.547	14.263	0.0483	-0.000076
15.50	9.671	124.461	7.1561	-0.011002
15.60	22.499	132.140	7.3023	-0.011333
15.70	36.108	140.077	7.4502	-0.011664
15.80	50.523	148.278	7.5998	-0.011994
15.90	65.772	156.749	7.7512	-0.012322
16.00	81.882	165.494	7.9043	-0.012648
16.10	98.880	174.519	8.0592	-0.012972
16.20	116.795	183.828	8.2159	-0.013293
16.30	135.656	193.428	8.3743	-0.013611
16.40	155.491	203.325	8.5345	-0.013925
16.50	176.331	213.524	8.6964	-0.014235
16.60	198.206	224.030	8.8601	-0.014540
16.70	221.147	234.852	9.0256	-0.014840
16.80	245.187	245.994	9.1929	-0.015135
16.90	270.357	257.463	9.3620	-0.015423
17.00	296.691	269.268	9.5330	-0.015706
17.10	324.222	281.414	9.7058	-0.015981
17.20	352.985	293.910	9.8805	-0.016250
17.30	383.016	306.764	10.0571	-0.016511
17.40	414.350	319.985	10.2357	-0.016764
17.50	447.025	333.580	10.4162	-0.017008
17.60	481.079	347.560	10.5987	-0.017244
17.70	516.551	361.935	10.7834	-0.017471
17.80	553.480	376.715	10.9701	-0.017689
17.90	591.908	391.912	11.1590	-0.017897
18.00	631.876	407.537	11.3501	-0.018096
18.10	673.430	423.604	11.5436	-0.018285
18.20	716.612	440.125	11.7394	-0.018464

Table 24. Calculated $P(P)$ isotherms (Continued)
THE ISOTHERM AT 260.00 DEG. K

MOL/L	P,BAR	DP/DD	DP/DT	O2P/DT2
0.10	2.110	20.604	0.0085	-0.000001
0.20	4.116	19.511	0.0175	-0.000006
0.30	6.014	18.446	0.0269	-0.000015
0.40	7.807	17.423	0.0367	-0.000028
0.50	9.499	16.433	0.0471	-0.000047
0.60	11.094	15.465	0.0579	-0.000071
0.70	12.593	14.511	0.0693	-0.000103
0.80	13.997	13.566	0.0811	-0.000143
0.90	15.306	12.629	0.0935	-0.000193
1.00	16.523	11.698	0.1065	-0.000255
14.30	17.323	75.033	5.4238	-0.004694
14.40	25.089	80.318	5.5430	-0.004975
14.50	33.393	85.806	5.6639	-0.005257
14.60	42.257	91.502	5.7865	-0.005538
14.70	51.701	97.411	5.9108	-0.005819
14.80	61.747	103.537	6.0368	-0.006101
14.90	72.416	109.885	6.1646	-0.006382
15.00	83.731	116.459	6.2941	-0.006663
15.10	95.715	123.264	6.4254	-0.006944
15.20	108.392	130.304	6.5584	-0.007225
15.30	121.784	137.585	6.6932	-0.007506
15.40	135.917	145.110	6.8297	-0.007786
15.50	150.814	152.885	6.9679	-0.008065
15.60	166.502	160.915	7.1080	-0.008343
15.70	183.006	169.205	7.2498	-0.008620
15.80	200.352	177.759	7.3934	-0.008895
15.90	218.567	186.584	7.5387	-0.009169
16.00	237.678	195.683	7.6859	-0.009441
16.10	257.713	205.064	7.8349	-0.009710
16.20	278.700	214.731	7.9856	-0.009978
16.30	300.669	224.690	8.1382	-0.010242
16.40	323.648	234.947	8.2927	-0.010504
16.50	347.669	245.509	8.4489	-0.010762
16.60	372.761	256.381	8.6071	-0.011016
16.70	398.956	267.571	8.7671	-0.011267
16.80	426.286	279.086	8.9290	-0.011514
16.90	454.784	290.932	9.0928	-0.011756
17.00	484.483	303.117	9.2586	-0.011993
17.10	515.419	315.650	9.4263	-0.012226
17.20	547.625	328.538	9.5961	-0.012453
17.30	581.139	341.791	9.7679	-0.012675
17.40	615.996	355.418	9.9418	-0.012891
17.50	652.235	369.428	10.1177	-0.013101
17.60	689.895	383.833	10.2959	-0.013305
17.70	729.015	398.642	10.4763	-0.013503

Table 24. Calculated $P(\rho)$ isotherms (Continued)

THE ISOTHERM AT 280.00 DEG. K

MOL/L	P, BAR	DP/DD	DP/DT	D ² P/DT ²
0.20	4.464	21.334	0.0174	-0.000004
0.40	8.537	19.416	0.0363	-0.000020
0.60	12.240	17.635	0.0568	-0.000048
0.80	15.595	15.918	0.0789	-0.000091
1.00	18.610	14.238	0.1026	-0.000152
1.20	21.292	12.596	0.1279	-0.000235
1.40	23.651	11.005	0.1549	-0.000346
1.60	25.699	9.482	0.1836	-0.000496
1.80	27.449	8.034	0.2141	-0.000706
12.80	29.399	35.601	3.8292	0.000011
13.00	37.133	41.834	4.0105	-0.000486
13.20	46.172	48.656	4.1979	-0.000961
13.40	56.637	56.100	4.3915	-0.001425
13.60	68.656	64.199	4.5916	-0.001882
13.80	82.363	72.985	4.7981	-0.002336
14.00	97.898	82.492	5.0112	-0.002789
14.20	115.410	92.751	5.2310	-0.003244
14.40	135.051	103.798	5.4575	-0.003700
14.60	156.984	115.667	5.6908	-0.004157
14.80	181.375	128.392	5.9309	-0.004617
15.00	208.400	142.008	6.1780	-0.005078
15.20	238.240	156.553	6.4320	-0.005539
15.40	271.085	172.064	6.6931	-0.006000
15.60	307.133	188.579	6.9613	-0.006459
15.80	346.587	206.139	7.2367	-0.006915
16.00	389.661	224.787	7.5193	-0.007366
16.20	436.577	244.567	7.8092	-0.007812
16.40	487.566	265.527	8.1066	-0.008250
16.60	542.870	287.718	8.4116	-0.008679
16.80	602.739	311.197	8.7244	-0.009097
17.00	667.438	336.024	9.0452	-0.009502
17.20	737.243	362.265	9.3742	-0.009894

Table 24. Calculated P(ρ) isotherms (Continued)

THE ISOTHERM AT 290.00 DEG. K

MOL/L	P,BAR	DP/D ρ	DP/DT	D ² P/D ρ T ²
0.20	4.638	22.237	0.0173	-0.000004
0.40	8.898	20.396	0.0361	-0.000017
0.60	12.805	18.691	0.0563	-0.000040
0.80	16.379	17.052	0.0780	-0.000076
1.00	19.628	15.448	0.1012	-0.000124
1.20	22.561	13.882	0.1258	-0.000187
1.40	25.185	12.368	0.1519	-0.000268
1.60	27.512	10.922	0.1793	-0.000369
1.80	29.559	9.554	0.2082	-0.000496
2.00	31.339	8.269	0.2384	-0.000659
2.20	32.872	7.068	0.2701	-0.000872
2.40	34.172	5.945	0.3033	-0.001165
11.80	36.715	19.597	3.0333	0.002241
12.00	41.028	23.606	3.1812	0.001695
12.20	46.187	28.061	3.3345	0.001209
12.40	52.284	32.991	3.4934	0.000760
12.60	59.417	38.427	3.6582	0.000336
12.80	67.691	44.398	3.8289	-0.000074
13.00	77.215	50.936	4.0057	-0.000476
13.20	88.105	58.070	4.1888	-0.000873
13.40	100.484	65.832	4.3781	-0.001268
13.60	114.482	74.253	4.5739	-0.001665
13.80	130.232	83.366	4.7762	-0.002063
14.00	147.876	93.204	4.9850	-0.002465
14.20	167.564	103.798	5.2005	-0.002869
14.40	189.448	115.183	5.4227	-0.003278
14.60	213.692	127.392	5.6516	-0.003689
14.80	240.462	140.461	5.8874	-0.004103
15.00	269.936	154.425	6.1301	-0.004520
15.20	302.294	169.319	6.3798	-0.004937
15.40	337.728	185.183	6.6365	-0.005355
15.60	376.435	202.056	6.9003	-0.005772
15.80	418.620	219.977	7.1713	-0.006187
16.00	464.499	238.991	7.4495	-0.006599
16.20	514.293	259.142	7.7352	-0.007007
16.40	568.235	280.481	8.0285	-0.007408
16.60	626.567	303.059	8.3294	-0.007802
16.80	689.545	326.934	8.6381	-0.008187

Table 24. Calculated $P(\rho)$ isotherms (Continued)

THE ISOTHERM AT 300.00 DEG. K

MOL/L	P,BAR	DP/CD	DP/DT	O2P/DT2
0.20	4.811	23.137	0.0173	-0.000003
0.40	9.258	21.366	0.0359	-0.000014
0.60	13.367	19.733	0.0559	-0.000034
0.80	17.156	18.164	0.0773	-0.000064
1.00	20.634	16.630	0.1001	-0.000103
1.20	23.810	15.132	0.1241	-0.000154
1.40	26.691	13.685	0.1495	-0.000216
1.60	29.289	12.304	0.1760	-0.000291
1.80	31.618	11.000	0.2038	-0.000380
2.00	33.694	9.778	0.2328	-0.000486
2.20	35.534	8.639	0.2628	-0.000611
2.40	37.155	7.580	0.2940	-0.000760
2.60	38.572	6.596	0.3262	-0.000940
2.80	39.798	5.681	0.3594	-0.001160
3.00	40.848	4.830	0.3936	-0.001439
3.20	41.734	4.040	0.4289	-0.001803
3.40	42.463	3.308	0.4653	-0.002303
3.60	43.062	2.633	0.5028	-0.003045
3.80	43.525	2.015	0.5420	-0.004278
10.20	44.034	5.581	2.0913	0.006320
10.40	45.307	7.188	2.1950	0.005196
10.60	46.926	9.043	2.3028	0.004369
10.80	48.942	11.169	2.4150	0.003717
11.00	51.413	13.590	2.5321	0.003176
11.20	54.399	16.331	2.6541	0.002708
11.40	57.968	19.419	2.7813	0.002289
11.60	62.192	22.879	2.9139	0.001903
11.80	67.147	26.737	3.0518	0.001540
12.00	72.915	31.022	3.1954	0.001191
12.20	79.586	35.762	3.3446	0.000852
12.40	87.252	40.983	3.4997	0.000517
12.60	96.013	46.717	3.6607	0.000185
12.80	105.975	52.992	3.8278	-0.000148
13.00	117.248	59.838	4.0010	-0.000482
13.20	129.950	67.285	4.1803	-0.000820
13.40	144.204	75.365	4.3660	-0.001162
13.60	160.140	84.108	4.5581	-0.001509
13.80	177.894	93.547	4.7566	-0.001860
14.00	197.607	103.714	4.9616	-0.002217
14.20	219.430	114.641	5.1733	-0.002579
14.40	243.517	126.362	5.3916	-0.002945
14.60	270.030	138.911	5.6167	-0.003316
14.80	299.139	152.322	5.8485	-0.003690
15.00	331.019	166.632	6.0873	-0.004067
15.20	365.854	181.877	6.3329	-0.004446
15.40	403.834	198.094	6.5856	-0.004826
15.60	445.159	215.324	6.8455	-0.005206
15.80	490.034	233.608	7.1125	-0.005585
16.00	538.675	252.989	7.3868	-0.005962
16.20	591.306	273.515	7.6686	-0.006335
16.40	648.161	295.236	7.9580	-0.006704
16.60	709.484	318.205	8.2551	-0.007067

Table 24. Calculated $P(\rho)$ isotherms (Continued)

THE ISOTHERM AT 305.37 DEG. K

MOL/L	P, BAR	DP/DD	DP/DT	D ² P/DT ²
0.40	9.451	21.884	0.0358	-0.000013
0.80	17.570	18.754	0.0770	-0.000059
1.20	24.474	15.792	0.1233	-0.000140
1.60	30.230	13.029	0.1746	-0.000260
2.00	34.937	10.563	0.2303	-0.000424
2.40	38.723	8.420	0.2902	-0.000641
2.80	41.713	6.571	0.3539	-0.000925
3.20	44.014	4.977	0.4207	-0.001304
3.60	45.725	3.616	0.4904	-0.001823
4.00	46.939	2.491	0.5623	-0.002567
4.40	47.751	1.609	0.6361	-0.003696
4.80	48.257	0.962	0.7110	-0.005536
5.20	48.547	0.519	0.7866	-0.008912
5.60	48.693	0.232	0.8625	-0.016770
6.00	48.748	0.057	0.9383	-0.049009
6.40	48.755	0.000	1.0104	-0.480413
6.80	48.755	-0.000	1.0567	17.287460
7.20	48.755	0.002	1.1174	0.285379
7.60	48.764	0.064	1.2016	0.061370
8.00	48.828	0.284	1.3013	0.025533
8.40	49.022	0.730	1.4149	0.014647
8.80	49.453	1.486	1.5429	0.009849
9.20	50.265	2.655	1.6862	0.007230
9.60	51.649	4.362	1.8458	0.005584
10.00	53.846	6.749	2.0227	0.004434
10.40	57.159	9.974	2.2179	0.003554
10.80	61.960	14.212	2.4324	0.002828
11.20	68.688	19.649	2.6672	0.002185
11.60	77.865	26.485	2.9232	0.001586
12.00	90.091	34.930	3.2012	0.001002
12.40	106.052	45.204	3.5022	0.000416
12.80	126.528	57.535	3.8269	-0.000183
13.20	152.387	72.162	4.1760	-0.000801
13.60	184.596	89.327	4.5502	-0.001443
14.00	224.220	109.282	4.9500	-0.002108
14.40	272.428	132.288	5.3762	-0.002795
14.80	330.493	158.613	5.8292	-0.003500
15.20	399.799	188.540	6.3097	-0.004219
15.60	481.845	222.370	6.8182	-0.004942
16.00	578.258	260.428	7.3556	-0.005664
16.40	690.800	303.083	7.9229	-0.006373

Table 24. Calculated P(ρ) isotherms (Continued)

THE ISOTHERM AT 310.00 DEG. K

MOL/L	P,BAR	DP/DD	DP/DT	D2P/DT2
0.40	9.617	22.329	0.0358	-0.000013
0.80	17.926	19.259	0.0767	-0.000055
1.20	25.044	16.354	0.1227	-0.000129
1.60	31.035	13.645	0.1734	-0.000237
2.00	35.999	11.228	0.2285	-0.000382
2.40	40.061	9.130	0.2875	-0.000564
2.80	43.342	7.320	0.3499	-0.000789
3.20	45.949	5.758	0.4153	-0.001059
3.60	47.978	4.424	0.4831	-0.001378
4.00	49.519	3.318	0.5526	-0.001736
4.40	50.664	2.447	0.6234	-0.002101
4.80	51.507	1.804	0.6948	-0.002402
5.20	52.133	1.359	0.7664	-0.002528
5.60	52.614	1.066	0.8384	-0.002353
6.00	53.000	0.885	0.9112	-0.001801
6.40	53.339	0.837	0.9862	-0.000910
6.80	53.682	0.879	1.0648	0.000162
7.20	54.045	0.945	1.1483	0.001334
7.60	54.451	1.113	1.2383	0.002503
8.00	54.961	1.474	1.3372	0.003449
8.40	55.664	2.084	1.4474	0.004001
8.80	56.672	3.018	1.5713	0.004148
9.20	58.134	4.377	1.7106	0.003995
9.60	60.246	6.283	1.8665	0.003667
10.00	63.253	8.880	2.0402	0.003253
10.40	67.463	12.326	2.2325	0.002803
10.80	73.250	16.794	2.4443	0.002337
11.20	81.060	22.472	2.6765	0.001860
11.60	91.416	29.559	2.9300	0.001371
12.00	104.923	38.264	3.2056	0.000866
12.40	122.272	48.808	3.5040	0.000340
12.80	144.244	61.417	3.8260	-0.000211
13.20	171.713	76.330	4.1723	-0.000789
13.60	205.647	93.788	4.5436	-0.001393
14.00	247.116	114.044	4.9405	-0.002024
14.40	297.290	137.357	5.3635	-0.002679
14.80	357.445	163.996	5.8134	-0.003352
15.20	428.968	194.244	6.2906	-0.004040
15.60	513.361	228.402	6.7958	-0.004734
16.00	612.255	266.800	7.3300	-0.005427
16.40	727.416	309.808	7.8940	-0.006111

Table 24. Calculated P(ρ) isotherms (Continued)

THE ISOTHERM AT 320.00 DEG. K

MOL/L	P,BAR	DP/DD	DP/DT	D2P/DT2
0.40	9.974	23.285	0.0357	-0.000011
0.80	18.691	20.340	0.0762	-0.000047
1.20	26.265	17.554	0.1215	-0.000110
1.60	32.758	14.954	0.1712	-0.000198
2.00	38.266	12.637	0.2250	-0.000311
2.40	42.909	10.627	0.2825	-0.000445
2.80	46.805	8.893	0.3431	-0.000597
3.20	50.055	7.395	0.4064	-0.000758
3.60	52.749	6.111	0.4719	-0.000916
4.00	54.973	5.043	0.5393	-0.001054
4.40	56.814	4.201	0.6082	-0.001146
4.80	58.363	3.581	0.6785	-0.001168
5.20	59.706	3.164	0.7504	-0.001100
5.60	60.916	2.911	0.8243	-0.000934
6.00	62.052	2.791	0.9008	-0.000677
6.40	63.171	2.834	0.9810	-0.000343
6.80	64.335	2.994	1.0657	0.000043
7.20	65.572	3.205	1.1558	0.000466
7.60	66.918	3.557	1.2526	0.000906
8.00	68.451	4.153	1.3576	0.001327
8.40	70.281	5.050	1.4725	0.001689
8.80	72.541	6.319	1.5990	0.001956
9.20	75.398	8.055	1.7391	0.002108
9.60	79.062	10.374	1.8942	0.002142
10.00	83.793	13.415	2.0659	0.002069
10.40	89.910	17.330	2.2555	0.001906
10.80	97.797	22.293	2.4640	0.001669
11.20	107.909	28.488	2.6925	0.001372
11.60	120.778	36.112	2.9419	0.001025
12.00	137.017	45.376	3.2130	0.000633
12.40	157.326	56.497	3.5067	0.000202
12.80	182.493	69.702	3.8236	-0.000266
13.20	213.397	85.226	4.1645	-0.000770
13.60	251.015	103.313	4.5301	-0.001305
14.00	296.423	124.213	4.9210	-0.001871
14.40	350.795	148.185	5.3379	-0.002462
14.80	415.416	175.499	5.7813	-0.003074
15.20	491.678	206.438	6.2519	-0.003701
15.60	581.090	241.306	6.7505	-0.004338
16.00	685.291	280.439	7.2780	-0.004976

Table 24. Calculated $P(\rho)$ isotherms (Continued)
THE ISOTHERM AT 330.00 DEG. K

MOL/L	P, BAR	DP/DD	DP/DT	D ² P/DT ²
0.40	10.330	24.236	0.0356	-0.000010
0.80	19.451	21.408	0.0758	-0.000041
1.20	27.475	18.734	0.1205	-0.000094
1.60	34.461	16.238	0.1694	-0.000168
2.00	40.502	14.015	0.2222	-0.000260
2.40	45.713	12.088	0.2784	-0.000365
2.80	50.208	10.426	0.3377	-0.000477
3.20	54.084	8.990	0.3997	-0.000589
3.60	57.427	7.759	0.4640	-0.000689
4.00	60.319	6.736	0.5304	-0.000765
4.40	62.846	5.936	0.5987	-0.000804
4.80	65.097	5.361	0.6690	-0.000794
5.20	67.163	4.997	0.7415	-0.000731
5.60	69.119	4.811	0.8168	-0.000612
6.00	71.031	4.777	0.8954	-0.000444
6.40	72.966	4.929	0.9782	-0.000232
6.80	74.993	5.218	1.0659	0.000010
7.20	77.150	5.583	1.1594	0.000276
7.60	79.482	6.119	1.2597	0.000555
8.00	82.083	6.937	1.3680	0.000829
8.40	85.077	8.096	1.4859	0.001078
8.80	88.615	9.669	1.6148	0.001283
9.20	92.880	11.751	1.7563	0.001426
9.60	98.099	14.455	1.9121	0.001496
10.00	104.545	17.915	2.0834	0.001489
10.40	112.551	22.281	2.2719	0.001408
10.80	122.513	27.722	2.4785	0.001258
11.20	134.897	34.421	2.7045	0.001045
11.60	150.244	42.572	2.9508	0.000776
12.00	169.176	52.384	3.2184	0.000456
12.40	192.401	64.073	3.5081	0.000092
12.80	220.714	77.864	3.8207	-0.000314
13.20	255.004	93.993	4.1569	-0.000758
13.60	296.252	112.701	4.5174	-0.001237
14.00	345.541	134.238	4.9030	-0.001747
14.40	404.054	158.863	5.3142	-0.002283
14.80	473.079	186.846	5.7517	-0.002841
15.20	554.017	218.473	6.2164	-0.003416
15.60	648.384	254.051	6.7089	-0.004002

Table 24. Calculated $P(\rho)$ isotherms (Continued)

THE ISOTHERM AT 340.00 DEG. K

MOL/L	P,BAR	DP/DD	DP/DT	D ² P/DT ²
0.40	10.686	25.181	0.0355	-0.000009
0.80	20.207	22.465	0.0754	-0.000036
1.20	28.675	19.898	0.1196	-0.000082
1.60	36.148	17.501	0.1679	-0.000145
2.00	42.712	15.368	0.2198	-0.000221
2.40	48.480	13.521	0.2751	-0.000306
2.80	53.563	11.931	0.3334	-0.000394
3.20	58.054	10.558	0.3944	-0.000478
3.60	62.035	9.383	0.4579	-0.000550
4.00	65.587	8.413	0.5236	-0.000600
4.40	68.795	7.666	0.5916	-0.000621
4.80	71.751	7.150	0.6620	-0.000606
5.20	74.545	6.853	0.7352	-0.000553
5.60	77.259	6.748	0.8115	-0.000463
6.00	79.965	6.813	0.8915	-0.000339
6.40	82.737	7.083	0.9761	-0.000185
6.80	85.652	7.508	1.0659	-0.000009
7.20	88.756	8.030	1.1616	0.000184
7.60	92.103	8.752	1.2643	0.000386
8.00	95.800	9.788	1.3750	0.000588
8.40	99.984	11.201	1.4950	0.000775
8.80	104.820	13.064	1.6257	0.000934
9.20	110.508	15.473	1.7686	0.0011053
9.60	117.287	18.543	1.9250	0.001121
10.00	125.447	22.402	2.0964	0.001132
10.40	135.334	27.202	2.2842	0.0011082
10.80	147.356	33.105	2.4896	0.000973
11.20	161.990	40.293	2.7137	0.000806
11.60	179.787	48.958	2.9576	0.000586
12.00	201.380	59.306	3.2223	0.000317
12.40	227.485	71.552	3.5086	0.000001
12.80	258.905	85.920	3.8173	-0.000356
13.20	296.535	102.643	4.1493	-0.000752
13.60	341.366	121.964	4.5053	-0.001183
14.00	394.485	144.131	4.8860	-0.001645
14.40	457.084	169.403	5.2921	-0.002134
14.80	530.458	198.051	5.7243	-0.002645
15.20	616.014	230.363	6.1834	-0.003174
15.60	715.278	266.648	6.6703	-0.003715

Table 24. Calculated P(ρ) isotherms (Continued)

THE ISOTHERM AT 360.00 DEG. K

MOL/L	P,BAR	DP/DD	DP/DT	D2P/DT2
0.40	11.393	27.058	0.0353	-0.000007
0.80	21.708	24.554	0.0748	-0.000028
1.20	31.053	22.187	0.1182	-0.000064
1.60	39.478	19.977	0.1653	-0.000111
2.00	47.068	18.015	0.2160	-0.000166
2.40	53.927	16.325	0.2698	-0.000226
2.80	60.160	14.878	0.3267	-0.000286
3.20	65.857	13.637	0.3863	-0.000341
3.60	71.095	12.588	0.4487	-0.000385
4.00	75.954	11.742	0.5137	-0.000414
4.40	80.519	11.124	0.5814	-0.000423
4.80	84.866	10.750	0.6521	-0.000410
5.20	89.152	10.616	0.7261	-0.000375
5.60	93.408	10.698	0.8039	-0.000317
6.00	97.737	10.982	0.8859	-0.000239
6.40	102.226	11.507	0.9729	-0.000144
6.80	106.966	12.219	1.0654	-0.000035
7.20	112.018	13.065	1.1642	0.000085
7.60	117.452	14.162	1.2700	0.000211
8.00	123.397	15.629	1.3839	0.000336
8.40	130.013	17.533	1.5069	0.000455
8.80	137.492	19.953	1.6402	0.000558
9.20	146.057	22.986	1.7850	0.000638
9.60	155.978	26.747	1.9426	0.000687
10.00	167.569	31.365	2.1143	0.000699
10.40	181.203	36.987	2.3013	0.000670
10.80	197.314	43.773	2.5050	0.000597
11.20	216.400	51.899	2.7263	0.000479
11.60	239.036	61.554	2.9664	0.000316
12.00	265.874	72.939	3.2264	0.000110
12.40	297.646	86.266	3.5071	-0.000138
12.80	335.175	101.758	3.8095	-0.000424
13.20	379.372	119.644	4.1344	-0.000747
13.60	431.242	140.165	4.4825	-0.001103
14.00	491.888	163.570	4.8548	-0.001489
14.40	562.516	190.118	5.2519	-0.001901
14.80	644.438	220.081	5.6747	-0.002336
15.20	739.075	253.751	6.1240	-0.002788

Table 24. Calculated $P(\rho)$ isotherms (Continued)
THE ISOTHERM AT 380.00 DEG. K

MOL/L	P,BAR	DP/DD	DP/DT	D2P/DT2
0.40	12.099	28.922	0.0352	-0.000006
0.80	23.198	26.613	0.0743	-0.000023
1.20	33.404	24.434	0.1170	-0.000051
1.60	42.764	22.400	0.1634	-0.000087
2.00	51.356	20.603	0.2130	-0.000130
2.40	59.282	19.068	0.2659	-0.000175
2.80	66.642	17.766	0.3217	-0.000219
3.20	73.522	16.665	0.3804	-0.000259
3.60	79.999	15.754	0.4420	-0.000290
4.00	86.153	15.051	0.5065	-0.000310
4.40	92.071	14.584	0.5741	-0.000317
4.80	97.854	14.375	0.6450	-0.000308
5.20	103.606	14.426	0.7196	-0.000283
5.60	109.427	14.718	0.7983	-0.000244
6.00	115.411	15.240	0.8817	-0.000191
6.40	121.656	16.035	0.9702	-0.000126
6.80	128.267	17.046	1.0646	-0.000052
7.20	135.315	18.227	1.1653	0.000030
7.60	142.888	19.701	1.2732	0.000115
8.00	151.132	21.595	1.3892	0.000200
8.40	160.229	23.980	1.5141	0.000280
8.80	170.392	26.936	1.6491	0.000350
9.20	181.868	30.565	1.7952	0.000404
9.60	194.949	34.982	1.9537	0.000436
10.00	209.976	40.319	2.1255	0.000442
10.40	227.346	46.719	2.3120	0.000417
10.80	247.515	54.343	2.5144	0.000359
11.20	271.006	63.362	2.7336	0.000264
11.60	298.415	73.962	2.9708	0.000133
12.00	330.413	86.342	3.2271	-0.000035
12.40	367.754	100.711	3.5033	-0.000238
12.80	411.276	117.289	3.8005	-0.000476
13.20	461.909	136.303	4.1194	-0.000747
13.60	520.675	157.993	4.4610	-0.001048
14.00	588.694	182.608	4.8262	-0.001376
14.40	667.186	210.407	5.2157	-0.001730

Table 24. Calculated $P(\rho)$ isotherms (Continued)

THE ISOTHERM AT 400.00 DEG. K

MOL/L	P,BAR	DP/DD	DP/DT	D ² P/DT ²
0.40	12.802	30.774	0.0351	-0.000005
0.80	24.679	28.650	0.0738	-0.000019
1.20	35.736	26.648	0.1161	-0.000041
1.60	46.015	24.783	0.1618	-0.000070
2.00	55.593	23.146	0.2107	-0.000104
2.40	64.567	21.764	0.2627	-0.000139
2.80	73.035	20.611	0.3178	-0.000174
3.20	81.082	19.657	0.3758	-0.000204
3.60	88.786	18.894	0.4369	-0.000229
4.00	96.226	18.345	0.5010	-0.000244
4.40	103.495	18.044	0.5685	-0.000250
4.80	110.698	18.017	0.6396	-0.000244
5.20	117.946	18.269	0.7146	-0.000228
5.60	125.348	18.784	0.7939	-0.000200
6.00	133.008	19.558	0.8781	-0.000163
6.40	141.036	20.635	0.9678	-0.000117
6.80	149.547	21.954	1.0634	-0.000064
7.20	158.625	23.473	1.1655	-0.000007
7.60	168.370	25.327	1.2749	0.000053
8.00	178.948	27.647	1.3922	0.000113
8.40	190.559	30.503	1.5185	0.000169
8.80	203.434	33.983	1.6547	0.000217
9.20	217.842	38.188	1.8017	0.000253
9.60	234.097	43.238	1.9606	0.000272
10.00	252.563	49.264	2.1326	0.000271
10.40	273.658	56.410	2.3186	0.000246
10.80	297.861	64.836	2.5198	0.000194
11.20	325.719	74.711	2.7373	0.000114
11.60	357.848	86.220	2.9721	0.000003
12.00	394.939	99.559	3.2253	-0.000140
12.40	437.767	114.934	3.4978	-0.000312
12.80	487.187	132.564	3.7905	-0.000515
13.20	544.149	152.675	4.1045	-0.000747
13.60	609.690	175.505	4.4405	-0.001007
14.00	684.948	201.303	4.7995	-0.001291

Table 24. Calculated $P(\rho)$ isotherms (Continued)
THE ISOTHERM AT 420.00 DEG. K

MOL/L	P,BAR	DP/DD	DP/DT	D2P/DT2
0.40	13.503	32.616	0.0350	-0.000004
0.80	26.153	30.668	0.0735	-0.000015
1.20	38.051	28.835	0.1154	-0.000034
1.60	49.238	27.133	0.1605	-0.000058
2.00	59.787	25.654	0.2088	-0.000085
2.40	69.795	24.425	0.2602	-0.000114
2.80	79.358	23.423	0.3146	-0.000141
3.20	88.560	22.621	0.3721	-0.000166
3.60	97.480	22.014	0.4327	-0.000186
4.00	106.201	21.629	0.4966	-0.000199
4.40	114.818	21.505	0.5640	-0.000204
4.80	123.443	21.670	0.6351	-0.000201
5.20	132.194	22.134	0.7104	-0.000190
5.60	141.189	22.884	0.7902	-0.000171
6.00	150.539	23.919	0.8751	-0.000144
6.40	160.368	25.285	0.9655	-0.000111
6.80	170.801	26.917	1.0620	-0.000074
7.20	181.932	28.780	1.1651	-0.000032
7.60	193.875	31.014	1.2755	0.000011
8.00	206.811	33.757	1.3939	0.000053
8.40	220.958	37.080	1.5211	0.000092
8.80	236.564	41.072	1.6580	0.000124
9.20	253.919	45.840	1.8057	0.000147
9.60	273.356	51.504	1.9649	0.000157
10.00	295.259	58.196	2.1367	0.000150
10.40	320.070	66.063	2.3222	0.000124
10.80	348.287	75.262	2.5224	0.000076
11.20	380.480	85.964	2.7384	0.000004
11.60	417.283	98.351	2.9711	-0.000093
12.00	459.411	112.618	3.2217	-0.000217
12.40	507.655	128.969	3.4909	-0.000368
12.80	562.893	147.620	3.7799	-0.000545
13.20	626.089	168.800	4.0895	-0.000747
13.60	698.301	192.744	4.4207	-0.000975

Table 24. Calculated $P(\rho)$ isotherms (Continued)

THE ISOTHERM AT 450.00 DEG. K

MOL/L	P, BAR	OP/DD	OP/DT	O2P/DT2
0.40	14.552	35.366	0.0349	-0.000003
0.80	28.352	33.667	0.0731	-0.000012
1.20	41.498	32.077	0.1145	-0.000026
1.60	54.030	30.612	0.1590	-0.000044
2.00	66.017	29.365	0.2066	-0.000065
2.40	77.555	28.365	0.2572	-0.000087
2.80	88.739	27.593	0.3109	-0.000108
3.20	99.656	27.025	0.3678	-0.000127
3.60	110.326	26.663	0.4279	-0.000142
4.00	121.018	26.537	0.4914	-0.000153
4.40	131.654	26.692	0.5586	-0.000159
4.80	142.414	27.162	0.6298	-0.000159
5.20	153.427	27.959	0.7053	-0.000153
5.60	164.823	29.075	0.7856	-0.000142
6.00	176.729	30.513	0.8710	-0.000126
6.40	189.284	32.323	0.9622	-0.000107
6.80	202.627	34.433	1.0596	-0.000084
7.20	216.866	36.816	1.1637	-0.000059
7.60	232.136	39.623	1.2751	-0.000033
8.00	248.640	42.997	1.3945	-0.000008
8.40	266.619	47.010	1.5226	0.000014
8.80	286.346	51.757	1.6603	0.000030
9.20	308.137	57.347	1.8083	0.000040
9.60	332.353	63.904	1.9677	0.000039
10.00	359.407	71.564	2.1392	0.000026
10.40	389.771	80.474	2.3239	-0.000002
10.80	423.974	90.791	2.5227	-0.000047
11.20	462.614	102.687	2.7367	-0.000111
11.60	506.359	116.343	2.9667	-0.000195
12.00	555.949	131.952	3.2138	-0.000300
12.40	612.208	149.718	3.4789	-0.000427
12.80	676.040	169.855	3.7631	-0.000575
13.20	748.439	192.591	4.0671	-0.000745

Table 24. Calculated $P(\rho)$ isotherms (Continued)
THE ISOTHERM AT 500.00 DEG. K

MOL/L	P,BAR	DP/DD	DP/DT	D2P/DT2
0.40	16.295	39.920	0.0348	-0.000002
0.80	31.994	38.610	0.0726	-0.000008
1.20	47.194	37.402	0.1134	-0.000018
1.60	61.931	36.315	0.1572	-0.000030
2.00	76.275	35.445	0.2039	-0.000044
2.40	90.321	34.827	0.2537	-0.000059
2.80	104.168	34.445	0.3065	-0.000074
3.20	117.906	34.281	0.3625	-0.000087
3.60	131.623	34.346	0.4220	-0.000099
4.00	145.418	34.676	0.4850	-0.000108
4.40	159.407	35.323	0.5519	-0.000114
4.80	173.724	36.327	0.6230	-0.000117
5.20	188.518	37.704	0.6986	-0.000117
5.60	203.937	39.454	0.7792	-0.000114
6.00	220.132	41.586	0.8652	-0.000109
6.40	237.265	44.153	0.9570	-0.000102
6.80	255.499	47.071	1.0552	-0.000094
7.20	274.966	50.327	1.1601	-0.000084
7.60	295.829	54.088	1.2723	-0.000075
8.00	318.324	58.503	1.3924	-0.000067
8.40	342.729	63.649	1.5212	-0.000062
8.80	369.354	69.623	1.6593	-0.000061
9.20	398.553	76.541	1.8074	-0.000065
9.60	430.730	84.534	1.9664	-0.000076
10.00	466.341	93.740	2.1371	-0.000096
10.40	505.903	104.310	2.3204	-0.000127
10.80	549.993	116.406	2.5170	-0.000169
11.20	599.254	130.198	2.7280	-0.000225
11.60	654.402	145.869	2.9542	-0.000295
12.00	716.226	163.612	3.1966	-0.000380

Table 24. Calculated $P(\rho)$ isotherms (Continued)
THE ISOTHERM AT 550.00 DEG. K

MOL/L	P, BAR	DP/DD	DP/DT	D ² P/D ² T
0.40	18.032	44.448	0.0347	-0.000002
0.80	35.616	43.501	0.0723	-0.000006
1.20	52.844	42.655	0.1127	-0.000013
1.60	69.756	41.933	0.1559	-0.000022
2.00	86.421	41.433	0.2020	-0.000032
2.40	102.938	41.194	0.2511	-0.000043
2.80	119.410	41.207	0.3033	-0.000054
3.20	135.935	41.458	0.3588	-0.000065
3.60	152.610	41.963	0.4177	-0.000074
4.00	169.545	42.767	0.4803	-0.000082
4.40	186.871	43.925	0.5469	-0.000089
4.80	204.738	45.482	0.6178	-0.000093
5.20	223.312	47.460	0.6933	-0.000097
5.60	242.763	49.861	0.7739	-0.000098
6.00	263.260	52.702	0.8600	-0.000099
6.40	284.991	56.035	0.9520	-0.000099
6.80	308.139	59.768	1.0504	-0.000098
7.20	332.858	63.900	1.1555	-0.000097
7.60	359.337	68.611	1.2679	-0.000097
8.00	387.845	74.057	1.3882	-0.000099
8.40	418.690	80.313	1.5169	-0.000103
8.80	452.217	87.485	1.6549	-0.000110
9.20	488.816	95.692	1.8026	-0.000121
9.60	528.927	105.069	1.9609	-0.000138
10.00	573.046	115.761	2.1305	-0.000162
10.40	621.731	127.921	2.3122	-0.000194
10.80	675.601	141.715	2.5068	-0.000234
11.20	735.343	157.315	2.7151	-0.000285

Table 24. Calculated P(ρ) isotherms (Continued)

THE ISOTHERM AT 600.00 DEG. K

MOL/L	P, BAR	DP/D0	DP/DT	D2P/DT2
0.40	19.766	48.957	0.0346	-0.000001
0.80	39.222	48.356	0.0720	-0.000005
1.20	58.462	47.858	0.1121	-0.000010
1.60	77.525	47.489	0.1549	-0.000017
2.00	96.485	47.353	0.2006	-0.000025
2.40	115.445	47.492	0.2492	-0.000033
2.80	134.514	47.900	0.3009	-0.000042
3.20	153.800	48.572	0.3559	-0.000051
3.60	173.409	49.526	0.4144	-0.000059
4.00	193.465	50.812	0.4766	-0.000066
4.40	214.111	52.491	0.5429	-0.000073
4.80	235.517	54.613	0.6135	-0.000079
5.20	257.864	57.202	0.6888	-0.000084
5.60	281.341	60.262	0.7693	-0.000088
6.00	306.139	63.818	0.8552	-0.000092
6.40	332.470	67.922	0.9472	-0.000096
6.80	360.534	72.472	1.0454	-0.000099
7.20	390.507	77.477	1.1504	-0.000104
7.60	422.604	83.132	1.2627	-0.000109
8.00	457.121	89.596	1.3827	-0.000116
8.40	494.398	96.947	1.5112	-0.000125
8.80	534.811	105.291	1.6486	-0.000137
9.20	578.781	114.756	1.7957	-0.000153
9.60	626.783	125.479	1.9531	-0.000173
10.00	679.352	137.610	2.1214	-0.000198
10.40	737.081	151.308	2.3015	-0.000230

Table 25. The Joule-Thomson inversion locus.

T, K	P, BAR	MOL/L	T, K	P, BAR	MOL/L
250	26.3	15.06	425	467.3	11.93
255	47.2	14.95	430	474.2	11.85
260	67.3	14.85	435	481.0	11.77
265	86.7	14.75	440	487.6	11.70
270	105.3	14.65	445	493.9	11.62
275	123.4	14.55	450	500.1	11.55
280	140.8	14.45	455	506.0	11.47
285	157.6	14.36	460	511.7	11.40
290	173.8	14.26	465	517.3	11.32
295	189.5	14.16	470	522.6	11.25
300	204.7	14.07	475	527.8	11.17
305	219.5	13.97	480	532.7	11.10
310	233.7	13.88	485	537.5	11.03
315	247.5	13.79	490	542.1	10.95
320	260.9	13.69	495	546.5	10.88
325	273.9	13.60	500	550.7	10.81
330	286.5	13.51	505	554.8	10.73
335	298.7	13.42	510	558.6	10.66
340	310.6	13.33	515	562.3	10.59
345	322.1	13.24	520	565.8	10.52
350	333.3	13.16	525	569.1	10.44
355	344.1	13.07	530	572.3	10.37
360	354.7	12.98	535	575.2	10.30
365	364.9	12.90	540	578.0	10.23
370	374.9	12.81	545	580.7	10.16
375	384.6	12.73	550	583.2	10.09
380	393.9	12.65	555	585.5	10.01
385	403.1	12.57	560	587.6	9.94
390	411.9	12.48	565	589.6	9.87
395	420.6	12.40	570	591.4	9.80
400	428.9	12.32	575	593.0	9.73
405	437.1	12.24	580	594.5	9.66
410	445.0	12.16	585	595.9	9.59
415	452.6	12.08	590	597.1	9.52
420	460.0	12.01	595	598.1	9.44
			600	599.0	9.37

Table 26. Thermophysical properties of the saturated liquid

This table was computed by integrating first along isotherm T_b of Figure 9, then along isobar P_b , and finally along each isotherm down to the saturated liquid boundary.

Column headings have the following interpretations--

DPS/DT	$\equiv$	dP_{σ}/dT , vapor pressure,
DDL/DT	$\equiv$	$d\rho_{\ell}/dT$, saturated liquid,
DP/DT	$\equiv$	$(\partial P/\partial T)$, single phase,
DP/DD	$\equiv$	$(\partial P/\partial \rho)$, single phase,
Q, VAP	$\equiv$	ΔH_{vap} , heat of vaporization,

CV	$\equiv$	$C_v(\rho, T)$
CS	$\equiv$	$C_{\sigma}(T)$
CP	$\equiv$	$C_p(\rho, T)$
W	$\equiv$	speed of sound

Table 26. Thermophysical properties of the saturated liquid.

PROPERTIES OF SATURATED LIQUID ETHANE

T DEG K	P BAR	DEN MOL/L	V, LIQ L/MOL	V, GAS L/MOL	DPS/DL BAR/K	DDL/DL MOL/L/K	DP/DL BAR/K	DP/DT BAR/K	DP/DO BAR-L/MOL	Q, VAP J/MOL	Q, XPT J/MOL
99.899	1.010-005	21.630	0.34613	7.401+005	2.686-006	-0.0364	3.507+001	3.507+001	9.625+002	17869	17509
100.000	1.037-005	21.676	0.34613	7.213+005	2.752-006	-0.0364	3.503+001	3.503+001	9.614+002	17867	17507
95.000	3.626-005	21.495	0.34632	2.178+005	8.575-006	-0.0362	3.296+001	3.296+001	9.099+002	17740	17412
100.000	1.110-004	21.314	0.34632	7.506+004	2.347-005	-0.0361	3.108+001	3.108+001	8.612+002	17617	17312
105.000	3.025-004	21.134	0.34732	2.895+004	5.750-005	-0.0360	2.936+001	2.936+001	8.150+002	17482	17206
110.000	7.463-004	20.954	0.34772	1.230+004	1.281-004	-0.0360	2.779+001	2.779+001	7.713+002	17329	17094
115.000	1.629-003	20.773	0.34814	5.682+003	2.626-004	-0.0361	2.633+001	2.633+001	7.297+002	17161	16976
120.000	3.546-003	20.593	0.34856	2.822+003	5.014-004	-0.0362	2.438+001	2.438+001	6.901+002	16979	16852
125.000	6.907-003	20.411	0.34899	1.494+003	8.993-004	-0.0364	2.373+001	2.373+001	6.524+002	16791	16722
130.000	1.292-002	20.229	0.34943	6.362+002	1.527-003	-0.0366	2.256+001	2.256+001	6.165+002	16600	16586
135.000	2.277-002	20.045	0.34989	4.918+002	2.472-003	-0.0368	2.145+001	2.145+001	5.823+002	16410	16444
140.000	3.833-002	19.860	0.35035	3.023+002	3.835-003	-0.0371	2.042+001	2.042+001	5.497+002	16225	16296
145.000	6.200-002	19.674	0.35083	1.931+002	5.731-003	-0.0375	1.944+001	1.944+001	5.185+002	16046	16142
150.000	9.674-002	19.486	0.35132	1.278+002	8.285-003	-0.0379	1.851+001	1.851+001	4.887+002	15873	15982
155.000	1.462-001	19.295	0.35183	8.719+001	1.163-002	-0.0383	1.763+001	1.763+001	4.602+002	15706	15816
160.000	2.146-001	19.103	0.35235	6.116+001	1.590-002	-0.0387	1.679+001	1.679+001	4.330+002	15542	15643
165.000	3.069-001	18.908	0.35289	4.397+001	2.122-002	-0.0393	1.600+001	1.600+001	4.070+002	15380	15464
170.000	4.268-001	18.710	0.35345	3.232+001	2.774-002	-0.0398	1.523+001	1.523+001	3.820+002	15217	15278
175.000	5.865-001	18.510	0.35403	2.423+001	3.557-002	-0.0404	1.451+001	1.451+001	3.582+002	15051	15085
180.000	7.869-001	18.306	0.35463	1.849+001	4.484-002	-0.0410	1.381+001	1.381+001	3.353+002	14879	14886
185.000	1.038+000	18.099	0.35525	1.127+001	5.566-002	-0.0417	1.314+001	1.314+001	3.135+002	14699	14679
190.000	1.346+000	17.889	0.35580	1.127+001	6.812-002	-0.0425	1.249+001	1.249+001	2.925+002	14509	14465
195.000	1.722+000	17.674	0.35638	8.970+000	8.232-002	-0.0433	1.187+001	1.187+001	2.724+002	14307	14242
200.000	2.172+000	17.456	0.35729	7.224+000	9.833-002	-0.0442	1.128+001	1.128+001	2.531+002	14093	14012
205.000	2.708+000	17.232	0.35803	5.877+000	1.162-001	-0.0451	1.070+001	1.070+001	2.346+002	13865	13773
210.000	3.338+000	17.004	0.35881	4.827+000	1.361-001	-0.0462	1.014+001	1.014+001	2.168+002	13624	13525
215.000	4.072+000	16.771	0.35963	3.997+000	1.579-001	-0.0473	9.605+000	9.605+000	1.998+002	13368	13266
220.000	4.920+000	16.531	0.36049	3.335+000	1.818-001	-0.0485	9.085+000	9.085+000	1.835+002	13098	12998
225.000	5.894+000	16.285	0.36141	2.802+000	2.078-001	-0.0499	8.581+000	8.581+000	1.678+002	12815	12718
230.000	7.002+000	16.032	0.36238	2.369+000	2.359-001	-0.0514	8.092+000	8.092+000	1.527+002	12517	12425
235.000	8.257+000	15.771	0.36341	2.014+000	2.663-001	-0.0532	7.618+000	7.618+000	1.383+002	12205	12119
240.000	9.668+000	15.500	0.36452	1.721+000	2.988-001	-0.0551	7.156+000	7.156+000	1.245+002	11878	11797
245.000	1.125+001	15.219	0.36571	1.477+000	3.337-001	-0.0573	6.707+000	6.707+000	1.112+002	11533	11458
250.000	1.301+001	14.926	0.36700	1.272+000	3.709-001	-0.0599	6.269+000	6.269+000	9.854+001	11169	11099
255.000	1.496+001	14.620	0.36840	1.098+000	4.105-001	-0.0628	5.840+000	5.840+000	8.644+001	10781	10718
260.000	1.712+001	14.297	0.36934	9.506-001	4.527-001	-0.0663	5.421+000	5.421+000	7.489+001	10365	10311
265.000	1.949+001	13.955	0.37106	8.236-001	4.975-001	-0.0706	5.008+000	5.008+000	6.391+001	9914	9872
270.000	2.210+001	13.590	0.37358	7.135-001	5.452-001	-0.0758	4.601+000	4.601+000	5.351+001	9420	9396
275.000	2.495+001	13.195	0.37579	6.172-001	5.960-001	-0.0824	4.198+000	4.198+000	4.369+001	8873	8872
280.000	2.806+001	12.762	0.37836	5.321-001	6.501-001	-0.0912	3.795+000	3.795+000	3.448+001	8260	8287
285.000	3.146+001	12.277	0.38145	4.562-001	7.081-001	-0.1035	3.389+000	3.389+000	2.592+001	7564	7620
290.000	3.515+001	11.717	0.38535	3.877-001	7.707-001	-0.1220	2.973+000	2.973+000	1.806+001	6758	6836
295.000	3.918+001	11.035	0.39062	3.243-001	8.393-001	-0.1542	2.536+000	2.536+000	1.100+001	5785	5865
300.000	4.356+001	10.110	0.09891	2.613-001	9.166-001	-0.2290	2.046+000	2.046+000	4.930+000	4483	4531
305.000	4.838+001	8.118	0.12318	1.780-001	1.018+000	-1.0772	1.323+000	1.323+000	2.831-001	1702	1625
305.370	4.876+001	6.740	0.14637	1.484-001	1.037+000	0.0000	1.053+000	1.053+000			

Table 26. Thermophysical properties of the saturated liquid (continued).

PROPERTIES OF SATURATED LIQUID ETHANE

T DEG K	P BAR	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CS J/MOL/K	CP J/MOL/K	M/SEC	W J/MOL/K	CS,XPT J/MOL/K
39.899	1.010-005	5298.6	5238.6	76.497	44.06	68.50	68.50	2231	68.16	
30.000	1.037-005	5305.5	5305.5	76.574	44.06	68.50	68.50	2230	68.17	
95.000	3.628-005	5648.2	5648.2	80.279	44.02	68.56	68.56	2171	68.28	
100.000	1.110-004	5391.2	5391.2	83.797	43.95	68.64	68.64	2115	68.41	
105.000	3.025-004	6334.6	6334.6	87.148	43.86	68.73	68.73	2061	68.55	
110.000	7.463-004	6678.4	6678.4	90.347	43.75	68.83	68.83	2009	68.70	
115.000	1.689-003	7022.9	7022.9	93.410	43.63	68.96	68.96	1958	68.87	
120.000	3.546-003	7368.1	7368.1	96.347	43.51	69.10	69.10	1909	69.04	
125.000	6.967-003	7714.0	7714.0	99.172	43.38	69.27	69.27	1661	69.24	
130.000	1.292-002	8060.8	8060.8	101.892	43.25	69.46	69.47	1815	69.44	
135.000	2.277-002	8408.7	8408.7	104.518	43.13	69.68	69.68	1769	69.66	
140.000	3.633-002	8757.6	8757.6	107.056	43.01	69.92	69.93	1724	69.90	
145.000	6.200-002	9107.9	9108.2	109.514	42.90	70.19	70.20	1680	70.15	
150.000	9.674-002	9459.6	9460.1	111.899	42.81	70.50	70.51	1636	70.43	
155.000	1.462-001	9812.9	9813.7	114.216	42.73	70.83	70.85	1593	70.72	
160.000	2.146-001	10168.0	10169.1	116.470	42.66	71.19	71.22	1550	71.04	
165.000	3.069-001	10524.9	10526.5	118.667	42.61	71.59	71.63	1508	71.38	
170.000	4.288-001	10883.9	10886.2	120.811	42.58	72.03	72.09	1467	71.75	
175.000	5.865-001	11245.2	11248.4	122.905	42.58	72.51	72.58	1425	72.15	
180.000	7.869-001	11609.0	11613.3	124.955	42.59	73.03	73.12	1384	72.58	
185.000	1.033-000	11975.5	11981.2	126.963	42.63	73.59	73.72	1343	73.05	
190.000	1.346-000	12344.8	12352.3	128.934	42.69	74.19	74.37	1302	73.55	
195.000	1.722-000	12717.3	12727.0	130.869	42.77	74.85	75.08	1261	74.09	
200.000	2.172-000	13093.2	13105.6	132.773	42.88	75.56	75.85	1220	74.68	
205.000	2.703-000	13472.7	13488.4	134.648	43.01	76.33	76.70	1179	75.33	
210.000	3.338-000	13856.2	13875.8	136.498	43.17	77.17	77.63	1139	76.03	
215.000	4.072-000	14244.0	14268.2	138.324	43.35	78.07	78.65	1098	76.80	
220.000	4.920-000	14636.3	14666.1	140.130	43.56	79.05	79.78	1057	77.65	
225.000	5.894-000	15033.7	15069.9	141.918	43.79	80.12	81.03	1016	78.58	
230.000	7.002-000	15436.6	15480.3	143.692	44.05	81.30	82.41	975	79.61	
235.000	8.257-000	15845.5	15897.8	145.454	44.32	82.59	83.97	933	80.77	
240.000	9.668-000	16260.9	16323.3	147.207	44.62	84.01	85.73	892	82.06	
245.000	1.125-001	16683.6	16757.5	148.955	44.95	85.60	87.73	850	83.51	
250.000	1.301-001	17114.5	17201.6	150.702	45.29	87.39	90.04	807	85.17	
255.000	1.496-001	17554.4	17656.8	152.453	45.66	89.43	92.74	764	87.09	
260.000	1.712-001	18004.8	18124.6	154.211	46.05	91.78	95.95	720	89.31	
265.000	1.949-001	18467.3	18607.0	155.985	46.46	94.56	99.86	676	91.95	
270.000	2.210-001	18944.2	19106.8	157.783	46.91	97.90	104.75	630	95.13	
275.000	2.495-001	19438.5	19627.6	159.616	47.38	102.05	111.10	584	99.07	
280.000	2.806-001	19954.7	20174.6	161.501	47.90	107.43	119.73	535	104.13	
285.000	3.140-001	20500.0	20756.2	163.463	48.49	114.80	132.31	485	110.93	
290.000	3.515-001	21066.5	21366.5	165.548	49.20	125.61	152.62	432	120.78	
295.000	3.918-001	21738.3	22093.3	167.843	50.12	144.82	191.67	374	137.02	
300.000	4.356-001	22519.4	22950.3	170.584	51.67	189.20	300.84	309	172.17	
305.000	4.833-001	23370.6	24466.4	175.417	60.59	720.24	2923.16	213	519.96	
305.370	4.875-001	24004.3	25368.2	178.420				0		

Table 27. Thermophysical properties along isobars *

The following pages give physical and thermodynamic properties along selected isobars, as computed by methods of section 3 of the text.

The first line of each table refers to freezing liquid on the $P(T)$ melting line.

Each table $P < P_c$ contains a blank line for the transition from saturated liquid to vapor, as seen by the abrupt decrease of density.

Table headings for partial derivatives have the following interpretations --

$$DP/DT \equiv \partial P / \partial T,$$

$$DP/DD \equiv \partial P / \partial \rho.$$

The specific heat interpretations are -

$$CV \equiv C_v(\rho, T),$$

$$CP \equiv C_p(\rho, T).$$

*These tables are extrapolated beyond the range of P - ρ - T data used for adjusting the equation of state ($P \sim 350$ bar).

Table 27. Thermophysical properties along isobars.

ETHANE ISOBAR AT P = 0.1 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DP/CT BAR/K	OP/DD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CF J/MOL/K	W M/SEC
89.901	21.680	0.04613	35.0703	962.504	5298.6	5299.1	76.497	44.06	68.50	2231
90.000	21.676	0.04613	35.0269	961.449	5305.5	5305.9	76.573	44.06	68.50	2230
100.000	21.314	0.04692	31.0780	861.212	5991.5	5991.5	83.796	43.95	68.64	2115
110.000	20.954	0.04772	27.7875	771.300	6678.3	6678.8	90.346	43.75	68.83	2009
120.000	20.593	0.04856	24.9852	690.149	7367.9	7368.4	96.346	43.51	69.10	1909
130.000	20.229	0.04943	22.5553	616.578	8060.7	8061.2	101.891	43.25	69.47	1815
140.000	19.861	0.05035	20.4166	549.676	8757.6	8758.1	107.055	43.01	69.93	1724
150.000	19.486	0.05132	18.5104	488.678	9459.6	9460.1	111.899	42.81	70.51	1636
150.368	19.471	0.05136	18.4405	486.423	9487.0	9487.5	112.081	42.80	70.53	1633
150.368	0.00807	123.911	0.000675	12.305	24200.1	25439.3	218.143	30.48	39.03	229
160.000	0.00758	131.996	0.000633	13.121	24497.3	25817.2	220.577	31.06	39.57	236
170.000	0.00712	140.391	0.000594	13.967	24812.4	26216.3	222.995	31.72	40.20	243
180.000	0.00672	148.774	0.000561	14.810	25134.1	26621.9	225.311	32.42	40.88	249
190.000	0.00636	157.147	0.000530	15.651	25463.1	27034.5	227.541	33.18	41.61	255
200.000	0.00604	165.513	0.000503	16.491	25799.6	27454.8	229.695	33.98	42.40	262
210.000	0.00575	173.873	0.000479	17.329	26144.4	27883.1	231.784	34.83	43.24	267
220.000	0.00549	182.228	0.000457	18.167	26497.8	28320.1	233.815	35.73	44.12	273
230.000	0.00525	190.579	0.000437	19.004	26860.4	28766.2	235.797	36.67	45.06	279
240.000	0.00503	198.927	0.000418	19.841	27232.6	29221.9	237.736	37.66	46.04	284
250.000	0.00482	207.273	0.000402	20.677	27614.9	29687.6	239.636	38.69	47.07	289
260.000	0.00464	215.616	0.000386	21.512	28007.6	30163.8	241.503	39.76	48.13	294
270.000	0.00447	223.957	0.000372	22.348	28411.2	30650.8	243.340	40.87	49.24	299
280.000	0.00430	232.296	0.000358	23.183	28826.0	31149.0	245.151	42.01	50.38	304
290.000	0.00416	240.633	0.000346	24.017	29252.4	31658.8	246.939	43.19	51.55	309
300.000	0.00402	248.969	0.000334	24.852	29690.7	32180.4	248.707	44.39	52.74	313
310.000	0.00389	257.304	0.000323	25.686	30141.0	32714.0	250.456	45.61	53.97	318
320.000	0.00376	265.638	0.000313	26.520	30603.6	33260.0	252.189	46.86	55.21	322
330.000	0.00365	273.971	0.000304	27.354	31078.8	33818.5	253.907	48.12	56.47	327
340.000	0.00354	282.303	0.000295	28.188	31566.7	34389.7	255.612	49.39	57.74	331
350.000	0.00344	290.634	0.000286	29.022	32067.3	34973.6	257.304	50.68	59.02	335
360.000	0.00334	298.965	0.000278	29.856	32580.8	35570.5	258.985	51.97	60.32	339
370.000	0.00325	307.294	0.000271	30.689	33107.3	36180.2	260.655	53.27	61.61	344
380.000	0.00317	315.623	0.000264	31.523	33646.8	36803.0	262.316	54.57	62.91	348
390.000	0.00309	323.952	0.000257	32.356	34199.2	37438.7	263.967	55.87	64.21	352
400.000	0.00301	332.279	0.000250	33.189	34764.7	38087.5	265.609	57.17	65.51	356
410.000	0.00294	340.607	0.000244	34.022	35343.1	38749.1	267.242	58.46	66.80	360
420.000	0.00287	348.934	0.000238	34.855	35934.4	39423.7	268.867	59.75	68.09	363
430.000	0.00280	357.260	0.000233	35.689	36538.5	40111.1	270.484	61.03	69.37	367
440.000	0.00274	365.586	0.000228	36.522	37155.4	40811.2	272.094	62.30	70.64	371
450.000	0.00267	373.912	0.000222	37.354	37784.9	41524.4	273.695	63.57	71.90	375
460.000	0.00262	382.237	0.000218	38.187	38427.0	42249.4	275.289	64.82	73.15	379
470.000	0.00256	390.562	0.000213	39.020	39081.5	42987.2	276.876	66.05	74.39	382
480.000	0.00251	398.887	0.000209	39.853	39748.4	43737.2	278.455	67.28	75.61	386
490.000	0.00246	407.211	0.000204	40.686	40427.4	44499.5	280.026	68.49	76.82	390
500.000	0.00241	415.535	0.000200	41.518	41118.5	45273.8	281.590	69.69	78.02	393
520.000	0.00231	432.182	0.000192	43.184	42536.2	46858.0	284.697	72.05	80.38	400
540.000	0.00223	448.828	0.000185	44.849	44000.5	48488.8	287.773	74.35	82.67	407
560.000	0.00215	465.473	0.000179	46.514	45510.2	50165.0	290.821	76.59	84.92	414
580.000	0.00207	482.118	0.000172	48.179	47064.2	51885.4	293.839	78.78	87.11	421
600.000	0.00200	498.761	0.000167	49.844	48661.5	53649.1	296.828	80.92	89.24	428

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 0.5 BAR

T DEG K	DEM MOL/L	VOL L/MOL	DF/CT BAR/K	DF/DD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	M M/SEC
89.907	21.580	0.04612	35.0678	962.565	5298.8	5301.1	76.499	44.06	68.50	2231
90.000	21.677	0.04612	35.0272	961.576	5305.2	5307.5	76.570	44.06	68.50	2230
100.000	21.315	0.04692	31.0786	861.350	5990.8	5993.1	83.793	43.95	68.63	2115
110.000	20.954	0.04772	27.7884	771.447	6678.0	6680.4	90.343	43.75	68.83	2009
120.000	20.593	0.04856	24.9863	690.304	7367.5	7370.0	96.343	43.51	69.10	1909
130.000	20.230	0.04943	22.5567	616.739	8060.3	8062.7	101.888	43.26	69.46	1815
140.000	19.861	0.05035	20.4182	549.843	8757.0	8759.6	107.052	43.02	69.93	1724
150.000	19.486	0.05132	18.5122	488.852	9459.0	9461.6	111.895	42.81	70.50	1636
160.000	19.103	0.05235	16.7953	433.117	10167.5	10170.1	116.467	42.66	71.22	1551
170.000	18.710	0.05345	15.2347	382.070	10883.8	10886.5	120.810	42.58	72.08	1467
172.413	18.614	0.05372	14.8786	370.397	11058.0	11060.7	121.827	42.58	72.32	1446
172.413	0.03564	28.061	0.003025	13.780	24832.7	26235.7	209.926	32.25	41.27	242
180.000	0.03405	29.368	0.002881	14.459	25081.8	26550.2	211.710	32.71	41.62	247
190.000	0.03217	31.081	0.002713	15.342	25415.3	26969.3	213.976	33.40	42.20	254
200.000	0.03050	32.785	0.002566	16.217	25755.5	27394.7	216.157	34.15	42.88	260
210.000	0.02900	34.483	0.002435	17.084	26103.2	27827.3	218.267	34.96	43.63	266
220.000	0.02764	36.176	0.002318	17.946	26459.0	28267.8	220.316	35.84	44.46	272
230.000	0.02641	37.865	0.002212	18.803	26823.7	28716.9	222.312	36.76	45.35	278
240.000	0.02528	39.550	0.002116	19.657	27197.6	29175.1	224.261	37.74	46.29	283
250.000	0.02425	41.233	0.002028	20.508	27581.4	29643.1	226.171	38.75	47.28	288
260.000	0.02330	42.914	0.001948	21.357	27975.5	30121.2	228.045	39.82	48.32	294
270.000	0.02243	44.592	0.001874	22.204	28380.3	30609.9	229.889	40.92	49.41	299
280.000	0.02161	46.269	0.001805	23.049	28796.1	31109.6	231.706	42.05	50.53	303
290.000	0.02086	47.945	0.001741	23.893	29223.5	31620.7	233.499	43.22	51.68	308
300.000	0.02015	49.620	0.001682	24.736	29662.5	32143.5	235.271	44.42	52.87	313
310.000	0.01950	51.294	0.001627	25.577	30113.6	32678.3	237.024	45.64	54.08	317
320.000	0.01888	52.966	0.001575	26.418	30577.0	33225.3	238.761	46.88	55.31	322
330.000	0.01830	54.639	0.001526	27.258	31052.8	33784.8	240.482	48.14	56.56	326
340.000	0.01776	56.310	0.001481	28.097	31541.3	34356.8	242.189	49.41	57.83	331
350.000	0.01725	57.981	0.001438	28.936	32042.5	34941.5	243.884	50.70	59.10	335
360.000	0.01676	59.651	0.001397	29.774	32556.5	35539.1	245.567	51.99	60.39	339
370.000	0.01631	61.321	0.001359	30.612	33083.5	36145.5	247.239	53.29	61.68	343
380.000	0.01588	62.990	0.001323	31.449	33623.4	36772.9	248.901	54.58	62.98	347
390.000	0.01547	64.659	0.001289	32.286	34176.3	37409.2	250.553	55.88	64.27	351
400.000	0.01508	66.328	0.001256	33.122	34742.1	38058.5	252.197	57.18	65.57	355
410.000	0.01471	67.996	0.001225	33.958	35320.9	38720.7	253.832	58.47	66.85	359
420.000	0.01435	69.664	0.001196	34.794	35912.6	39395.8	255.458	59.76	68.14	363
430.000	0.01402	71.332	0.001168	35.630	36517.0	40083.6	257.077	61.04	69.42	367
440.000	0.01370	73.000	0.001141	36.465	37134.2	40784.2	258.687	62.31	70.68	371
450.000	0.01339	74.667	0.001115	37.300	37764.1	41497.4	260.290	63.57	71.94	375
460.000	0.01310	76.334	0.001091	38.135	38406.5	42223.2	261.884	64.82	73.19	378
470.000	0.01282	78.001	0.001068	38.970	39061.3	42961.4	263.472	66.06	74.42	382
480.000	0.01255	79.668	0.001045	39.805	39728.4	43711.8	265.051	67.29	75.65	386
490.000	0.01229	81.334	0.001024	40.639	40407.7	44474.4	266.624	68.50	76.86	389
500.000	0.01205	83.001	0.001003	41.473	41099.1	45249.1	268.189	69.70	78.05	393
510.000	0.01158	86.333	0.000964	43.142	42517.3	46834.0	271.296	72.05	80.41	400
520.000	0.01115	89.665	0.000928	44.809	43982.0	48465.3	274.374	74.35	82.70	407
530.000	0.01075	92.997	0.000895	46.477	45492.2	50142.0	277.422	76.59	84.94	414
540.000	0.01038	96.328	0.000864	48.144	47046.6	51863.0	280.441	78.78	87.13	421
550.000	0.01003	99.659	0.000835	49.810	48644.3	53627.2	283.431	80.92	89.27	427

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 1.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DP/CT BAR/K	DF/DO BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CF J/MOL/K	W M/SEC
89.915	21.680	0.04612	35.0647	962.641	5299.0	5303.6	76.501	44.07	68.50	2231
90.000	21.677	0.04613	35.0275	961.736	5304.8	5309.4	76.566	44.07	68.50	2230
100.000	21.315	0.04691	31.0793	861.522	5990.4	5995.1	83.789	43.96	68.63	2115
110.000	20.955	0.04772	27.7894	771.630	6677.5	6682.3	90.339	43.76	68.83	2009
120.000	20.594	0.04856	24.9877	690.497	7367.0	7371.9	96.339	43.52	69.10	1910
130.000	20.230	0.04943	22.5584	616.941	8059.7	8064.6	101.883	43.26	69.46	1815
140.000	19.862	0.05035	20.4202	550.053	8756.4	8761.4	107.047	43.02	69.92	1724
150.000	19.487	0.05132	18.5145	489.069	9458.3	9463.3	111.890	42.82	70.50	1636
160.000	19.104	0.05234	16.7978	433.341	10166.6	10171.9	116.462	42.67	71.21	1551
170.000	18.712	0.05344	15.2375	382.301	10882.8	10888.2	120.804	42.59	72.08	1467
180.000	18.307	0.05463	13.8082	335.442	11608.5	11614.0	124.952	42.59	73.12	1384
184.316	18.128	0.05516	13.2266	316.391	11925.2	11930.7	126.691	42.62	73.63	1348
184.316	0.06745	14.825	0.005806	14.352	25172.1	26654.6	206.666	33.41	42.92	248
190.000	0.06524	15.328	0.005592	14.891	25366.2	26899.0	207.972	33.73	43.11	252
200.000	0.06171	16.206	0.005261	15.821	25711.8	27332.4	210.195	34.40	43.59	258
210.000	0.05856	17.076	0.004973	16.734	26063.7	27771.3	212.336	35.16	44.21	265
220.000	0.05574	17.939	0.004719	17.633	26423.0	28216.9	214.409	35.99	44.94	271
230.000	0.05320	18.799	0.004493	18.523	26790.4	28670.2	216.424	36.89	45.75	276
240.000	0.05088	19.654	0.004289	19.405	27166.7	29132.1	218.390	37.84	46.63	282
250.000	0.04877	20.506	0.004105	20.281	27552.4	29603.1	220.312	38.84	47.58	287
260.000	0.04682	21.356	0.003936	21.151	27948.2	30083.8	222.198	39.89	48.58	293
270.000	0.04504	22.204	0.003782	22.016	28354.4	30574.8	224.050	40.98	49.63	298
280.000	0.04338	23.050	0.003640	22.878	28771.6	31076.6	225.875	42.11	50.72	303
290.000	0.04185	23.895	0.003509	23.737	29200.0	31589.5	227.675	43.27	51.86	308
300.000	0.04042	24.738	0.003387	24.593	29640.1	32113.9	229.452	44.46	53.02	312
310.000	0.03909	25.580	0.003273	25.447	30092.1	32650.1	231.210	45.68	54.22	317
320.000	0.03785	26.422	0.003168	26.299	30556.2	33198.4	232.951	46.91	55.44	321
330.000	0.03668	27.262	0.003069	27.149	31032.7	33758.9	234.675	48.17	56.67	326
340.000	0.03558	28.102	0.002976	27.997	31521.8	34332.0	236.386	49.44	57.93	330
350.000	0.03455	28.941	0.002889	28.844	32023.6	34917.7	238.084	50.72	59.20	335
360.000	0.03358	29.779	0.002806	29.690	32538.2	35516.1	239.769	52.01	60.48	339
370.000	0.03266	30.617	0.002729	30.535	33065.6	36127.3	241.444	53.30	61.76	343
380.000	0.03179	31.455	0.002656	31.378	33606.0	36751.5	243.108	54.60	63.05	347
390.000	0.03097	32.292	0.002586	32.221	34159.2	37388.5	244.762	55.90	64.34	351
400.000	0.03019	33.129	0.002520	33.063	34725.5	38038.4	246.408	57.20	65.63	355
410.000	0.02944	33.965	0.002458	33.905	35304.6	38701.1	248.044	58.49	66.91	359
420.000	0.02873	34.801	0.002398	34.746	35896.6	39376.7	249.672	59.77	68.19	363
430.000	0.02806	35.637	0.002342	35.586	36501.4	40065.1	251.291	61.05	69.47	367
440.000	0.02742	36.473	0.002288	36.425	37118.9	40766.2	252.903	62.32	70.73	371
450.000	0.02680	37.308	0.002236	37.265	37749.0	41479.8	254.507	63.58	71.99	375
460.000	0.02622	38.143	0.002187	38.103	38391.6	42206.0	256.102	64.83	73.23	378
470.000	0.02566	38.978	0.002140	38.942	39044.7	42944.6	257.691	66.07	74.47	382
480.000	0.02512	39.813	0.002095	39.780	39714.0	43695.4	259.271	67.29	75.69	386
490.000	0.02460	40.648	0.002052	40.617	40393.6	44458.3	260.844	68.50	76.89	389
500.000	0.02411	41.482	0.002010	41.454	41085.1	45233.3	262.410	69.70	78.09	393
520.000	0.02317	43.151	0.001932	43.128	42503.7	46818.8	265.518	72.06	80.44	400
540.000	0.02231	44.819	0.001860	44.801	43968.8	48450.7	268.597	74.36	82.73	407
560.000	0.02151	46.487	0.001793	46.473	45479.2	50127.9	271.647	76.60	84.97	414
580.000	0.02077	48.154	0.001731	48.144	47033.9	51849.3	274.667	78.75	87.15	421
600.000	0.02007	49.821	0.001673	49.814	48631.9	53613.9	277.657	80.92	89.29	428

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 1.5 PAR

T DEG K	DEN MOL/L	VOL L/MOL	DP/CT BAR/K	DP/DO BAR-L/MOL	F J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CF J/MOL/K	W M/SEC
89.922	21.681	0.04612	35.0616	962.716	5299.2	5306.1	76.503	44.07	68.50	2231
90.000	21.678	0.04613	35.0278	961.895	5304.5	5311.4	76.562	44.07	68.50	2230
100.000	21.316	0.04691	31.0800	861.694	5590.0	5997.0	83.785	43.96	68.63	2115
110.000	20.956	0.04772	27.7905	771.813	6677.1	6684.2	90.335	43.76	68.83	2009
120.000	20.595	0.04856	24.5851	690.690	7366.5	7373.8	96.334	43.52	69.10	1910
130.000	20.231	0.04943	22.5601	617.143	8055.1	8066.5	101.879	43.26	69.46	1815
140.000	19.863	0.05034	20.4222	550.262	8755.7	8763.3	107.042	43.02	69.92	1724
150.000	19.488	0.05131	18.5167	489.286	9457.5	9465.2	111.885	42.82	70.50	1637
160.000	19.106	0.05234	16.8004	433.555	10165.8	10173.6	116.456	42.67	71.21	1551
170.000	18.713	0.05344	15.2403	382.532	10881.9	10889.9	120.798	42.59	72.07	1467
180.000	18.308	0.05462	13.8113	335.681	11607.4	11615.6	124.946	42.60	73.11	1384
190.000	17.889	0.05590	12.4933	292.555	12344.4	12352.8	128.932	42.69	74.36	1302
192.164	17.796	0.05619	12.2211	283.671	12505.6	12514.0	129.776	42.72	74.67	1284
192.164	0.09811	10.193	0.008546	14.598	25392.0	26920.9	204.833	34.25	44.24	250
200.000	0.09376	10.666	0.008110	15.375	25668.2	27268.1	206.604	34.70	44.43	256
210.000	0.08880	11.262	0.007630	16.339	26025.1	27714.4	208.782	35.39	44.88	263
220.000	0.08438	11.851	0.007215	17.282	26388.3	28165.9	210.883	36.17	45.48	269
230.000	0.08042	12.435	0.006850	18.207	26758.9	28624.1	212.920	37.03	46.20	275
240.000	0.07684	13.015	0.006525	19.120	27137.8	29090.0	214.903	37.96	47.01	281
250.000	0.07358	13.591	0.006233	20.022	27525.7	29564.4	216.840	38.94	47.90	286
260.000	0.07060	14.165	0.005969	20.915	27923.4	30048.1	218.737	39.97	48.86	292
270.000	0.06786	14.737	0.005728	21.801	28331.2	30541.7	220.600	41.05	49.87	297
280.000	0.06533	15.307	0.005507	22.681	28749.7	31045.7	222.433	42.17	50.94	302
290.000	0.06299	15.875	0.005304	23.556	29179.4	31560.6	224.239	43.32	52.05	307
300.000	0.06082	16.441	0.005116	24.427	29620.5	32086.7	226.023	44.50	53.19	312
310.000	0.05880	17.007	0.004941	25.294	30073.4	32624.5	227.786	45.71	54.37	316
320.000	0.05691	17.572	0.004779	26.158	30538.4	33174.2	229.532	46.95	55.57	321
330.000	0.05514	18.135	0.004627	27.019	31015.7	33736.0	231.260	48.20	56.80	325
340.000	0.05348	18.698	0.004486	27.878	31505.5	34310.2	232.974	49.46	58.04	330
350.000	0.05192	19.260	0.004352	28.734	32007.9	34896.9	234.675	50.74	59.30	334
360.000	0.05045	19.822	0.004227	29.589	32523.0	35496.3	236.363	52.03	60.57	338
370.000	0.04906	20.383	0.004109	30.441	33050.9	36108.4	238.040	53.32	61.85	343
380.000	0.04775	20.944	0.003998	31.292	33591.7	36733.3	239.707	54.62	63.13	347
390.000	0.04650	21.504	0.003892	32.142	34145.5	37371.0	241.363	55.92	64.42	351
400.000	0.04532	22.063	0.003792	32.991	34712.1	38021.6	243.010	57.21	65.70	355
410.000	0.04420	22.623	0.003697	33.838	35291.6	38685.0	244.648	58.50	66.98	359
420.000	0.04314	23.182	0.003607	34.684	35883.9	39361.2	246.278	59.79	68.25	363
430.000	0.04212	23.741	0.003522	35.530	36489.0	40050.1	247.899	61.06	69.52	367
440.000	0.04115	24.299	0.003440	36.374	37106.8	40751.7	249.511	62.33	70.78	371
450.000	0.04023	24.858	0.003362	37.218	37737.2	41465.8	251.116	63.59	72.04	374
460.000	0.03935	25.416	0.003288	38.061	38380.1	42192.4	252.713	64.84	73.28	378
470.000	0.03850	25.973	0.003216	38.904	39035.5	42931.4	254.302	66.08	74.51	382
480.000	0.03769	26.531	0.003148	39.746	39702.9	43682.6	255.884	67.30	75.73	386
490.000	0.03692	27.089	0.003083	40.587	40382.7	44445.9	257.458	68.51	76.93	389
500.000	0.03617	27.646	0.003020	41.428	41074.4	45221.3	259.024	69.71	78.13	393
520.000	0.03477	28.760	0.002903	43.108	42493.4	46807.4	262.134	72.06	80.47	400
540.000	0.03347	29.874	0.002794	44.786	43958.8	48436.8	265.214	74.36	82.76	407
560.000	0.03227	30.987	0.002693	46.463	45469.5	50117.6	268.264	76.60	85.00	414
580.000	0.03115	32.100	0.002599	48.139	47024.5	51839.5	271.285	78.79	87.18	421
600.000	0.03011	33.212	0.002512	49.813	48622.7	53604.5	274.277	80.93	89.31	428

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 2.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DF/CT BAR/K	DF/DO BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	W M/SEC
89.930	21.681	0.04612	35.0584	962.794	5299.3	5308.6	76.505	44.07	68.50	2231
90.000	21.678	0.04613	35.0281	962.054	5304.1	5313.4	76.558	44.07	68.50	2230
100.000	21.316	0.04691	31.0808	861.867	5589.6	5998.9	83.781	43.96	68.63	2115
110.000	20.956	0.04772	27.7916	771.997	6676.6	6886.2	90.331	43.77	68.83	2009
120.000	20.596	0.04855	24.9905	690.883	7366.0	7375.7	96.330	43.52	69.10	1910
130.000	20.232	0.04943	22.5618	617.344	8058.5	8068.4	101.874	43.27	69.45	1815
140.000	19.864	0.05034	20.4241	550.472	8755.1	8765.1	107.037	43.03	69.91	1725
150.000	19.489	0.05131	18.5190	489.502	9456.8	9467.1	111.880	42.82	70.49	1637
160.000	19.107	0.05234	16.8029	433.789	10164.9	10175.4	116.451	42.68	71.20	1551
170.000	18.714	0.05344	15.2432	382.763	10880.9	10891.6	120.793	42.60	72.06	1467
180.000	18.310	0.05462	13.8145	335.919	11606.3	11617.3	124.940	42.60	73.10	1385
190.000	17.891	0.05589	12.4968	292.801	12343.2	12354.3	128.925	42.69	74.35	1302
198.191	17.535	0.05703	11.4887	259.968	12956.8	12968.2	132.088	42.84	75.56	1235
198.191	0.12816	7.803	0.011284	14.706	25557.6	27118.1	203.561	34.95	45.39	252
200.000	0.12679	7.887	0.011140	14.896	25622.8	27200.2	203.974	35.04	45.40	253
210.000	0.11980	8.348	0.010424	15.917	25985.4	27654.9	206.193	35.64	45.63	260
220.000	0.11363	8.800	0.009818	16.906	26353.0	28113.1	208.325	36.36	46.08	267
230.000	0.10814	9.248	0.009293	17.869	26727.1	28576.6	210.387	37.18	46.69	273
240.000	0.10320	9.690	0.008831	18.814	27108.9	29047.0	212.389	38.08	47.42	279
250.000	0.09872	10.129	0.008420	19.744	27499.3	29525.1	214.341	39.04	48.25	285
260.000	0.09465	10.566	0.008050	20.662	27898.9	30012.0	216.251	40.06	49.16	290
270.000	0.09091	10.999	0.007715	21.569	28308.5	30508.4	218.124	41.12	50.14	296
280.000	0.08748	11.431	0.007409	22.468	28728.5	31014.8	219.966	42.23	51.17	301
290.000	0.08431	11.861	0.007129	23.360	29159.5	31531.7	221.781	43.37	52.25	306
300.000	0.08137	12.290	0.006871	24.246	29601.7	32059.8	223.571	44.55	53.37	311
310.000	0.07863	12.718	0.006632	25.127	30055.7	32599.2	225.340	45.75	54.53	316
320.000	0.07608	13.144	0.006411	26.004	30521.6	33150.3	227.090	46.98	55.72	320
330.000	0.07370	13.569	0.006204	26.876	30999.6	33713.5	228.823	48.23	56.93	325
340.000	0.07146	13.994	0.006011	27.745	31490.1	34288.9	230.540	49.49	58.16	329
350.000	0.06936	14.418	0.005830	28.611	31993.2	34876.8	232.244	50.77	59.41	334
360.000	0.06738	14.841	0.005660	29.475	32508.9	35477.1	233.936	52.05	60.67	338
370.000	0.06551	15.264	0.005501	30.336	33037.4	36090.2	235.615	53.34	61.94	342
380.000	0.06375	15.686	0.005350	31.195	33578.7	36715.9	237.284	54.64	63.22	346
390.000	0.06208	16.108	0.005207	32.052	34132.8	37354.4	238.943	55.93	64.49	351
400.000	0.06050	16.529	0.005073	32.907	34699.9	38005.7	240.592	57.23	65.77	355
410.000	0.05900	16.950	0.004945	33.760	35279.7	38668.8	242.231	58.51	67.05	359
420.000	0.05757	17.371	0.004823	34.613	35872.4	39346.6	243.862	59.80	68.32	363
430.000	0.05621	17.791	0.004708	35.464	36477.9	40036.1	245.485	61.08	69.58	367
440.000	0.05491	18.211	0.004598	36.313	37095.9	40738.2	247.099	62.34	70.84	370
450.000	0.05367	18.631	0.004493	37.162	37726.6	41452.9	248.705	63.60	72.09	374
460.000	0.05249	19.051	0.004393	38.010	38369.8	42179.9	250.303	64.85	73.33	378
470.000	0.05136	19.470	0.004297	38.856	39025.3	42919.4	251.893	66.09	74.55	382
480.000	0.05028	19.889	0.004206	39.702	39693.1	43671.0	253.475	67.31	75.77	386
490.000	0.04924	20.308	0.004118	40.548	40373.1	44434.7	255.050	68.52	76.97	389
500.000	0.04825	20.727	0.004034	41.392	41065.0	45210.4	256.617	69.72	78.16	393
520.000	0.04637	21.564	0.003876	43.079	42484.3	46797.2	259.728	72.07	80.50	400
540.000	0.04464	22.401	0.003731	44.764	43950.1	48430.3	262.810	74.37	82.79	407
560.000	0.04303	23.237	0.003595	46.446	45461.1	50108.6	265.861	76.61	85.02	414
580.000	0.04154	24.073	0.003470	48.127	47016.4	51830.9	268.883	78.80	87.20	421
600.000	0.04015	24.908	0.003353	49.806	48614.8	53596.5	271.875	80.93	89.33	428

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 3.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DF/CT BAR/K	BAR-L/MOL	DF/DO	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	W M/SEC
89.946	21.681	0.04612	35.0522	962.947	5299.7	5313.6	76.509	44.08	58.50	2231	
90.000	21.679	0.04613	35.0286	962.373	5303.4	5317.3	76.550	44.08	58.50	2230	
100.000	21.317	0.04691	31.0822	862.211	5988.8	6002.8	83.773	43.97	68.63	2215	
110.000	20.958	0.04772	27.7937	772.363	6675.7	6690.0	90.323	43.77	68.82	2010	
120.000	20.597	0.04855	24.9933	691.268	7365.0	7379.5	96.322	43.53	69.09	1910	
130.000	20.234	0.04942	22.5651	617.747	8057.4	8072.2	101.865	43.28	69.45	1816	
140.000	19.866	0.05034	20.4281	550.890	8753.8	8768.9	107.028	43.03	69.91	1725	
150.000	19.492	0.05130	18.5235	489.936	9455.3	9470.7	111.870	42.83	70.48	1637	
160.000	19.109	0.05233	16.8080	434.236	10163.2	10178.9	116.441	42.68	71.19	1552	
170.000	18.717	0.05343	15.2488	383.225	10879.0	10895.0	120.781	42.60	72.05	1468	
180.000	18.313	0.05461	13.8207	336.396	11604.1	11620.5	124.928	42.61	73.09	1385	
190.000	17.894	0.05588	12.5037	293.293	12340.6	12357.4	128.912	42.70	74.33	1303	
200.000	17.459	0.05728	11.2814	253.503	13090.8	13107.9	132.761	42.89	75.83	1221	
207.416	17.123	0.05840	10.4279	225.912	13657.5	13675.0	135.545	43.09	77.14	1160	
207.416	0.18734	5.338	0.016817	14.727	25803.2	27404.6	201.803	36.10	47.45	254	
210.000	0.18444	5.422	0.016494	15.019	25900.5	27527.0	202.390	36.22	47.40	256	
220.000	0.17421	5.740	0.015391	16.110	26278.6	28000.7	204.595	36.80	47.45	263	
230.000	0.16523	6.052	0.014468	17.157	26660.9	28476.5	206.711	37.52	47.80	270	
240.000	0.15727	6.359	0.013675	18.171	27049.3	28956.8	208.756	38.35	48.34	276	
250.000	0.15013	6.661	0.012983	19.159	27445.0	29443.3	210.743	39.26	49.02	282	
260.000	0.14368	6.960	0.012370	20.127	27849.2	29937.2	212.680	40.24	49.81	288	
270.000	0.13781	7.257	0.011822	21.079	28262.6	30439.5	214.577	41.27	50.70	293	
280.000	0.13244	7.551	0.011327	22.017	28685.9	30951.1	216.438	42.36	51.66	299	
290.000	0.12750	7.843	0.010877	22.944	29119.7	31472.7	218.268	43.48	52.68	304	
300.000	0.12294	8.134	0.010466	23.862	29564.4	32004.7	220.072	44.65	53.76	309	
310.000	0.11871	8.424	0.010087	24.771	30020.6	32547.7	221.853	45.84	54.87	314	
320.000	0.11478	8.712	0.009738	25.673	30488.4	33102.1	223.613	47.05	56.03	319	
330.000	0.11112	9.000	0.009414	26.568	30968.2	33668.1	225.356	48.29	57.21	324	
340.000	0.10769	9.286	0.009112	27.459	31460.3	34246.1	227.081	49.55	58.42	328	
350.000	0.10447	9.572	0.008831	28.345	31964.7	34836.3	228.792	50.82	59.64	333	
360.000	0.10145	9.857	0.008567	29.226	32481.7	35438.8	230.490	52.10	60.88	337	
370.000	0.09860	10.142	0.008319	30.104	33011.3	36053.8	232.175	53.38	62.13	341	
380.000	0.09592	10.426	0.008087	30.978	33553.7	36681.4	233.849	54.67	63.39	346	
390.000	0.09338	10.709	0.007867	31.850	34108.8	37321.6	235.512	55.97	64.66	350	
400.000	0.09097	10.992	0.007660	32.719	34676.7	37974.4	237.165	57.26	65.92	354	
410.000	0.08869	11.275	0.007463	33.585	35257.4	38639.9	238.808	58.54	67.19	358	
420.000	0.08653	11.557	0.007277	34.449	35850.8	39318.0	240.442	59.82	68.45	362	
430.000	0.08446	11.839	0.007101	35.311	36457.0	40008.8	242.067	61.10	69.71	366	
440.000	0.08250	12.121	0.006932	36.172	37075.7	40712.0	243.684	62.37	70.95	370	
450.000	0.08063	12.402	0.006772	37.030	37707.0	41427.7	245.293	63.62	72.20	374	
460.000	0.07884	12.684	0.006620	37.888	38350.7	42155.8	246.893	64.87	73.43	378	
470.000	0.07713	12.965	0.006474	38.743	39006.8	42896.2	248.485	66.10	74.65	381	
480.000	0.07550	13.245	0.006335	39.598	39675.1	43648.7	250.070	67.33	75.86	385	
490.000	0.07393	13.526	0.006202	40.451	40355.5	44413.3	251.646	68.54	77.06	389	
500.000	0.07243	13.806	0.006074	41.303	41047.9	45189.8	253.215	69.73	78.24	393	
520.000	0.06961	14.367	0.005834	43.004	42468.0	46778.0	256.329	72.08	80.58	400	
540.000	0.06700	14.926	0.005613	44.702	43934.5	48412.4	259.413	74.38	82.86	407	
560.000	0.06458	15.486	0.005408	46.396	45446.2	50091.9	262.467	76.62	85.08	414	
580.000	0.06233	16.044	0.005218	48.088	47002.0	51815.3	265.491	78.81	87.26	421	
600.000	0.06023	16.603	0.005040	49.777	48600.9	53581.8	268.485	80.94	89.38	428	

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 4.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DP/CT BAR/K	DP/DD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	M/SEC
89.961	21.682	0.04612	35.0460	963.101	5300.1	5318.5	76.513	44.09	68.49	2231
90.000	21.680	0.04612	35.0292	962.692	5302.7	5321.2	76.543	44.09	68.50	2230
100.000	21.319	0.04691	31.0836	862.555	5988.0	6006.7	83.765	43.98	68.63	2116
110.000	20.959	0.04771	27.7959	772.730	6674.8	6693.9	90.314	43.78	68.82	2010
120.000	20.598	0.04855	24.9961	691.654	7364.0	7383.4	96.313	43.54	69.09	1910
130.000	20.235	0.04942	22.5685	618.150	8056.2	8076.0	101.857	43.28	69.44	1816
140.000	19.868	0.05033	20.4320	551.309	8752.4	8772.6	107.019	43.04	69.90	1726
150.000	19.494	0.05130	18.5280	490.369	9453.8	9474.3	111.860	42.84	70.47	1638
160.000	19.111	0.05232	16.8130	434.684	10161.5	10182.5	116.430	42.69	71.18	1552
170.000	18.719	0.05342	15.2544	383.686	10877.0	10898.4	120.770	42.61	72.04	1469
180.000	18.316	0.05460	13.8269	336.872	11601.9	11623.8	124.916	42.62	73.07	1386
190.000	17.898	0.05587	12.5105	293.785	12338.1	12360.4	128.898	42.71	74.31	1304
200.000	17.463	0.05726	11.2889	254.012	13087.9	13110.8	132.747	42.89	75.80	1222
210.000	17.007	0.05880	10.1483	217.180	13854.0	13877.5	136.487	43.18	77.60	1139
214.541	16.792	0.05955	9.6538	201.332	14208.2	14232.0	138.157	43.34	78.55	1102
214.541	0.24597	4.066	0.022469	14.623	25983.7	27610.0	200.573	37.06	49.31	254
220.000	0.23794	4.203	0.021535	15.274	26197.2	27878.3	201.809	37.30	49.10	259
230.000	0.22481	4.448	0.020079	16.414	26589.3	28368.6	203.989	37.90	49.08	266
240.000	0.21333	4.687	0.018865	17.503	26985.4	28860.4	206.083	38.65	49.37	273
250.000	0.20316	4.922	0.017826	18.555	27387.3	29356.2	208.108	39.50	49.87	279
260.000	0.19405	5.153	0.016920	19.576	27797.5	29858.8	210.077	40.44	50.53	285
270.000	0.18582	5.381	0.016121	20.574	28215.1	30367.7	211.998	41.44	51.32	291
280.000	0.17834	5.607	0.015407	21.552	28642.1	30885.0	213.880	42.50	52.19	297
290.000	0.17149	5.831	0.014764	22.514	29079.0	31411.5	215.728	43.60	53.15	302
300.000	0.16520	6.053	0.014180	23.463	29526.5	31947.8	217.547	44.75	54.17	307
310.000	0.15939	6.274	0.013646	24.400	29985.0	32494.6	219.341	45.93	55.24	312
320.000	0.15400	6.494	0.013156	25.328	30454.9	33052.4	221.112	47.13	56.35	317
330.000	0.14898	6.712	0.012703	26.247	30936.6	33621.5	222.863	48.36	57.50	322
340.000	0.14430	6.930	0.012284	27.159	31430.3	34202.3	224.597	49.61	58.68	327
350.000	0.13993	7.147	0.011894	28.064	31936.3	34794.9	226.316	50.87	59.88	331
360.000	0.13582	7.363	0.011530	28.964	32454.6	35399.7	228.020	52.15	61.10	336
370.000	0.13196	7.578	0.011189	29.859	32985.5	36016.8	229.711	53.41	62.34	340
380.000	0.12832	7.793	0.010869	30.749	33529.0	36646.3	231.390	54.71	63.58	345
390.000	0.12488	8.008	0.010568	31.635	34085.1	37288.2	233.057	56.00	64.83	349
400.000	0.12163	8.222	0.010284	32.517	34654.0	37942.7	234.714	57.29	66.08	353
410.000	0.11855	8.435	0.010016	33.396	35235.6	38609.7	236.362	58.57	67.34	357
420.000	0.11563	8.648	0.009762	34.272	35829.8	39289.2	237.999	59.85	68.59	361
430.000	0.11285	8.861	0.009522	35.146	36436.7	39981.2	239.628	61.12	69.83	365
440.000	0.11021	9.074	0.009293	36.016	37056.1	40685.7	241.247	62.39	71.07	369
450.000	0.10769	9.286	0.009076	36.885	37688.0	41402.5	242.858	63.64	72.31	373
460.000	0.10528	9.498	0.008868	37.752	38332.4	42131.7	244.461	64.89	73.53	377
470.000	0.10299	9.710	0.008671	38.616	38989.0	42873.0	246.056	66.12	74.75	381
480.000	0.10079	9.922	0.008482	39.479	39657.8	43626.5	247.642	67.34	75.95	385
490.000	0.09869	10.133	0.008302	40.340	40338.7	44392.0	249.220	68.55	77.15	389
500.000	0.09667	10.344	0.008129	41.200	41031.5	45169.3	250.791	69.75	78.33	392
520.000	0.09288	10.766	0.007805	42.5915	42452.5	46755.0	253.908	72.10	80.65	400
540.000	0.08938	11.188	0.007507	44.626	43919.8	48394.8	256.995	74.39	82.92	407
560.000	0.08614	11.608	0.007231	46.6332	45432.1	50075.5	260.051	76.63	85.15	414
580.000	0.08313	12.029	0.006975	48.6035	46988.6	51800.1	263.077	78.82	87.31	421
600.000	0.08033	12.449	0.006736	49.734	48588.1	53567.6	266.073	80.95	89.43	427

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 5.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DF/CT BAR/K	OF/DD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	W M/SEC
89.977	21.682	0.04612	35.0398	963.254	5300.5	5323.5	76.517	44.10	68.49	2231
90.000	21.682	0.04612	35.0298	963.011	5302.0	5325.1	76.535	44.10	68.49	2230
100.000	21.320	0.04690	31.0851	862.900	5987.2	6010.6	83.757	43.99	68.62	2116
110.000	20.960	0.04771	27.7980	773.096	6673.9	6697.8	90.306	43.79	68.82	2010
120.000	20.600	0.04854	24.9989	692.040	7362.9	7387.2	96.305	43.55	69.08	1911
130.000	20.237	0.04941	22.5719	618.553	8055.0	8079.7	101.848	43.29	69.44	1816
140.000	19.869	0.05033	20.4360	551.727	8751.1	8776.3	107.009	43.05	69.89	1726
150.000	19.496	0.05129	18.5325	490.802	9452.3	9478.0	111.850	42.85	70.46	1638
160.000	19.114	0.05232	16.8181	435.131	10159.9	10186.0	116.419	42.70	71.17	1553
170.000	18.722	0.05341	15.2600	384.148	10875.1	10901.8	120.759	42.62	72.02	1469
180.000	18.319	0.05459	13.8331	337.348	11599.7	11627.0	124.903	42.62	73.05	1387
190.000	17.901	0.05586	12.5174	294.277	12335.6	12363.5	128.885	42.72	74.29	1305
200.000	17.467	0.05725	11.2965	254.520	13084.9	13113.6	132.732	42.90	75.77	1223
210.000	17.012	0.05878	10.1567	217.708	13850.6	13880.0	136.471	43.18	77.57	1140
220.000	16.532	0.06049	9.0856	183.495	14636.0	14666.3	140.128	43.56	79.77	1057
220.435	16.510	0.06057	9.0404	182.062	14670.7	14701.0	140.286	43.58	79.88	1053
220.435	0.30448	3.284	0.028265	14.458	26127.3	27769.5	199.623	37.91	51.05	254
230.000	0.28719	3.482	0.026199	15.649	26513.7	28254.7	201.780	38.33	50.57	262
240.000	0.27161	3.682	0.024444	16.821	26918.6	28759.5	203.930	38.98	50.54	269
250.000	0.25797	3.876	0.022977	17.939	27327.6	29265.8	205.998	39.76	50.82	276
260.000	0.24588	4.067	0.021721	19.017	27742.5	29776.1	208.000	40.65	51.32	283
270.000	0.23504	4.255	0.020627	20.062	28164.9	30292.2	209.949	41.61	51.98	289
280.000	0.22525	4.439	0.019661	21.082	28595.8	30815.6	211.853	42.64	52.76	295
290.000	0.21634	4.622	0.018797	22.080	29036.2	31347.3	213.719	43.73	53.64	300
300.000	0.20819	4.803	0.018020	23.061	29486.6	31888.3	215.554	44.85	54.60	306
310.000	0.20068	4.983	0.017314	24.027	29947.7	32439.1	217.361	46.02	55.62	311
320.000	0.19375	5.161	0.016669	24.980	30420.8	33001.4	219.143	47.21	56.69	316
330.000	0.18732	5.338	0.016076	25.923	30904.5	33573.7	220.905	48.43	57.81	321
340.000	0.18133	5.515	0.015529	26.856	31400.0	34157.3	222.647	49.67	58.96	326
350.000	0.17574	5.690	0.015022	27.781	31907.5	34752.6	224.373	50.93	60.13	330
360.000	0.17050	5.865	0.014551	28.698	32427.3	35359.8	226.084	52.20	61.33	335
370.000	0.16559	6.039	0.014110	29.609	32959.4	35979.0	227.781	53.47	62.55	339
380.000	0.16096	6.213	0.013698	30.515	33504.1	36610.4	229.465	54.75	63.77	344
390.000	0.15660	6.386	0.013311	31.415	34061.4	37254.2	231.138	56.04	65.01	348
400.000	0.15248	6.558	0.012947	32.311	34631.2	37910.3	232.799	57.32	66.25	352
410.000	0.14858	6.730	0.012603	33.202	35213.7	38578.9	234.450	58.60	67.49	357
420.000	0.14488	6.902	0.012279	34.090	35808.8	39259.8	236.091	59.88	68.73	361
430.000	0.14137	7.074	0.011972	34.974	36416.4	39953.2	237.723	61.15	69.97	365
440.000	0.13803	7.245	0.011680	35.855	37036.6	40658.9	239.346	62.41	71.20	369
450.000	0.13485	7.415	0.011403	36.734	37669.2	41376.9	240.959	63.66	72.42	373
460.000	0.13182	7.586	0.011140	37.610	38314.2	42107.2	242.565	64.91	73.64	377
470.000	0.12893	7.756	0.010889	38.483	38971.4	42849.6	244.161	66.14	74.85	381
480.000	0.12616	7.926	0.010649	39.354	39640.7	43604.0	245.750	67.36	76.05	384
490.000	0.12351	8.096	0.010420	40.223	40322.2	44370.4	247.330	68.57	77.24	388
500.000	0.12098	8.266	0.010202	41.090	41015.5	45148.5	248.902	69.76	78.41	392
510.000	0.11821	8.605	0.009791	42.820	42437.4	46739.9	252.023	72.11	80.73	399
520.000	0.11621	8.943	0.009414	44.543	43905.4	48377.1	255.112	74.40	82.99	406
530.000	0.11481	9.281	0.009065	46.261	45418.5	50059.1	258.171	76.64	85.21	414
540.000	0.11396	9.619	0.008742	47.974	46975.5	51784.9	261.199	78.82	87.37	421
550.000	0.11336	9.956	0.008441	49.683	48575.6	53553.5	264.197	80.96	89.49	427

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 7.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DF/CT BAR/K	DF/DO BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CF J/MOL/K	W M/SEC
90.000	21.683	0.04612	35.0274	963.561	5301.2	5333.5	198.189	39.39	54.36	254
100.000	21.322	0.04690	31.0879	863.588	5985.6	6018.4	198.191	39.39	54.36	254
110.000	20.963	0.04770	27.8023	773.829	6672.1	6705.5	200.481	39.75	53.36	262
120.000	20.603	0.04854	25.0045	692.811	7360.9	7394.9	202.650	40.35	53.02	270
130.000	20.240	0.04941	22.5787	619.358	8052.7	8087.3	204.731	41.12	53.10	277
140.000	19.873	0.05032	20.4439	552.564	8748.5	8783.7	206.741	42.00	53.46	284
150.000	19.500	0.05128	18.5415	491.668	9449.4	9485.3	208.694	42.96	54.01	290
160.000	19.118	0.05231	16.8281	436.025	10156.5	10193.1	210.601	43.99	54.71	296
170.000	18.727	0.05340	15.2712	385.070	10871.3	10908.7	212.469	45.08	55.53	302
180.000	18.324	0.05457	13.8455	338.299	11595.3	11633.5	214.305	46.21	56.43	308
190.000	17.908	0.05584	12.5310	295.259	12330.6	12369.6	216.112	47.38	57.41	313
200.000	17.475	0.05723	11.3115	255.536	13079.2	13119.2	217.894	48.58	58.45	318
210.000	17.021	0.05875	10.1733	218.762	13843.8	13885.0	219.655	49.80	59.53	323
220.000	16.543	0.06045	9.1041	184.595	14628.1	14670.4	221.397	51.04	60.65	328
229.991	16.032	0.06237	8.0930	152.747	15435.9	15479.6	223.122	52.30	61.80	333
229.991	0.42199	2.370	0.040343	14.038	26344.5	28003.3	198.189	39.39	54.36	254
230.000	0.42197	2.370	0.040340	14.039	26344.9	28003.8	198.191	39.39	54.36	254
240.000	0.39574	2.527	0.036995	15.411	26773.4	28542.2	200.481	39.75	53.36	262
250.000	0.37353	2.677	0.034347	16.684	27199.3	29073.4	202.650	40.35	53.02	270
260.000	0.35430	2.863	0.032167	17.886	27627.6	29603.5	204.731	41.12	53.10	277
270.000	0.33738	2.964	0.030323	19.034	28060.8	30135.7	206.741	42.00	53.46	284
280.000	0.32230	3.103	0.028733	20.141	28500.7	30672.6	208.694	42.96	54.01	290
290.000	0.30875	3.239	0.027339	21.214	28948.6	31215.8	210.601	43.99	54.71	296
300.000	0.29646	3.373	0.026102	22.261	29405.4	31766.7	212.469	45.08	55.53	302
310.000	0.28524	3.506	0.024994	23.285	29872.1	32326.2	214.305	46.21	56.43	308
320.000	0.27494	3.637	0.023994	24.290	30349.2	32895.1	216.112	47.38	57.41	313
330.000	0.26545	3.767	0.023083	25.279	30837.2	33474.2	217.894	48.58	58.45	318
340.000	0.25665	3.896	0.022249	26.254	31336.5	34063.9	219.655	49.80	59.53	323
350.000	0.24847	4.025	0.021482	27.218	31847.4	34664.6	221.397	51.04	60.65	328
360.000	0.24085	4.152	0.020773	28.170	32370.3	35276.7	223.122	52.30	61.80	333
370.000	0.23371	4.279	0.020115	29.114	32905.3	35900.5	224.831	53.56	62.98	337
380.000	0.22701	4.405	0.019501	30.049	33452.5	36536.0	226.526	54.83	64.17	342
390.000	0.22072	4.531	0.018928	30.977	34012.0	37183.5	228.209	56.11	65.37	346
400.000	0.21478	4.656	0.018391	31.899	34584.0	37843.1	229.879	57.39	66.58	351
410.000	0.20917	4.781	0.017886	32.814	35168.4	38514.9	231.538	58.66	67.80	355
420.000	0.20387	4.905	0.017410	33.725	35765.3	39198.9	233.186	59.93	69.02	359
430.000	0.19884	5.029	0.016961	34.630	36375.5	39895.9	234.825	61.20	70.23	364
440.000	0.19407	5.153	0.016537	35.532	36997.2	40604.2	236.453	62.46	71.45	368
450.000	0.18953	5.276	0.016134	36.429	37631.2	41324.7	238.072	63.71	72.66	372
460.000	0.18520	5.399	0.015752	37.322	38277.5	42057.2	239.683	64.95	73.86	376
470.000	0.18108	5.522	0.015388	38.213	38936.0	42801.7	241.284	66.18	75.06	380
480.000	0.17714	5.645	0.015042	39.100	39606.5	43558.1	242.877	67.39	76.25	384
490.000	0.17338	5.768	0.014712	39.984	40289.0	44326.3	244.461	68.60	77.42	387
500.000	0.16978	5.890	0.014397	40.866	40983.3	45106.3	246.037	69.79	78.59	391
510.000	0.16630	6.013	0.014087	41.742	41707.1	45890.9	247.604	70.93	79.74	394
520.000	0.16303	6.134	0.013807	42.622	42407.1	46700.9	249.164	72.13	80.89	399
530.000	0.15968	6.257	0.013526	43.500	43107.8	47534.1	250.717	73.31	82.04	403
540.000	0.15660	6.377	0.013266	44.370	43806.8	48341.0	252.259	74.42	83.14	406
550.000	0.15310	6.497	0.013017	45.233	44509.8	49184.7	253.792	75.49	84.21	409
560.000	0.15015	6.620	0.012767	46.100	45225.7	50025.7	255.322	76.66	85.34	413
570.000	0.14751	6.745	0.012536	46.964	45949.8	50893.8	256.845	77.84	86.49	417
580.000	0.14571	6.863	0.012306	47.824	46684.8	51753.8	258.355	78.84	87.49	420
590.000	0.14405	6.981	0.012087	48.684	47435.1	52635.1	259.856	79.79	88.49	423
600.000	0.14245	7.105	0.011877	49.542	48205.1	53524.6	261.356	80.97	89.59	427

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 8.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DF/CT BAR/K	DF/DO BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	M M/SEC
90.024	21.684	0.04612	35.0213	963.714	5301.6	5338.5	76.530	44.12	68.49	2230
100.000	21.323	0.04690	31.0894	863.933	5984.8	6022.3	83.734	44.01	68.62	2116
110.000	20.964	0.04770	27.8045	774.195	6671.2	6709.4	90.282	43.81	68.81	2011
120.000	20.604	0.04853	25.0072	693.196	7359.9	7398.7	96.279	43.57	69.07	1912
130.000	20.242	0.04940	22.5820	619.761	8051.6	8091.1	101.821	43.31	69.42	1818
140.000	19.875	0.05031	20.4478	552.982	8747.2	8787.5	106.981	43.07	69.87	1727
150.000	19.502	0.05128	18.5459	492.101	9447.9	9488.9	111.820	42.87	70.44	1640
160.000	19.121	0.05230	16.8332	436.472	10154.8	10196.6	116.388	42.72	71.13	1555
170.000	18.730	0.05339	15.2768	385.530	10869.4	10912.1	120.725	42.64	71.98	1471
180.000	18.327	0.05456	13.8517	338.774	11593.2	11636.8	124.867	42.65	73.00	1389
190.000	17.911	0.05583	12.5379	295.749	12328.1	12372.7	128.845	42.74	74.22	1307
200.000	17.478	0.05721	11.3191	256.044	13076.3	13122.0	132.689	42.93	75.69	1225
210.000	17.026	0.05873	10.1816	219.289	13840.5	13887.5	136.423	43.21	77.46	1143
220.000	16.548	0.06043	9.1133	185.144	14624.2	14672.5	140.074	43.59	79.63	1061
230.000	16.038	0.06235	8.1024	153.295	15431.9	15481.8	143.671	44.05	82.35	976
234.025	15.822	0.06320	7.7090	141.058	15765.3	15815.8	145.111	44.27	83.65	942
234.025	0.48124	2.078	0.046541	13.802	26430.4	28092.7	197.615	40.05	55.98	253
240.000	0.46221	2.163	0.044105	14.676	26693.3	28424.1	199.014	40.20	55.09	259
250.000	0.43465	2.301	0.040647	16.040	27129.6	28970.2	201.245	40.69	54.32	267
260.000	0.41112	2.432	0.037864	17.311	27565.7	29511.6	203.370	41.38	54.12	274
270.000	0.39064	2.560	0.035548	18.516	28006.1	30054.1	205.415	42.20	54.28	281
280.000	0.37254	2.684	0.033575	19.670	28451.0	30598.4	207.396	43.13	54.69	288
290.000	0.35537	2.806	0.031863	20.783	28903.0	31147.9	209.325	44.13	55.29	294
300.000	0.34179	2.926	0.030357	21.864	29363.3	31704.1	211.211	45.20	56.02	300
310.000	0.32853	3.044	0.029016	22.918	29833.1	32268.2	213.062	46.31	56.87	306
320.000	0.31641	3.161	0.027812	23.950	30312.8	32841.2	214.882	47.47	57.79	311
330.000	0.30526	3.276	0.026722	24.962	30803.1	33423.8	216.675	48.66	58.79	317
340.000	0.29496	3.390	0.025728	25.959	31304.4	34016.7	218.446	49.87	59.83	322
350.000	0.28540	3.504	0.024817	26.941	31817.2	34620.2	220.196	51.10	60.92	327
360.000	0.27651	3.617	0.023977	27.911	32344.7	35234.9	221.928	52.35	62.05	332
370.000	0.26820	3.729	0.023199	28.871	32878.1	35860.9	223.643	53.61	63.20	336
380.000	0.26042	3.840	0.022477	29.821	33426.6	36498.6	225.344	54.88	64.37	341
390.000	0.25311	3.951	0.021803	30.763	33987.3	37148.0	227.032	56.15	65.56	346
400.000	0.24623	4.061	0.021173	31.697	34560.4	37809.4	228.706	57.42	66.75	350
410.000	0.23974	4.171	0.020582	32.624	35145.8	38482.8	230.369	58.69	67.96	354
420.000	0.23360	4.281	0.020026	33.546	35743.6	39168.3	232.022	59.96	69.16	359
430.000	0.22779	4.390	0.019502	34.461	36353.8	39865.8	233.663	61.23	70.37	363
440.000	0.22227	4.499	0.019006	35.372	36976.3	40575.4	235.295	62.48	71.58	367
450.000	0.21703	4.608	0.018538	36.279	37611.0	41297.1	236.917	63.73	72.78	371
460.000	0.21205	4.716	0.018093	37.181	38258.0	42030.8	238.529	64.97	73.98	375
470.000	0.20730	4.824	0.017671	38.079	38917.1	42776.3	240.133	66.20	75.16	379
480.000	0.20276	4.932	0.017269	38.974	39588.3	43533.8	241.728	67.41	76.34	383
490.000	0.19843	5.040	0.016886	39.866	40272.3	44303.9	243.314	68.61	77.52	387
500.000	0.19429	5.147	0.016521	40.754	40967.2	45084.8	244.892	69.81	78.68	391
510.000	0.18951	5.252	0.016188	41.623	41674.9	45881.1	246.461	71.00	79.83	395
520.000	0.18500	5.362	0.015868	42.523	42391.9	46681.7	248.023	72.15	80.97	398
530.000	0.18036	5.475	0.015562	43.443	43124.2	47492.4	249.578	73.28	82.11	402
540.000	0.17596	5.589	0.015275	44.384	43882.4	48322.7	251.120	74.44	83.21	406
550.000	0.17175	5.709	0.014999	45.344	44673.8	49198.7	252.648	75.67	84.34	410
560.000	0.16775	5.834	0.014735	46.324	45500.0	50112.0	254.166	76.85	85.40	414
570.000	0.16393	5.964	0.014483	47.324	46363.9	51068.1	255.671	78.05	86.55	418
580.000	0.16029	6.099	0.014243	48.344	47270.0	52068.1	257.166	79.25	87.75	422
590.000	0.15683	6.239	0.014013	49.384	48212.0	53110.0	258.651	80.45	88.95	426
600.000	0.15353	6.384	0.013793	50.444	49184.0	54192.0	260.126	81.65	90.15	430

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 9.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DF/CT BAR/K	DF/DD BAR-L/MOL	E J/MOL	H J/MOL	S J/MCL/K	CV J/MOL/K	CP J/MOL/K	W M/SEC
90.039	21.684	0.04612	35.0151	963.868	5302.0	5343.5	76.534	44.13	68.45	2230
100.000	21.324	0.04689	31.0908	864.277	5984.0	6026.2	83.726	44.02	68.62	2117
110.000	20.965	0.04770	27.8066	774.561	6670.3	6713.3	90.274	43.82	68.80	2011
120.000	20.606	0.04853	25.0100	693.581	7358.9	7402.5	96.271	43.58	69.07	1912
130.000	20.243	0.04940	22.5854	620.163	8050.4	8094.9	101.812	43.32	69.41	1818
140.000	19.877	0.05031	20.4517	553.400	8745.9	8791.2	106.972	43.08	69.86	1728
150.000	19.504	0.05127	18.5504	492.533	9446.4	9492.5	111.810	42.88	70.43	1640
160.000	19.123	0.05229	16.8382	436.918	10153.1	10200.2	116.377	42.73	71.12	1555
170.000	18.732	0.05338	15.2824	385.991	10867.4	10915.5	120.713	42.65	71.97	1472
180.000	18.330	0.05445	13.8579	339.248	11591.0	11640.1	124.855	42.66	72.98	1389
190.000	17.915	0.05582	12.5447	296.239	12325.6	12375.8	128.832	42.75	74.20	1308
200.000	17.482	0.05720	11.3266	256.551	13073.4	13124.9	132.674	42.94	75.66	1226
210.000	17.030	0.05872	10.1899	219.815	13837.1	13890.0	136.407	43.22	77.42	1144
220.000	16.553	0.06041	9.1225	185.692	14620.2	14674.6	140.056	43.60	79.58	1062
230.000	16.045	0.06232	8.1127	153.670	15427.2	15483.3	143.651	44.06	82.28	977
237.704	15.625	0.06400	7.3664	130.737	16069.3	16126.9	146.403	44.48	84.89	911
237.704	0.54095	1.849	0.053120	13.554	26505.1	28168.8	197.104	40.68	57.59	253
240.000	0.53218	1.879	0.051900	13.913	26509.2	28300.3	197.655	40.71	57.11	255
250.000	0.49831	2.007	0.047427	15.379	27057.4	28863.5	199.956	41.05	55.78	264
260.000	0.46988	2.128	0.043918	16.728	27502.3	29417.7	202.131	41.65	55.23	272
270.000	0.44542	2.245	0.041050	17.994	27948.5	29969.0	204.213	42.42	55.17	279
280.000	0.42400	2.358	0.038638	19.197	28398.8	30521.4	206.223	43.31	55.42	286
290.000	0.40499	2.469	0.036568	20.352	28855.3	31077.6	208.176	44.28	55.90	292
300.000	0.38794	2.578	0.034761	21.468	29320.5	31640.4	210.081	45.32	56.54	298
310.000	0.37251	2.684	0.033165	22.553	29793.3	32209.3	211.948	46.42	57.32	304
320.000	0.35846	2.790	0.031739	23.612	30275.7	32786.5	213.781	47.56	58.19	310
330.000	0.34557	2.894	0.030454	24.649	30768.4	33372.8	215.586	48.73	59.13	315
340.000	0.33370	2.997	0.029288	25.666	31271.9	33968.9	217.366	49.94	60.14	321
350.000	0.32271	3.099	0.028222	26.668	31786.5	34575.4	219.124	51.16	61.20	326
360.000	0.31250	3.200	0.027244	27.656	32312.6	35192.6	220.864	52.40	62.30	331
370.000	0.30298	3.301	0.026340	28.632	32850.6	35821.0	222.586	53.66	63.42	335
380.000	0.29408	3.400	0.025503	29.596	33400.4	36460.8	224.293	54.92	64.58	340
390.000	0.28573	3.500	0.024723	30.551	33962.4	37112.2	225.985	56.19	65.75	345
400.000	0.27788	3.599	0.023996	31.498	34536.6	37775.4	227.664	57.46	66.93	349
410.000	0.27048	3.697	0.023315	32.437	35123.0	38450.5	229.332	58.73	68.12	354
420.000	0.26349	3.795	0.022675	33.370	35721.8	39137.5	230.987	59.99	69.31	358
430.000	0.25688	3.893	0.022072	34.296	36332.8	39836.4	232.632	61.25	70.51	362
440.000	0.25061	3.990	0.021504	35.216	36956.1	40547.4	234.267	62.51	71.71	367
450.000	0.24466	4.087	0.020967	36.131	37591.6	41270.3	235.892	63.75	72.90	371
460.000	0.23899	4.184	0.020458	37.042	38239.3	42005.1	237.507	64.99	74.09	375
470.000	0.23360	4.281	0.019975	37.948	38898.1	42751.8	239.113	66.21	75.27	379
480.000	0.22846	4.377	0.019516	38.851	39570.8	43510.2	240.710	67.43	76.44	383
490.000	0.22355	4.473	0.019078	39.749	40254.4	44280.4	242.298	68.63	77.61	387
500.000	0.21886	4.569	0.018662	40.645	40949.9	45062.1	243.878	69.82	78.77	390
520.000	0.21006	4.761	0.017883	42.427	42375.6	46660.1	247.012	72.16	81.04	398
540.000	0.20197	4.951	0.017171	44.198	43847.0	48303.2	250.112	74.45	83.28	405
560.000	0.19449	5.142	0.016515	45.960	45364.1	49991.5	253.181	76.68	85.47	413
580.000	0.18757	5.331	0.015910	47.713	46923.9	51722.2	256.217	78.86	87.61	420
600.000	0.18114	5.521	0.015349	49.459	48526.5	53495.2	259.223	80.99	89.70	427

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 10.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DF/CT BAR/K	OP/DD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	W M/SEC
90.055	21.685	0.04612	35.0085	964.022	5302.3	5348.5	76.538	44.14	68.49	2230
100.000	21.326	0.04669	31.0922	864.621	5983.2	6030.1	83.718	44.03	68.61	2117
110.000	20.967	0.04770	27.8088	774.927	6669.4	6717.1	90.265	43.83	68.80	2011
120.000	20.607	0.04853	25.0128	693.966	7357.8	7406.4	96.262	43.58	69.06	1912
130.000	20.245	0.04939	22.5888	620.565	8049.3	8098.7	101.803	43.33	69.41	1818
140.000	19.878	0.05031	20.4557	553.818	8744.6	8794.9	106.962	43.09	69.86	1728
150.000	19.506	0.05127	18.5549	492.965	9444.6	9496.2	111.801	42.89	70.42	1641
160.000	19.125	0.05229	16.8432	437.364	10151.4	10203.7	116.367	42.74	71.11	1556
170.000	18.735	0.05336	15.2880	386.451	10865.5	10918.9	120.702	42.66	71.95	1472
180.000	18.333	0.05455	13.8641	339.723	11588.8	11643.3	124.843	42.66	72.96	1390
190.000	17.918	0.05591	12.5515	296.729	12323.1	12378.9	128.819	42.76	74.18	1308
200.000	17.486	0.05719	11.3341	257.057	13070.5	13127.7	132.660	42.94	75.63	1227
210.000	17.035	0.05870	10.1982	220.340	13833.8	13892.5	136.391	43.23	77.39	1145
220.000	16.559	0.06039	9.1317	186.239	14616.3	14676.7	140.038	43.60	79.53	1063
230.000	16.051	0.06230	8.1230	154.444	15422.6	15484.9	143.630	44.07	82.21	979
240.000	15.503	0.06451	7.1600	124.661	16259.0	16323.5	147.199	44.63	85.69	892
241.096	15.439	0.06477	7.0566	121.507	16352.9	16417.7	147.591	44.69	86.14	883
241.096	0.60119	1.663	0.059787	13.295	26569.8	28233.1	196.641	41.28	59.21	252
250.000	0.56481	1.771	0.054751	14.598	26981.5	28752.0	198.753	41.45	57.43	260
260.000	0.53074	1.884	0.050366	16.133	27436.3	29320.4	200.984	41.95	56.47	269
270.000	0.50183	1.993	0.046851	17.465	27889.9	29882.7	203.107	42.66	56.13	276
280.000	0.47675	2.098	0.043938	18.721	28346.2	30443.7	205.149	43.50	56.20	284
290.000	0.45466	2.199	0.041463	19.920	28807.4	31006.9	207.126	44.44	56.54	290
300.000	0.43496	2.299	0.039323	21.074	29275.5	31574.6	209.052	45.45	57.09	297
310.000	0.41721	2.397	0.037445	22.190	29751.8	32148.6	210.935	46.53	57.78	303
320.000	0.40111	2.493	0.035778	23.277	30237.1	32730.1	212.782	47.65	58.59	309
330.000	0.38640	2.588	0.034283	24.338	30733.2	33321.2	214.598	48.82	59.49	314
340.000	0.37288	2.682	0.032931	25.377	31238.9	33920.7	216.388	50.01	60.46	319
350.000	0.36040	2.775	0.031701	26.399	31755.4	34530.1	218.156	51.22	61.48	325
360.000	0.34883	2.867	0.030575	27.404	32283.3	35150.0	219.902	52.46	62.55	330
370.000	0.33805	2.958	0.029538	28.396	32822.7	35780.8	221.631	53.71	63.65	335
380.000	0.32799	3.049	0.028579	29.375	33374.0	36422.8	223.344	54.96	64.79	339
390.000	0.31857	3.139	0.027689	30.344	33937.2	37076.2	225.041	56.23	65.94	344
400.000	0.30972	3.229	0.026860	31.303	34512.6	37741.2	226.726	57.49	67.10	349
410.000	0.30139	3.318	0.026084	32.254	35100.1	38418.0	228.397	58.76	68.28	353
420.000	0.29354	3.407	0.025357	33.197	35699.8	39106.5	230.056	60.02	69.46	357
430.000	0.28610	3.495	0.024674	34.133	36311.7	39806.9	231.705	61.28	70.65	362
440.000	0.27907	3.583	0.024030	35.063	36935.8	40515.2	233.343	62.53	71.84	366
450.000	0.27239	3.671	0.023422	35.987	37572.1	41243.3	234.970	63.77	73.02	370
460.000	0.26604	3.759	0.022846	36.906	38220.5	41979.3	236.588	65.01	74.20	374
470.000	0.26000	3.846	0.022300	37.820	38880.9	42727.1	238.196	66.23	75.38	378
480.000	0.25424	3.933	0.021782	38.730	39553.2	43486.5	239.796	67.45	76.54	382
490.000	0.24874	4.020	0.021289	39.636	40237.5	44257.7	241.386	68.65	77.70	386
500.000	0.24349	4.107	0.020820	40.538	40933.4	45040.3	242.967	69.84	78.85	390
520.000	0.23365	4.280	0.019944	42.332	42360.1	46639.9	246.104	72.19	81.12	398
540.000	0.22461	4.452	0.019142	44.114	43832.5	48284.6	249.208	74.46	83.35	405
560.000	0.21627	4.624	0.018406	45.886	45349.4	49973.3	252.279	76.69	85.53	413
580.000	0.20854	4.795	0.017727	47.649	46910.0	51705.2	255.317	78.87	87.67	420
600.000	0.20137	4.966	0.017098	49.405	48513.2	53479.3	258.325	81.00	89.76	427

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 12.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DP/DT BAR/K	DP/DD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CF J/MOL/K	W M/SEC
90.086	21.686	0.04611	34.5966	964.330	5303.1	5358.4	76.546	44.16	68.49	2230
100.000	21.328	0.04689	31.0951	865.309	5981.7	6037.9	83.702	44.04	68.61	2117
110.000	20.969	0.04769	27.8131	775.659	6667.7	6724.9	90.249	43.84	68.79	2012
120.000	20.610	0.04852	25.0184	694.737	7355.8	7414.0	96.245	43.60	69.05	1913
130.000	20.248	0.04939	22.5955	621.370	8047.0	8106.2	101.785	43.34	69.40	1819
140.000	19.882	0.05030	20.4635	554.653	8742.0	8802.3	106.944	43.10	69.84	1729
150.000	19.510	0.05126	18.5638	493.829	9442.0	9503.5	111.781	42.90	70.40	1652
160.000	19.130	0.05227	16.8533	438.256	10148.1	10210.8	116.346	42.75	71.09	1557
170.000	18.740	0.05336	15.2952	387.370	10861.7	10925.8	120.680	42.68	71.93	1473
180.000	18.339	0.05453	13.8764	340.671	11584.4	11649.9	124.818	42.68	72.93	1391
190.000	17.925	0.05579	12.5651	297.707	12318.1	12385.0	128.793	42.77	74.13	1310
200.000	17.494	0.05716	11.3490	258.069	13064.8	13133.4	132.631	42.96	75.58	1229
210.000	17.044	0.05867	10.2146	221.389	13827.1	13897.6	136.359	43.24	77.31	1147
220.000	16.569	0.06035	9.1499	187.332	14608.5	14680.9	140.003	43.62	79.43	1065
230.000	16.064	0.06225	8.1434	155.588	15413.2	15487.9	143.590	44.09	82.08	981
240.000	15.519	0.06444	7.1832	125.871	16247.7	16325.0	147.152	44.64	85.50	895
247.199	15.092	0.06626	6.5128	105.571	16872.1	16951.6	149.724	45.10	88.70	831
247.199	0.72357	1.382	0.073717	12.752	26678.8	28337.3	195.822	42.40	62.52	250
250.000	0.70794	1.413	0.071397	13.251	26815.8	28510.9	196.521	42.38	61.57	253
260.000	0.65968	1.516	0.064634	14.894	27294.8	29113.9	198.888	42.62	59.37	263
270.000	0.62003	1.613	0.059464	16.378	27765.9	29701.3	201.106	43.16	58.32	271
280.000	0.58643	1.705	0.055313	17.753	28236.3	30282.6	203.219	43.90	57.93	279
290.000	0.55732	1.794	0.051872	19.048	28708.2	30861.4	205.251	44.76	57.95	286
300.000	0.53169	1.881	0.048949	20.281	29185.0	31441.9	207.220	45.72	58.26	293
310.000	0.50885	1.965	0.046422	21.465	29668.4	32026.7	209.138	46.76	58.78	300
320.000	0.48829	2.048	0.044206	22.610	30159.9	32617.4	211.015	47.85	59.45	306
330.000	0.46964	2.129	0.042239	23.722	30660.3	33215.5	212.856	48.98	60.24	311
340.000	0.45259	2.209	0.040476	24.806	31170.5	33821.9	214.667	50.15	61.12	317
350.000	0.43694	2.289	0.038883	25.868	31691.1	34437.5	216.452	51.35	62.07	322
360.000	0.42248	2.367	0.037434	26.909	32222.6	35063.0	218.215	52.57	63.07	328
370.000	0.40907	2.445	0.036107	27.934	32765.2	35698.7	219.957	53.81	64.13	333
380.000	0.39659	2.522	0.034886	28.943	33320.4	36346.2	221.682	55.05	65.21	338
390.000	0.38493	2.598	0.033758	29.939	33886.2	37003.7	223.390	56.31	66.33	342
400.000	0.37401	2.674	0.032711	30.923	34463.9	37672.4	225.083	57.56	67.46	347
410.000	0.36375	2.749	0.031735	31.897	35053.6	38352.6	226.763	58.82	68.61	352
420.000	0.35409	2.824	0.030823	32.861	35655.3	39044.2	228.430	60.08	69.77	356
430.000	0.34497	2.899	0.029969	33.817	36269.0	39747.5	230.085	61.33	70.93	361
440.000	0.33635	2.973	0.029165	34.766	36894.8	40462.5	231.729	62.58	72.10	365
450.000	0.32818	3.047	0.028408	35.707	37532.6	41189.1	233.363	63.82	73.26	369
460.000	0.32043	3.121	0.027693	36.643	38182.5	41927.5	234.986	65.05	74.43	373
470.000	0.31306	3.194	0.027017	37.572	38844.2	42677.4	236.599	66.27	75.59	378
480.000	0.30660	3.268	0.026376	38.497	39517.8	43438.9	238.202	67.48	76.74	382
490.000	0.29935	3.341	0.025767	39.416	40203.2	44212.0	239.797	68.68	77.89	386
500.000	0.29296	3.413	0.025187	40.331	40900.3	44986.5	241.382	69.87	79.03	390
510.000	0.28610	3.485	0.024610	41.245	41599.4	45769.4	242.959	71.03	80.18	394
520.000	0.27903	3.559	0.024039	42.159	42329.0	46599.4	244.525	72.20	81.28	397
530.000	0.27173	3.633	0.023475	43.073	43093.2	47477.1	246.085	73.35	82.44	400
540.000	0.26425	3.707	0.022915	43.987	43893.2	48400.5	247.635	74.48	83.49	405
550.000	0.25666	3.781	0.022362	44.901	44729.7	49270.5	249.171	75.59	84.56	410
560.000	0.24892	3.855	0.021815	45.815	45603.7	50192.5	250.711	76.71	85.66	415
570.000	0.24103	3.929	0.021279	46.729	46518.7	51167.8	252.254	77.89	86.79	419
580.000	0.23299	4.003	0.020754	47.643	47475.2	52194.2	253.794	79.03	87.96	423
590.000	0.22481	4.077	0.020239	48.557	48473.2	53272.2	255.324	80.18	89.13	426
600.000	0.21649	4.151	0.019734	49.471	49513.2	54400.2	256.849	81.33	90.30	429

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 14.0 BAR

T OEG K	DEN MOL/L	VCL L/MOL	OF/CT BAR/K	DF/DO BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CF J/MOL/K	W M/SEC
90.117	21.687	0.04611	34.9843	964.639	5303.8	5368.4	76.555	44.17	68.48	2230
100.000	21.330	0.04688	31.0980	865.997	5980.1	6045.7	83.606	44.06	68.60	2118
110.000	20.972	0.04768	27.8174	776.390	6665.9	6732.6	90.233	43.86	68.79	2012
120.000	20.613	0.04851	25.0240	695.506	7353.8	7421.7	96.228	43.62	69.04	1913
130.000	20.251	0.04938	22.6023	622.173	8044.7	8113.8	101.768	43.36	69.39	1820
140.000	19.886	0.05029	20.4714	555.188	8739.4	8809.8	106.925	43.12	69.83	1730
150.000	19.514	0.05125	18.5728	494.693	9439.0	9510.8	111.761	42.92	70.38	1643
160.000	19.134	0.05226	16.8633	439.147	10144.7	10217.9	116.325	42.77	71.07	1558
170.000	18.745	0.05335	15.3103	388.289	10857.9	10932.6	120.657	42.69	71.90	1475
180.000	18.345	0.05451	13.8887	341.618	11580.1	11656.4	124.794	42.70	72.90	1393
190.000	17.931	0.05577	12.5786	298.684	12313.1	12391.2	128.766	42.79	74.09	1311
200.000	17.502	0.05714	11.3639	259.078	13059.1	13139.1	132.602	42.98	75.52	1230
210.000	17.053	0.05864	10.2311	222.436	13820.5	13902.6	136.327	43.26	77.24	1149
220.000	16.580	0.06031	9.1681	188.421	14600.7	14685.2	139.967	43.64	79.34	1067
230.000	16.077	0.06220	8.1637	156.729	15404.0	15491.1	143.549	44.11	81.95	984
240.000	15.534	0.06437	7.2063	127.075	16236.4	16326.6	147.104	44.66	85.30	898
250.000	14.936	0.06695	6.2818	99.179	17107.5	17201.2	150.674	45.30	89.89	809
252.601	14.769	0.06771	6.0446	92.173	17342.1	17436.9	151.612	45.48	91.39	785
252.601	0.84896	1.178	0.088500	12.175	26763.8	28412.8	195.103	43.45	66.00	248
260.000	0.80025	1.250	0.081161	13.564	27139.7	28889.2	196.963	43.40	63.12	256
270.000	0.74657	1.339	0.073656	15.236	27633.5	29508.8	199.300	43.73	60.98	266
280.000	0.70237	1.424	0.067864	16.751	28119.0	30112.3	201.497	44.34	59.94	274
290.000	0.66484	1.504	0.063191	18.155	28603.2	30709.0	203.592	45.11	59.54	282
300.000	0.63231	1.582	0.059303	19.477	29089.7	31303.9	205.610	46.01	59.56	290
310.000	0.60364	1.657	0.055994	21.935	29581.2	31900.5	207.567	47.00	59.86	296
320.000	0.57808	1.730	0.053129	23.942	30080.2	32502.1	209.475	48.05	60.37	303
330.000	0.55506	1.802	0.050613	26.108	30586.4	33108.7	211.343	49.16	61.03	309
340.000	0.53415	1.872	0.048378	28.240	31101.6	33722.5	213.176	50.30	61.81	315
350.000	0.51505	1.942	0.046374	30.344	31626.5	34344.7	214.980	51.48	62.68	320
360.000	0.49748	2.010	0.044562	32.423	32161.7	34975.9	216.759	52.69	63.62	326
370.000	0.48126	2.078	0.042913	34.481	32707.7	35616.8	218.515	53.91	64.61	331
380.000	0.46620	2.145	0.041404	36.520	33264.9	36267.9	220.252	55.14	65.65	336
390.000	0.45218	2.212	0.040014	38.544	33833.4	36929.5	221.971	56.39	66.73	341
400.000	0.43908	2.278	0.038729	40.553	34413.6	37602.1	223.675	57.64	67.82	346
410.000	0.42680	2.343	0.037537	42.550	35005.5	38285.7	225.363	58.89	68.94	350
420.000	0.41526	2.408	0.036426	44.536	35609.2	38980.6	227.038	60.14	70.07	355
430.000	0.40438	2.473	0.035387	46.513	36224.8	39686.9	228.700	61.39	71.21	360
440.000	0.39412	2.537	0.034413	48.480	36853.4	40405.6	230.351	62.63	72.36	364
450.000	0.38441	2.601	0.033498	50.439	37492.8	41134.8	231.989	63.87	73.51	368
460.000	0.37520	2.665	0.032635	52.390	38144.1	41875.4	233.618	65.09	74.66	373
470.000	0.36646	2.729	0.031820	54.335	38807.2	42627.6	235.236	66.31	75.80	377
480.000	0.35814	2.792	0.031049	56.274	39482.1	43391.2	236.844	67.52	76.95	381
490.000	0.35022	2.855	0.030318	58.207	40168.7	44166.2	238.442	68.72	78.08	385
500.000	0.34267	2.918	0.029624	60.135	40866.9	44952.5	240.031	69.90	79.21	389
520.000	0.32855	3.044	0.028333	62.077	42297.7	46558.8	243.181	72.23	81.44	397
540.000	0.31561	3.168	0.027159	64.002	43773.6	48209.4	246.296	74.51	83.64	404
560.000	0.30371	3.293	0.026084	65.914	45293.8	49903.6	249.377	76.74	85.79	412
580.000	0.29270	3.416	0.025056	67.813	46857.3	51640.3	252.424	78.91	87.90	419
600.000	0.28250	3.540	0.024184	69.701	48463.2	53419.0	255.439	81.03	89.97	426

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 16.0 BAR

T DEG K	DEN MOL/L	VCL L/MOL	DP/CT BAR/K	DF/DD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	W M/SEC
90.149	21.688	0.04611	34.5721	964.948	5304.6	5378.4	76.563	44.19	68.48	2230
100.000	21.333	0.04688	31.1009	866.688	5978.5	6053.5	83.670	44.08	68.60	2118
110.000	20.974	0.04768	27.8217	777.122	6664.1	6740.4	90.216	43.88	68.78	2013
120.000	20.616	0.04851	25.0295	696.276	7351.8	7429.4	96.211	43.63	69.04	1914
130.000	20.255	0.04937	22.6090	622.977	8042.4	8121.4	101.750	43.38	69.38	1820
140.000	19.889	0.05028	20.4792	556.322	8736.8	8817.2	106.907	43.14	69.82	1730
150.000	19.518	0.05124	18.5817	495.556	9436.1	9518.0	111.741	42.93	70.37	1644
160.000	19.139	0.05225	16.8733	440.038	10141.4	10225.0	116.304	42.78	71.05	1559
170.000	18.750	0.05333	15.3214	389.207	10854.1	10939.5	120.635	42.71	71.87	1476
180.000	18.351	0.05449	13.5010	342.584	11575.8	11663.0	124.770	42.71	72.86	1394
190.000	17.938	0.05575	12.5921	299.660	12308.2	12397.4	128.740	42.81	74.05	1313
200.000	17.509	0.05711	11.3787	260.087	13053.4	13144.8	132.574	42.99	75.47	1232
210.000	17.062	0.05861	10.2474	223.481	13813.9	13907.7	136.296	43.28	77.17	1151
220.000	16.591	0.06027	9.1862	189.508	14593.0	14689.5	139.932	43.66	79.25	1070
230.000	16.090	0.06215	8.1839	157.867	15394.8	15494.3	143.509	44.12	81.82	987
240.000	15.550	0.06431	7.2291	128.275	16225.3	16328.2	147.058	44.68	85.12	901
250.000	14.956	0.06686	6.3083	100.459	17093.5	17200.5	150.618	45.32	89.59	813
257.468	14.463	0.06914	5.6321	80.667	17775.4	17886.0	153.319	45.85	94.25	743
257.468	0.97801	1.022	0.104224	11.567	26830.7	28466.7	194.450	44.45	69.73	246
260.000	0.95609	1.046	0.100728	12.106	26967.6	28641.0	195.124	44.35	68.19	249
270.000	0.88331	1.132	0.089809	14.019	27489.3	29300.7	197.616	44.39	64.29	260
280.000	0.82563	1.211	0.081803	15.701	27994.4	29932.3	199.915	44.82	62.33	269
290.000	0.77789	1.286	0.075550	17.231	28493.7	30550.5	202.083	45.49	61.37	278
300.000	0.73722	1.356	0.070467	18.652	28991.4	31161.7	204.157	46.32	61.01	286
310.000	0.70186	1.425	0.066216	19.992	29491.8	31771.4	206.157	47.25	61.05	293
320.000	0.67066	1.491	0.062585	21.267	29997.3	32383.0	208.100	48.26	61.37	300
330.000	0.64278	1.556	0.059432	22.492	30509.7	32998.9	209.996	49.34	61.88	306
340.000	0.61764	1.619	0.056657	23.674	31030.1	33620.6	211.853	50.46	62.55	312
350.000	0.59479	1.681	0.054188	24.822	31560.5	34250.5	213.677	51.62	63.32	318
360.000	0.57388	1.743	0.051971	25.940	32099.7	34887.8	215.472	52.81	64.19	324
370.000	0.55463	1.803	0.049964	27.033	32649.3	35534.1	217.244	54.01	65.12	329
380.000	0.53684	1.863	0.048136	28.104	33209.6	36190.0	218.993	55.24	66.11	334
390.000	0.52032	1.922	0.046461	29.156	33780.9	36855.9	220.724	56.47	67.14	340
400.000	0.50493	1.980	0.044919	30.192	34363.6	37532.4	222.437	57.71	68.20	344
410.000	0.49053	2.039	0.043491	31.213	34957.8	38219.6	224.134	58.96	69.28	349
420.000	0.47703	2.096	0.042166	32.220	35563.7	38917.8	225.817	60.20	70.39	354
430.000	0.46433	2.154	0.040930	33.217	36181.2	39627.0	227.486	61.44	71.50	359
440.000	0.45236	2.211	0.039774	34.202	36810.5	40347.5	229.143	62.68	72.63	363
450.000	0.44105	2.267	0.038690	35.179	37451.6	41079.3	230.788	63.91	73.76	367
460.000	0.43035	2.324	0.037671	36.147	38104.4	41822.3	232.421	65.14	74.89	372
470.000	0.42019	2.380	0.036710	37.107	38768.9	42576.7	234.044	66.35	76.02	376
480.000	0.41054	2.436	0.035803	38.060	39445.1	43342.4	235.656	67.56	77.15	380
490.000	0.40137	2.491	0.034943	39.007	40133.0	44119.4	237.259	68.75	78.27	384
500.000	0.39262	2.547	0.034128	39.947	40833.3	44908.5	238.851	69.93	79.39	388
520.000	0.37629	2.658	0.032617	41.813	42266.2	46518.2	242.008	72.26	81.60	396
540.000	0.36135	2.767	0.031244	43.659	43744.0	48171.8	245.129	74.53	83.78	404
560.000	0.34761	2.877	0.029950	45.490	45255.8	49868.7	248.214	76.76	85.92	412
580.000	0.33493	2.986	0.028840	47.306	46830.8	51607.9	251.266	78.93	88.02	419
600.000	0.32319	3.094	0.027780	49.110	48438.0	53388.7	254.285	81.05	90.08	426

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 18.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	OP/DT BAR/K	OP/DD BAR/L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	W M/SEC
90.180	21.688	0.04611	34.9599	965.257	5305.3	5388.3	76.571	44.20	68.48	2230
100.000	21.335	0.04687	31.1038	867.372	5977.0	6061.3	83.655	44.09	68.60	2118
110.000	20.977	0.04767	27.8260	777.853	6662.3	6748.1	90.200	43.89	68.77	2013
120.000	20.619	0.04850	25.0351	697.045	7349.8	7437.1	96.194	43.65	69.03	1915
130.000	20.258	0.04936	22.8157	623.780	8040.1	8129.0	101.732	43.39	69.37	1821
140.000	19.893	0.05027	20.4870	557.156	8734.2	8824.7	106.888	43.15	69.80	1731
150.000	19.522	0.05122	18.5906	494.418	9433.1	9525.3	111.722	42.95	70.35	1644
160.000	19.143	0.05224	16.8833	440.927	10138.1	10232.1	116.283	42.80	71.03	1560
170.000	18.756	0.05332	15.3325	390.124	10850.4	10946.3	120.612	42.72	71.85	1477
180.000	18.357	0.05448	13.9132	343.508	11571.5	11669.6	124.746	42.73	72.83	1395
190.000	17.945	0.05573	12.6056	300.634	12303.3	12403.6	128.714	42.82	74.01	1314
200.000	17.517	0.05709	11.3935	261.093	13047.7	13150.5	132.545	43.01	75.42	1234
210.000	17.071	0.05858	10.2637	224.523	13807.4	13912.8	136.264	43.29	77.11	1153
220.000	16.601	0.06024	9.2042	190.593	14585.4	14693.8	139.897	43.67	79.15	1072
230.000	16.102	0.06210	8.2040	159.001	15385.7	15497.5	143.469	44.14	81.69	989
240.000	15.566	0.06424	7.2518	129.470	16214.3	16329.9	147.011	44.70	84.93	905
250.000	14.976	0.06677	6.3346	101.733	17079.7	17199.9	150.562	45.33	89.30	816
260.000	14.309	0.06989	5.4345	75.501	17996.9	18122.6	154.180	46.06	95.73	722
261.912	14.169	0.07058	5.2621	70.628	18180.1	18307.2	154.887	46.20	97.35	703
261.912	1.11138	0.900	0.120953	10.933	26881.0	28500.6	193.842	45.41	73.80	243
270.000	1.03301	0.968	0.108487	12.703	27331.3	29073.8	195.999	45.15	68.59	253
280.000	0.95769	1.044	0.097417	14.590	27861.6	29741.2	198.426	45.37	65.22	264
290.000	0.89731	1.114	0.089114	16.267	28377.4	30383.4	200.681	45.91	63.49	274
300.000	0.84695	1.181	0.082544	17.801	28887.9	31013.2	202.818	46.65	62.65	282
310.000	0.80385	1.244	0.077155	19.230	29398.3	31637.6	204.866	47.52	62.37	290
320.000	0.76624	1.305	0.072620	20.580	29912.8	32261.9	206.847	48.49	62.45	297
330.000	0.73295	1.364	0.068728	21.867	30431.8	32887.7	208.773	49.53	62.80	304
340.000	0.70315	1.422	0.065335	23.104	30958.0	33517.9	210.656	50.62	63.33	310
350.000	0.67622	1.479	0.062341	24.298	31492.3	34154.2	212.501	51.76	64.00	316
360.000	0.65170	1.534	0.059671	25.457	32035.8	34797.8	214.314	52.93	64.78	322
370.000	0.62924	1.589	0.057268	26.597	32589.0	35449.6	216.101	54.12	65.65	327
380.000	0.60854	1.643	0.055091	27.691	33152.6	36110.5	217.864	55.33	66.58	333
390.000	0.58938	1.697	0.053104	28.772	33727.8	36781.9	219.606	56.56	67.56	338
400.000	0.57157	1.750	0.051282	29.835	34313.1	37462.4	221.329	57.79	68.58	343
410.000	0.55495	1.802	0.049601	30.880	34909.7	38153.2	223.036	59.03	69.63	348
420.000	0.53940	1.854	0.048046	31.910	35517.7	38854.7	224.727	60.27	70.71	353
430.000	0.52481	1.905	0.046599	32.927	36137.2	39567.1	226.403	61.50	71.80	358
440.000	0.51107	1.957	0.045250	33.932	36768.3	40290.4	228.066	62.73	72.90	362
450.000	0.49811	2.008	0.043987	34.926	37411.1	41024.7	229.717	63.96	74.01	367
460.000	0.48586	2.058	0.042802	35.911	38065.4	41770.2	231.356	65.18	75.12	371
470.000	0.47425	2.109	0.041687	36.886	38731.4	42526.9	232.983	66.39	76.24	375
480.000	0.46324	2.159	0.040636	37.854	39408.9	43294.6	234.600	67.59	77.35	380
490.000	0.45277	2.209	0.039642	38.814	40098.0	44073.6	236.207	68.78	78.46	384
500.000	0.44277	2.258	0.038701	39.767	40798.5	44863.6	237.803	69.96	79.57	388
510.000	0.43324	2.307	0.037821	40.715	41513.5	45676.6	240.966	72.29	81.76	396
520.000	0.42421	2.357	0.036959	41.656	42233.5	46476.6	244.093	74.56	83.92	404
530.000	0.41564	2.406	0.036100	42.593	42953.1	47273.1	247.183	76.78	86.05	411
540.000	0.40723	2.456	0.035241	43.523	43673.1	48083.8	250.239	78.95	88.14	419
550.000	0.39916	2.505	0.034381	44.453	44393.1	48894.2	253.262	81.07	90.19	426
560.000	0.39164	2.553	0.033521	45.373	45113.1	49704.2	256.262	83.19	92.24	433
570.000	0.38423	2.601	0.032662	46.293	45833.1	50514.2	259.262	85.31	94.29	440
580.000	0.37726	2.651	0.031802	47.206	46553.1	51324.2	262.262	87.43	96.34	447
590.000	0.37029	2.700	0.030943	48.126	47273.1	52134.2	265.262	89.55	98.39	454
600.000	0.36332	2.748	0.030084	49.046	48004.2	52944.2	268.262	91.67	100.44	461

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 20.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DF/CT BAR/K	DF/DD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CF J/MOL/K	W M/SEC
90.211	21.689	0.04611	34.5477	965.567	5306.1	5398.3	76.579	44.22	68.48	2230
100.000	21.337	0.04687	31.1067	868.059	5975.4	6069.1	83.639	44.11	68.59	2119
110.000	20.979	0.04767	27.8303	778.584	6660.5	6755.9	90.184	43.91	68.77	2014
120.000	20.621	0.04849	25.0407	697.814	7347.7	7444.7	96.178	43.66	69.02	1915
130.000	20.261	0.04936	22.6224	624.582	8037.8	8136.5	101.715	43.41	69.35	1822
140.000	19.896	0.05026	20.4949	557.989	8731.6	8832.1	106.869	43.17	69.79	1732
150.000	19.526	0.05121	18.5995	497.280	9430.2	9532.6	111.702	42.96	70.33	1645
160.000	19.148	0.05223	16.8933	441.816	10134.8	10239.2	116.262	42.82	71.00	1561
170.000	18.761	0.05330	15.3436	391.040	10846.6	10953.2	120.590	42.74	71.82	1478
180.000	18.363	0.05446	13.9254	344.452	11567.2	11676.1	124.722	42.74	72.80	1397
190.000	17.951	0.05571	12.6190	301.607	12298.4	12409.8	128.688	42.84	73.97	1316
200.000	17.525	0.05706	11.4083	262.098	13042.1	13156.2	132.517	43.03	75.36	1236
210.000	17.080	0.05855	10.2799	225.564	13800.9	13918.0	136.233	43.31	77.04	1155
220.000	16.612	0.06020	9.2221	191.674	14577.8	14698.1	139.862	43.69	79.06	1074
230.000	16.115	0.06205	8.2240	160.131	15376.7	15500.8	143.429	44.16	81.57	992
240.000	15.581	0.06418	7.2744	130.660	16203.3	16331.7	146.965	44.71	84.75	908
250.000	14.996	0.06659	6.3606	102.999	17066.0	17199.4	150.507	45.35	89.02	820
260.000	14.335	0.06976	5.4656	76.873	17979.0	18118.5	154.111	46.07	95.24	727
266.010	13.884	0.07203	4.9257	61.767	18562.4	18706.4	156.346	46.55	100.76	667
266.010	1.250	0.80009	0.1389	10.275	26917.3	28517.4	193.262	46.34	78.34	240
270.000	1.200	0.83336	0.1306	11.261	27155.4	28822.1	194.398	46.07	74.47	246
280.000	1.101	0.90861	0.1151	13.406	27717.4	29534.7	196.992	45.98	68.83	258
290.000	1.024	0.97637	0.1041	15.256	28254.1	30206.8	199.352	46.36	66.00	269
300.000	0.962	1.03931	0.0957	16.917	28780.3	30858.9	201.562	47.00	64.53	278
310.000	0.910	1.09888	0.0889	18.447	29302.1	31499.9	203.665	47.80	63.84	286
320.000	0.865	1.15592	0.0833	19.878	29824.7	32136.6	205.688	48.72	63.64	294
330.000	0.826	1.21100	0.0785	21.232	30351.2	32773.2	207.648	49.72	63.78	301
340.000	0.791	1.26452	0.0744	22.526	30884.2	33413.2	209.557	50.79	64.16	308
350.000	0.759	1.31676	0.0709	23.770	31423.7	34057.2	211.424	51.90	64.72	314
360.000	0.731	1.36795	0.0677	24.972	31971.6	34707.5	213.257	53.05	65.41	320
370.000	0.705	1.41824	0.0648	26.140	32528.8	35365.3	215.060	54.23	66.20	326
380.000	0.681	1.46777	0.0623	27.278	33095.8	36031.3	216.837	55.43	67.07	331
390.000	0.659	1.51664	0.0599	28.390	33673.2	36706.4	218.591	56.64	68.00	337
400.000	0.639	1.56493	0.0578	29.480	34261.2	37391.1	220.325	57.87	68.98	342
410.000	0.620	1.61273	0.0559	30.551	34860.2	38085.7	222.040	59.10	69.99	347
420.000	0.602	1.66008	0.0541	31.604	35470.5	38790.6	223.739	60.33	71.03	352
430.000	0.586	1.70704	0.0524	32.642	36092.9	39507.0	225.423	61.56	72.10	357
440.000	0.570	1.75364	0.0508	33.666	36725.9	40233.2	227.093	62.79	73.18	361
450.000	0.556	1.79993	0.0494	34.679	37370.3	40970.2	228.750	64.01	74.26	366
460.000	0.542	1.84593	0.0480	35.680	38026.2	41718.1	230.394	65.23	75.36	370
470.000	0.529	1.89167	0.0468	36.671	38693.7	42477.0	232.026	66.43	76.46	375
480.000	0.516	1.93718	0.0455	37.653	39372.6	43246.9	233.648	67.63	77.56	379
490.000	0.504	1.98247	0.0444	38.627	40062.9	44027.8	235.258	68.82	78.65	383
500.000	0.493	2.02757	0.0433	39.593	40764.6	44819.7	236.858	70.00	79.75	387
520.000	0.472	2.11723	0.0414	41.505	42201.7	46436.1	240.028	72.31	81.92	395
540.000	0.453	2.20628	0.0396	43.394	43683.2	48095.8	243.160	74.58	84.07	403
560.000	0.436	2.29479	0.0379	45.262	45208.4	49798.0	246.256	76.80	86.18	411
580.000	0.420	2.38285	0.0364	47.113	46776.4	51542.1	249.316	78.97	88.25	418
600.000	0.405	2.47050	0.0351	48.948	48386.4	53327.4	252.343	81.09	90.29	426

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 22.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DF/DT BAR/K	DF/DD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CF J/MOL/K	W M/SEC
90.242	21.690	0.04610	34.9356	965.878	5306.8	5408.2	76.588	44.24	68.47	2230
100.000	21.339	0.04686	31.1096	868.747	5973.8	6076.9	83.623	44.12	68.55	2119
110.000	20.982	0.04766	27.8347	779.314	6658.8	6763.6	90.168	43.92	68.76	2014
120.000	20.624	0.04849	25.0462	698.582	7345.7	7452.4	96.161	43.68	69.01	1916
130.000	20.264	0.04935	22.6292	625.385	8035.5	8144.1	101.697	43.42	69.34	1822
140.000	19.900	0.05025	20.5027	558.821	8729.0	8839.6	106.851	43.18	69.77	1733
150.000	19.530	0.05120	18.6084	498.141	9427.3	9539.9	111.682	42.98	70.32	1646
160.000	19.152	0.05221	16.9032	442.704	10131.5	10246.3	116.241	42.83	70.98	1562
170.000	18.766	0.05329	15.3547	391.955	10842.8	10960.1	120.568	42.75	71.79	1479
180.000	18.368	0.05444	13.9376	345.394	11562.9	11682.7	124.698	42.76	72.77	1398
190.000	17.958	0.05569	12.6324	302.578	12293.5	12416.0	128.662	42.85	73.93	1318
200.000	17.532	0.05704	11.4230	263.101	13036.5	13162.0	132.488	43.04	75.31	1237
210.000	17.088	0.05852	10.2961	226.602	13794.4	13923.1	136.202	43.33	76.97	1157
220.000	16.622	0.06016	9.2400	192.753	14570.2	14702.5	139.827	43.71	78.97	1076
230.000	16.127	0.06201	8.2438	161.258	15367.7	15504.2	143.390	44.18	81.44	994
240.000	15.596	0.06412	7.2967	131.845	16192.5	16333.6	146.920	44.73	84.58	911
250.000	15.015	0.06660	6.3864	104.259	17052.6	17199.1	150.452	45.37	88.75	824
260.000	14.361	0.06963	5.4963	78.235	17961.4	18114.6	154.042	46.09	94.77	731
269.819	13.604	0.07351	4.6160	53.075	18926.6	19088.3	157.717	46.89	104.55	632
269.819	1.394	0.71720	0.1582	9.597	26940.9	28518.8	192.699	47.27	83.46	237
270.000	1.391	0.71874	0.1577	9.649	26952.7	28533.9	192.755	47.24	83.18	238
280.000	1.257	0.79540	0.1355	12.135	27559.7	29309.5	195.579	46.69	73.48	252
290.000	1.160	0.86202	0.1208	14.191	28123.1	30019.6	198.071	46.86	69.01	264
300.000	1.084	0.92276	0.1100	15.998	28666.4	30696.5	200.368	47.38	66.69	274
310.000	1.021	0.97955	0.1015	17.638	29201.2	31356.2	202.532	48.10	65.48	283
320.000	0.968	1.03349	0.0946	19.157	29734.6	32008.3	204.601	48.97	64.95	291
330.000	0.921	1.08528	0.0889	20.583	30269.0	32656.6	206.598	49.93	64.85	298
340.000	0.881	1.13536	0.0840	21.938	30807.9	33305.7	208.536	50.96	65.06	305
350.000	0.845	1.18408	0.0797	23.234	31353.0	33958.0	210.428	52.05	65.48	312
360.000	0.812	1.23167	0.0760	24.482	31905.6	34615.3	212.280	53.18	66.07	318
370.000	0.782	1.27832	0.0727	25.690	32467.7	35280.0	214.100	54.35	66.78	324
380.000	0.755	1.32417	0.0697	26.863	33038.3	35951.5	215.891	55.53	67.58	330
390.000	0.730	1.36934	0.0670	28.007	33618.8	36631.4	217.658	56.73	68.45	335
400.000	0.707	1.41391	0.0645	29.126	34209.7	37320.3	219.402	57.95	69.39	341
410.000	0.686	1.45797	0.0623	30.223	34811.3	38016.8	221.128	59.17	70.36	346
420.000	0.666	1.50157	0.0602	31.300	35423.8	38727.2	222.835	60.39	71.37	351
430.000	0.647	1.54476	0.0583	32.359	36047.4	39445.9	224.527	61.62	72.40	356
440.000	0.630	1.58760	0.0565	33.404	36682.2	40175.0	226.203	62.84	73.46	360
450.000	0.613	1.63011	0.0549	34.434	37328.4	40914.7	227.866	64.06	74.52	365
460.000	0.598	1.67234	0.0534	35.452	37986.9	41666.0	229.516	65.27	75.60	370
470.000	0.583	1.71430	0.0519	36.460	38655.8	42427.3	231.153	66.47	76.68	374
480.000	0.569	1.75602	0.0505	37.456	39336.1	43199.3	232.779	67.67	77.76	378
490.000	0.556	1.79752	0.0493	38.444	40027.7	43982.2	234.393	68.85	78.85	383
500.000	0.544	1.83883	0.0481	39.423	40730.5	44775.9	235.997	70.03	79.93	387
520.000	0.521	1.92091	0.0458	41.359	42169.8	46395.8	239.174	72.34	82.08	395
540.000	0.499	2.00237	0.0438	43.269	43653.2	48058.4	242.312	74.61	84.21	403
560.000	0.480	2.08330	0.0420	45.180	45180.1	49763.4	245.412	76.82	86.31	411
580.000	0.462	2.16376	0.0403	47.024	46749.6	51509.9	248.477	78.99	88.37	418
600.000	0.446	2.24383	0.0388	48.875	48361.0	53297.4	251.507	81.11	90.40	426

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 24.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DP/CT BAR/K	DF/DD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CF J/MOL/K	W M/SEC
90.273	21.691	0.04610	34.9235	966.188	5307.6	5418.2	76.596	44.25	68.47	2230
100.000	21.342	0.04686	31.1125	869.434	5972.3	6084.7	83.607	44.14	68.58	2120
110.000	20.985	0.04765	27.8390	780.045	6657.0	6771.4	90.151	43.94	68.76	2015
120.000	20.627	0.04848	25.0518	699.350	7343.7	7460.1	96.144	43.69	69.00	1916
130.000	20.267	0.04934	22.6359	626.186	8033.3	8151.7	101.679	43.44	69.33	1823
140.000	19.904	0.05024	20.5105	559.654	8726.5	8847.1	106.832	43.20	69.76	1734
150.000	19.534	0.05119	18.6173	499.001	9424.4	9547.2	111.863	42.99	70.30	1647
160.000	19.157	0.05220	16.9132	443.592	10128.2	10253.4	116.220	42.85	70.96	1563
170.000	18.771	0.05327	15.3657	392.869	10839.1	10966.9	120.546	42.77	71.77	1481
180.000	18.374	0.05442	13.9498	346.336	11558.7	11689.3	124.674	42.78	72.73	1399
190.000	17.965	0.05567	12.6458	303.548	12288.6	12422.2	128.636	42.87	73.89	1319
200.000	17.540	0.05701	11.4377	264.102	13030.9	13167.7	132.460	43.06	75.26	1239
210.000	17.097	0.05849	10.3122	227.638	13787.9	13928.3	136.171	43.34	76.90	1159
220.000	16.632	0.06012	9.2577	193.829	14562.6	14706.9	139.792	43.72	78.89	1078
230.000	16.140	0.06196	8.2636	162.381	15358.8	15507.5	143.351	44.19	81.32	997
240.000	15.611	0.06406	7.3189	133.025	16181.8	16335.5	146.874	44.75	84.40	913
250.000	15.034	0.06652	6.4119	105.512	17039.2	17198.9	150.398	45.39	88.48	827
260.000	14.386	0.06951	5.5267	79.586	17944.1	18110.9	153.974	46.10	94.32	736
270.000	13.625	0.07339	4.6379	54.935	18921.0	19097.2	157.695	46.92	103.87	636
273.382	13.326	0.07504	4.3283	46.800	19276.4	19456.5	159.018	47.22	108.85	599
273.382	1.546	0.64697	0.1790	8.907	26951.6	28504.4	192.144	48.18	89.33	234
280.000	1.432	0.69831	0.1594	10.757	27383.9	29059.9	194.154	47.54	79.78	245
290.000	1.307	0.76521	0.1396	13.066	27981.4	29817.9	196.815	47.42	72.73	258
300.000	1.213	0.82468	0.1257	15.039	28546.1	30525.3	199.215	47.79	69.21	269
310.000	1.137	0.87949	0.1151	16.802	29096.6	31207.3	201.451	48.42	67.34	279
320.000	1.074	0.93105	0.1068	18.416	29640.6	31875.1	203.572	49.22	66.39	287
330.000	1.020	0.98022	0.0999	19.920	30183.9	32536.4	205.608	50.14	66.01	295
340.000	0.973	1.02753	0.0940	21.340	30730.6	33196.6	207.578	51.14	66.02	303
350.000	0.932	1.07338	0.0890	22.691	31281.6	33857.7	209.495	52.20	66.29	310
360.000	0.894	1.11802	0.0847	23.986	31839.3	34522.6	211.369	53.31	66.76	316
370.000	0.861	1.16168	0.0808	25.235	32404.9	35192.9	213.206	54.46	67.38	322
380.000	0.830	1.20449	0.0774	26.446	32979.3	35870.0	215.013	55.63	68.11	328
390.000	0.802	1.24660	0.0743	27.623	33563.1	36554.9	216.792	56.82	68.92	334
400.000	0.776	1.28808	0.0715	28.771	34157.7	37249.1	218.548	58.03	69.81	339
410.000	0.752	1.32904	0.0689	29.894	34761.9	37951.6	220.283	59.24	70.74	345
420.000	0.730	1.36952	0.0665	30.996	35376.7	38663.6	222.000	60.46	71.71	350
430.000	0.709	1.40959	0.0644	32.078	36002.5	39385.5	223.699	61.68	72.72	355
440.000	0.690	1.44929	0.0624	33.143	36639.3	40117.6	225.382	62.89	73.74	359
450.000	0.672	1.48867	0.0605	34.192	37287.3	40860.1	227.051	64.11	74.75	364
460.000	0.655	1.52775	0.0588	35.228	37946.4	41613.0	228.706	65.31	75.84	369
470.000	0.638	1.56656	0.0571	36.251	38616.8	42376.6	230.349	66.52	76.91	373
480.000	0.623	1.60513	0.0556	37.263	39288.5	43150.8	231.979	67.71	77.97	378
490.000	0.608	1.64348	0.0542	38.265	39991.4	43935.7	233.598	68.89	79.04	382
500.000	0.595	1.68162	0.0528	39.257	40696.4	44732.3	235.205	70.06	80.11	386
520.000	0.569	1.75738	0.0503	41.217	42137.8	46355.5	238.389	72.37	82.24	395
540.000	0.546	1.83252	0.0481	43.148	43623.2	48021.3	241.533	74.63	84.35	403
560.000	0.524	1.90712	0.0461	45.054	45151.8	49728.9	244.638	76.85	86.43	411
580.000	0.505	1.98127	0.0442	46.939	46722.8	51477.9	247.707	79.01	88.49	418
600.000	0.487	2.05501	0.0425	48.806	48335.6	53267.6	250.741	81.12	90.50	426

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 26.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DP/CT BAR/K	DF/DD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	W M/SEC
90.304	21.692	0.04610	34.9114	966.500	5308.3	5428.2	76.604	44.27	68.47	2230
100.000	21.344	0.04685	31.1154	870.121	5970.7	6092.5	83.592	44.15	68.58	2120
110.000	20.987	0.04765	27.8433	780.775	6655.2	6775.1	90.135	43.95	68.75	2015
120.000	20.630	0.04847	25.0573	700.118	7341.7	7467.8	96.127	43.71	68.99	1917
130.000	20.271	0.04933	22.6426	626.988	8031.0	8159.3	101.662	43.45	69.32	1824
140.000	19.907	0.05023	20.5183	560.485	8723.9	8854.5	106.814	43.21	69.75	1735
150.000	19.538	0.05118	18.6261	499.861	9421.5	9554.6	111.643	43.01	70.28	1648
160.000	19.161	0.05219	16.5231	444.479	10124.9	10260.5	116.199	42.86	70.94	1564
170.000	18.776	0.05326	15.3767	393.762	10835.4	10973.8	120.523	42.79	71.74	1482
180.000	18.380	0.05441	13.9619	347.276	11554.4	11695.9	124.650	42.79	72.70	1401
190.000	17.971	0.05564	12.6591	304.517	12283.8	12428.4	128.611	42.89	73.85	1321
200.000	17.548	0.05699	11.4523	265.102	13025.4	13173.5	132.432	43.08	75.21	1241
210.000	17.106	0.05846	10.3282	228.673	13781.5	13933.5	136.140	43.36	76.84	1161
220.000	16.643	0.06009	9.2754	194.903	14555.2	14711.4	139.758	43.74	78.80	1081
230.000	16.152	0.06191	8.2832	163.501	15350.0	15511.0	143.312	44.21	81.20	999
240.000	15.626	0.06399	7.3410	134.201	16171.1	16337.5	146.829	44.76	84.23	916
250.000	15.053	0.06643	6.4371	106.758	17026.1	17198.8	150.345	45.40	88.22	831
260.000	14.411	0.06939	5.5566	80.928	17927.1	18107.5	153.908	46.12	93.88	740
270.000	13.661	0.07320	4.6755	56.419	18897.2	19087.6	157.606	46.93	102.99	642
276.734	13.050	0.07663	4.0584	40.423	19614.8	19814.0	160.263	47.56	113.77	567
276.734	1.705	0.58650	0.2014	8.207	26950.1	28475.0	191.589	49.10	96.16	231
280.000	1.632	0.61269	0.1864	9.244	27183.2	28776.1	192.672	48.59	98.92	237
290.000	1.467	0.68154	0.1609	11.873	27827.2	29599.2	195.562	48.05	77.44	252
300.000	1.350	0.74065	0.1430	14.040	28418.9	30344.5	198.089	48.23	72.21	264
310.000	1.259	0.79415	0.1299	15.938	28986.3	31051.1	200.408	48.76	69.47	275
320.000	1.185	0.84392	0.1197	17.656	29543.7	31737.9	202.587	49.49	68.00	284
330.000	1.122	0.89101	0.1115	19.243	30096.8	32413.4	204.667	50.36	67.28	292
340.000	1.068	0.93608	0.1046	20.730	30650.6	33084.4	206.672	51.33	67.05	300
350.000	1.021	0.97956	0.0987	22.139	31208.1	33754.9	208.616	52.36	67.15	307
360.000	0.979	1.02176	0.0937	23.484	31771.8	34428.4	210.512	53.45	67.49	314
370.000	0.941	1.06292	0.0892	24.776	32342.0	35105.5	212.368	54.58	68.01	320
380.000	0.906	1.10319	0.0853	26.025	32920.3	35788.6	214.190	55.73	68.66	327
390.000	0.875	1.14273	0.0818	27.235	33507.5	36478.6	215.983	56.91	69.41	332
400.000	0.846	1.18162	0.0786	28.414	34104.4	37176.6	217.751	58.11	70.24	338
410.000	0.820	1.21996	0.0757	29.565	34711.3	37883.2	219.496	59.31	71.13	343
420.000	0.795	1.25782	0.0730	30.691	35329.4	38599.7	221.221	60.52	72.06	349
430.000	0.772	1.29526	0.0706	31.796	35957.3	39325.0	222.928	61.74	73.04	354
440.000	0.751	1.33231	0.0683	32.882	36596.1	40060.1	224.619	62.95	74.04	359
450.000	0.730	1.36903	0.0662	33.951	37245.9	40805.4	226.294	64.16	75.05	363
460.000	0.712	1.40545	0.0643	35.004	37906.7	41560.9	227.955	65.36	76.09	368
470.000	0.694	1.44160	0.0625	36.044	38578.7	42326.8	229.602	66.56	77.13	373
480.000	0.677	1.47751	0.0608	37.071	39261.7	43103.3	231.237	67.75	78.19	377
490.000	0.661	1.51319	0.0592	38.087	39955.9	43890.2	232.860	68.92	79.24	382
500.000	0.646	1.54867	0.0577	39.093	40661.2	44687.8	234.472	70.09	80.30	386
520.000	0.618	1.61908	0.0549	41.077	42104.9	46314.5	237.662	72.40	82.40	394
540.000	0.592	1.68887	0.0524	43.030	43593.1	47984.2	240.811	74.66	84.50	402
560.000	0.569	1.75812	0.0502	44.956	45123.5	49694.6	243.922	76.87	86.56	410
580.000	0.547	1.82691	0.0481	46.858	46696.0	51446.0	246.995	79.03	88.60	418
600.000	0.520	1.89529	0.0463	48.740	48310.1	53237.9	250.033	81.14	90.61	425

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 28.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DF/CT BAR/K	DF/DO BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CF J/MOL/K	W M/SEC
90.335	21.693	0.04610	34.8994	966.812	5309.1	5438.1	76.612	44.28	68.47	2230
100.000	21.346	0.04685	31.1183	870.807	5969.2	6100.3	83.576	44.17	68.57	2120
110.000	20.990	0.04764	27.8476	781.505	6653.5	6786.9	90.119	43.97	68.74	2016
120.000	20.633	0.04847	25.0629	700.886	7339.7	7475.4	96.110	43.72	68.99	1918
130.000	20.274	0.04932	22.6453	627.789	8028.7	8166.9	101.644	43.47	69.31	1825
140.000	19.911	0.05022	20.5261	561.316	8721.3	8862.0	106.795	43.23	69.73	1735
150.000	19.542	0.05117	18.6350	500.720	9418.6	9561.9	111.624	43.02	70.26	1649
160.000	19.166	0.05218	16.9330	445.365	10121.6	10267.7	116.179	42.88	70.92	1565
170.000	18.781	0.05325	15.3877	394.694	10831.6	10980.7	120.501	42.80	71.71	1483
180.000	18.386	0.05439	13.9740	348.215	11550.2	11702.5	124.626	42.81	72.67	1402
190.000	17.978	0.05562	12.6724	305.484	12278.9	12434.7	128.585	42.90	73.81	1322
200.000	17.555	0.05696	11.4668	266.100	13019.8	13179.3	132.404	43.09	75.16	1242
210.000	17.115	0.05843	10.3442	229.705	13775.1	13938.7	136.109	43.38	76.77	1163
220.000	16.653	0.06005	9.2930	195.974	14547.7	14715.9	139.724	43.76	78.71	1083
230.000	16.164	0.06186	8.3027	164.617	15341.2	15514.4	143.273	44.23	81.09	1002
240.000	15.641	0.06393	7.3629	135.372	16160.6	16339.6	146.785	44.78	84.07	919
250.000	15.072	0.06635	6.4622	107.999	17013.1	17198.8	150.292	45.42	87.97	834
260.000	14.436	0.06927	5.5861	82.260	17910.3	18104.3	153.842	46.13	93.46	744
270.000	13.696	0.07301	4.7124	57.886	18874.0	19078.5	157.518	46.94	102.16	647
279.901	12.771	0.07830	3.8033	34.654	19944.3	20163.5	161.463	47.89	119.53	536
279.901	1.874	0.53370	0.2259	7.504	26936.3	28430.7	191.027	50.02	104.22	228
280.000	1.871	0.53455	0.2253	7.540	26944.2	28440.9	191.064	50.00	103.86	228
290.000	1.645	0.60779	0.1857	10.605	27656.9	29358.7	194.288	48.79	83.63	246
300.000	1.498	0.66749	0.1623	12.999	28282.1	30151.1	196.975	48.72	75.83	259
310.000	1.388	0.72029	0.1460	15.047	28871.0	30887.8	199.391	49.12	71.91	271
320.000	1.301	0.76876	0.1336	16.877	29442.3	31594.8	201.637	49.77	69.79	281
330.000	1.228	0.81422	0.1238	18.551	30006.3	32286.1	203.766	50.59	68.67	289
340.000	1.166	0.85746	0.1157	20.110	30569.3	32970.2	205.807	51.52	68.16	297
350.000	1.112	0.89898	0.1089	21.578	31133.6	33650.8	207.781	52.52	68.07	305
360.000	1.065	0.93914	0.1031	22.975	31702.4	34332.0	209.700	53.59	68.27	312
370.000	1.022	0.97819	0.0980	24.312	32277.3	35016.3	211.576	54.70	68.68	319
380.000	0.984	1.01632	0.0935	25.599	32860.5	35706.2	213.415	55.84	69.24	325
390.000	0.949	1.05367	0.0895	26.845	33451.4	36401.6	215.222	57.01	69.92	331
400.000	0.917	1.09036	0.0859	28.055	34051.4	37104.4	217.001	58.19	70.69	337
410.000	0.888	1.12647	0.0826	29.234	34661.1	37815.2	218.757	59.39	71.53	342
420.000	0.861	1.16209	0.0796	30.386	35280.9	38534.7	220.492	60.59	72.43	348
430.000	0.835	1.19728	0.0769	31.514	35911.1	39263.4	222.207	61.79	73.36	353
440.000	0.812	1.23207	0.0744	32.621	36551.9	40001.7	223.904	63.00	74.33	358
450.000	0.790	1.26653	0.0721	33.710	37204.3	40750.6	225.586	64.21	75.33	363
460.000	0.769	1.30067	0.0699	34.781	37866.9	41508.7	227.252	65.41	76.34	367
470.000	0.749	1.33454	0.0679	35.838	38540.4	42277.1	228.905	66.60	77.37	372
480.000	0.731	1.36817	0.0660	36.881	39224.9	43055.7	230.545	67.78	78.40	377
490.000	0.713	1.40156	0.0642	37.911	39920.4	43844.8	232.172	68.96	79.44	381
500.000	0.697	1.43476	0.0626	38.931	40626.9	44644.2	233.788	70.13	80.48	385
520.000	0.666	1.50059	0.0595	40.940	42072.8	46274.5	236.985	72.43	82.57	394
540.000	0.639	1.56579	0.0568	42.914	43562.1	47946.3	240.140	74.68	84.64	402
560.000	0.613	1.63046	0.0544	44.860	45094.1	49659.4	243.255	76.89	86.69	410
580.000	0.590	1.69465	0.0521	46.780	46659.2	51414.2	246.333	79.05	88.72	418
600.000	0.569	1.75845	0.0501	48.678	48284.7	53208.4	249.374	91.16	90.71	425

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 30.0 BAR

T DEG. K	DEN MOL/L	VOL L/MOL	DF/CT BAR/K	DF/DD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	W M/SEC
90.356	21.694	0.04610	34.8873	967.124	5309.8	5448.1	76.621	44.30	68.46	2229
100.000	21.349	0.04684	31.1213	871.494	5967.6	6106.1	83.560	44.19	68.57	2121
110.000	20.992	0.04764	27.8519	782.234	6651.7	6794.6	90.103	43.98	68.74	2016
120.000	20.636	0.04846	25.0685	701.653	7337.7	7483.1	96.093	43.74	68.98	1918
130.000	20.277	0.04932	22.6560	628.589	8026.5	8174.4	101.627	43.48	69.30	1825
140.000	19.914	0.05022	20.5339	562.147	8718.8	8869.4	106.777	43.24	69.72	1736
150.000	19.546	0.05116	18.6438	501.179	9415.7	9569.2	111.604	43.04	70.25	1650
160.000	19.170	0.05216	16.8429	446.250	10118.3	10274.8	116.158	42.89	70.90	1566
170.000	18.786	0.05323	15.3987	395.506	10827.9	10987.6	120.479	42.82	71.69	1484
180.000	18.391	0.05437	13.9861	349.153	11546.0	11709.1	124.603	42.82	72.64	1403
190.000	17.984	0.05560	12.6856	306.451	12274.1	12440.9	128.559	42.92	73.77	1323
200.000	17.563	0.05694	11.4814	267.099	13014.3	13185.1	132.376	43.11	75.11	1244
210.000	17.123	0.05840	10.3601	230.735	13768.8	13944.0	136.078	43.39	76.71	1165
220.000	16.663	0.06001	9.3105	197.042	14540.3	14720.4	139.690	43.77	78.63	1085
230.000	16.176	0.06182	8.3221	165.730	15332.5	15518.0	143.235	44.24	80.97	1004
240.000	15.656	0.06387	7.3847	136.539	16150.1	16341.8	146.740	44.80	83.91	922
250.000	15.090	0.06627	6.4870	109.233	17000.2	17199.0	150.239	45.43	87.73	838
260.000	14.460	0.06916	5.6152	83.582	17893.8	18101.3	153.777	46.15	93.06	749
270.000	13.730	0.07283	4.7485	59.537	18851.4	19069.9	157.432	46.95	101.38	653
280.000	12.817	0.07802	3.8442	36.102	19919.8	20153.9	161.372	47.90	117.68	543
282.904	12.488	0.08008	3.5603	29.423	20267.3	20507.5	162.629	48.24	126.39	506
282.904	2.053	0.48705	0.2525	6.800	26909.8	28371.0	190.453	50.97	113.92	225
290.000	1.847	0.54183	0.2151	9.244	27465.1	29089.4	192.962	49.67	92.23	239
300.000	1.659	0.60286	0.1841	11.913	28134.5	29943.1	195.858	49.27	80.29	254
310.000	1.525	0.65555	0.1636	14.130	28748.5	30715.2	198.391	49.51	74.75	266
320.000	1.422	0.70314	0.1486	16.079	29336.7	31446.1	200.713	50.07	71.80	277
330.000	1.338	0.74734	0.1369	17.846	29913.4	32155.4	202.895	50.83	70.19	286
340.000	1.267	0.78909	0.1275	19.480	30485.1	32852.4	204.977	51.71	69.37	295
350.000	1.206	0.82899	0.1196	21.011	31056.9	33543.8	206.982	52.69	69.05	303
360.000	1.153	0.86742	0.1129	22.460	31632.3	34234.6	208.927	53.73	69.09	310
370.000	1.105	0.90468	0.1070	23.843	32212.4	34926.5	210.823	54.82	69.37	317
380.000	1.063	0.94097	0.1019	25.171	32799.2	35622.1	212.679	55.95	69.84	323
390.000	1.024	0.97645	0.0974	26.452	33393.8	36323.2	214.501	57.10	70.44	329
400.000	0.989	1.01124	0.0934	27.694	33997.8	37031.5	216.293	58.27	71.15	335
410.000	0.957	1.04544	0.0897	28.901	34610.4	37746.7	218.060	59.46	71.94	341
420.000	0.927	1.07913	0.0864	30.079	35232.8	38470.2	219.804	60.66	72.80	346
430.000	0.899	1.11237	0.0834	31.231	35865.3	39202.4	221.527	61.85	73.70	352
440.000	0.873	1.14522	0.0806	32.360	36508.2	39943.9	223.232	63.06	74.64	357
450.000	0.849	1.17771	0.0780	33.468	37161.8	40694.9	224.920	64.26	75.61	362
460.000	0.827	1.20989	0.0756	34.558	37826.0	41455.7	226.593	65.45	76.60	367
470.000	0.805	1.24179	0.0734	35.632	38501.1	42226.5	228.251	66.64	77.60	371
480.000	0.785	1.27344	0.0713	36.691	39187.9	43008.2	229.895	67.82	78.62	376
490.000	0.766	1.30486	0.0694	37.736	39884.8	43799.4	231.527	69.00	79.64	381
500.000	0.748	1.33607	0.0676	38.770	40592.6	44600.8	233.146	70.16	80.67	385
520.000	0.715	1.39794	0.0642	40.804	42040.7	46234.5	236.350	72.46	82.73	394
540.000	0.685	1.45917	0.0613	42.801	43532.0	47909.5	239.511	74.71	84.79	402
560.000	0.658	1.51986	0.0586	44.765	45065.8	49625.3	242.631	76.91	86.82	410
580.000	0.633	1.58008	0.0561	46.703	46641.4	51381.7	245.713	79.07	88.84	418
600.000	0.610	1.63989	0.0539	48.617	48258.3	53176.0	248.758	81.18	90.82	425

Table 27. Thermophysical properties along isobars (Continued)
ETHANE ISOBAR AT P = 32.0 BAR

T	DEN	VOL	DP/CT	BAR/L/MOL	DP/DO	E	H	S	CV	CP
DEG K	MOL/L	L/MOL	BAR/K			J/MOL	J/MOL	J/MOL/K	J/MOL/K	J/MOL/K
90.397	21.695	0.04609	34.8754	967.436	5310.6	5458.1	76.629	44.32	68.46	2229
100.000	21.351	0.04684	31.1242	872.180	5666.1	6115.9	83.545	44.20	68.57	2121
110.000	20.995	0.04763	27.8562	782.964	6645.9	6802.4	90.087	44.00	68.73	2017
120.000	20.639	0.04845	25.0740	702.420	7335.7	7490.8	96.077	43.75	68.97	1919
130.000	20.280	0.04931	22.6627	629.390	8024.2	8182.0	101.609	43.50	69.29	1826
140.000	19.918	0.05021	20.5416	562.977	8715.2	8876.9	106.758	43.26	69.71	1737
150.000	19.550	0.05115	18.6527	502.437	9412.8	9576.5	111.585	43.05	70.23	1651
160.000	19.175	0.05215	16.9528	447.134	10115.0	10281.9	116.137	42.91	70.88	1567
170.000	18.791	0.05322	15.4096	396.516	10824.2	10994.5	120.457	42.83	71.66	1485
180.000	18.397	0.05436	13.9982	350.091	11541.8	11715.7	124.579	42.84	72.61	1405
190.000	17.991	0.05558	12.6988	307.415	12269.3	12447.2	128.534	42.93	73.73	1325
200.000	17.570	0.05691	11.4959	268.094	13008.8	13190.9	132.348	43.12	75.06	1246
210.000	17.132	0.05837	10.3760	231.763	13762.4	13949.2	136.048	43.41	76.64	1167
220.000	16.673	0.05998	9.3220	198.108	14533.0	14724.9	139.656	43.79	78.55	1087
230.000	16.188	0.06177	8.3414	166.841	15323.8	15521.5	143.196	44.26	80.86	1007
240.000	15.670	0.06381	7.4063	137.702	16139.8	16344.0	146.696	44.81	83.75	925
250.000	15.108	0.06619	6.5116	110.461	16987.5	17199.3	150.187	45.45	87.49	841
260.000	14.484	0.06904	5.6440	84.896	17877.6	18098.5	153.714	46.16	92.67	753
270.000	13.763	0.07266	4.7840	60.773	18829.2	19061.8	157.348	46.97	100.64	658
280.000	12.871	0.07769	3.8928	37.746	19885.3	20133.9	161.245	47.91	115.76	551
285.760	12.198	0.08198	3.3270	24.673	20586.1	20848.5	163.771	48.59	134.76	477
285.760	2.245	0.44539	0.2819	6.099	26870.1	28295.3	189.858	51.95	125.79	222
290.000	2.082	0.48021	0.2513	7.764	27242.6	28779.3	191.540	50.78	105.17	231
300.000	1.835	0.54492	0.2088	10.779	27973.5	29717.3	194.723	49.89	85.93	248
310.000	1.672	0.59812	0.1830	13.187	28618.6	30532.6	197.397	49.93	78.10	262
320.000	1.550	0.64524	0.1648	15.266	29226.7	31291.5	199.807	50.39	74.08	273
330.000	1.452	0.68850	0.1509	17.131	29816.6	32019.8	202.049	51.08	71.87	283
340.000	1.372	0.72904	0.1398	18.842	30399.1	32732.0	204.175	51.91	70.67	292
350.000	1.303	0.76757	0.1307	20.437	30978.9	33435.2	206.214	52.86	70.10	300
360.000	1.243	0.80455	0.1231	21.940	31560.3	34134.9	208.186	53.87	69.95	308
370.000	1.190	0.84027	0.1165	23.370	32146.4	34835.3	210.105	54.94	70.10	315
380.000	1.143	0.87498	0.1107	24.739	32737.8	35537.7	211.979	56.05	70.47	322
390.000	1.100	0.90885	0.1056	26.056	33336.3	36244.6	213.815	57.19	70.99	328
400.000	1.062	0.94199	0.1011	27.330	33943.0	36957.4	215.621	58.36	71.63	334
410.000	1.026	0.97453	0.0970	28.567	34558.6	37677.1	217.398	59.53	72.37	340
420.000	0.994	1.00654	0.0934	29.771	35184.4	38405.3	219.152	60.72	73.18	345
430.000	0.963	1.03809	0.0900	30.947	35819.3	39141.1	220.884	61.92	74.04	351
440.000	0.935	1.06923	0.0869	32.098	36464.3	39885.9	222.596	63.11	74.95	356
450.000	0.909	1.10001	0.0841	33.227	37119.8	40639.8	224.291	64.31	75.89	361
460.000	0.885	1.13048	0.0815	34.336	37785.8	41403.4	225.969	65.50	76.86	366
470.000	0.862	1.16066	0.0790	35.427	38462.6	42176.7	227.633	66.68	77.84	371
480.000	0.840	1.19058	0.0767	36.501	39150.0	42959.9	229.282	67.86	78.84	376
490.000	0.819	1.22027	0.0746	37.562	39848.3	43753.2	230.918	69.03	79.85	380
500.000	0.800	1.24976	0.0726	38.609	40557.3	44556.5	232.541	70.19	80.86	385
520.000	0.764	1.30816	0.0690	40.669	42008.6	46194.7	235.753	72.49	82.90	393
540.000	0.732	1.36591	0.0657	42.688	43501.8	47872.7	238.919	74.73	84.93	402
560.000	0.703	1.42312	0.0628	44.673	45037.4	49591.4	242.045	76.93	86.95	410
580.000	0.676	1.47986	0.0602	46.628	46614.6	51350.2	245.131	79.09	88.95	418
600.000	0.651	1.53620	0.0578	48.559	48232.9	53148.7	248.180	81.19	90.92	425

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 34.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	CF/CT BAR/K	DF/DD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CF J/MOL/K	M M/SEC
90.429	21.696	0.04609	34.8634	967.750	5311.3	5468.0	76.637	44.33	68.46	2229
100.000	21.353	0.04683	31.1271	872.866	5964.5	6123.7	83.529	44.22	68.56	2122
110.000	20.997	0.04763	27.8606	783.693	6648.2	6810.1	90.071	44.01	68.73	2017
120.000	20.641	0.04845	25.0756	703.187	7333.8	7498.5	96.060	43.77	68.96	1920
130.000	20.283	0.04930	22.6694	630.189	8022.0	8189.6	101.592	43.51	69.28	1827
140.000	19.921	0.05020	20.5494	563.807	8713.7	8884.4	106.740	43.27	69.69	1738
150.000	19.554	0.05114	18.6615	503.294	9409.9	9583.8	111.565	43.07	70.21	1652
160.000	19.179	0.05214	16.9627	448.018	10111.8	10289.1	116.117	42.92	70.86	1568
170.000	18.796	0.05320	15.4205	397.426	10820.5	11001.4	120.435	42.85	71.64	1487
180.000	18.403	0.05434	14.0102	351.027	11537.6	11722.3	124.555	42.85	72.57	1406
190.000	17.997	0.05556	12.7120	308.379	12264.6	12453.5	128.508	42.95	73.69	1326
200.000	17.578	0.05689	11.5103	269.087	13003.3	13196.8	132.321	43.14	75.01	1247
210.000	17.141	0.05834	10.3918	232.789	13756.1	13954.5	136.017	43.42	76.58	1168
220.000	16.683	0.05994	9.3454	199.172	14525.6	14729.4	139.622	43.80	78.46	1089
230.000	16.200	0.06173	8.3607	167.947	15315.2	15525.1	143.158	44.27	80.75	1009
240.000	15.685	0.06376	7.4277	138.861	16129.5	16346.2	146.653	44.83	83.59	928
250.000	15.126	0.06611	6.5359	111.683	16974.9	17199.6	150.136	45.47	87.26	844
260.000	14.507	0.06893	5.6725	86.201	17861.6	18095.9	153.651	46.18	92.30	757
270.000	13.796	0.07249	4.8188	62.194	18807.6	19054.1	157.266	46.98	99.94	663
280.000	12.923	0.07738	3.9398	39.360	19852.1	20115.2	161.123	47.91	114.03	558
288.484	11.897	0.08406	3.1011	20.360	20903.3	21189.1	164.899	48.97	145.24	448
288.484	2.452	0.40780	0.3143	5.401	26816.0	28202.5	189.238	52.98	140.71	218
290.000	2.371	0.42168	0.2985	6.101	26971.6	28405.3	189.938	52.31	127.62	222
300.000	2.032	0.49222	0.2375	9.593	27795.7	29469.2	193.550	50.59	93.32	243
310.000	1.829	0.54663	0.2045	12.220	28479.8	30338.4	196.402	50.39	82.09	257
320.000	1.684	0.59365	0.1823	14.439	29110.9	31129.3	198.913	50.72	76.67	269
330.000	1.572	0.63624	0.1658	16.406	29716.7	31879.9	201.223	51.34	73.73	280
340.000	1.480	0.67583	0.1529	18.198	30310.0	32607.8	203.397	52.12	72.08	289
350.000	1.402	0.71323	0.1425	19.858	30898.6	33323.5	205.473	53.03	71.22	298
360.000	1.335	0.74895	0.1337	21.417	31487.5	34033.9	207.473	54.02	70.87	306
370.000	1.277	0.78336	0.1262	22.894	32078.7	34742.1	209.415	55.07	70.87	313
380.000	1.224	0.81670	0.1198	24.304	32674.9	35451.6	211.308	56.16	71.12	320
390.000	1.178	0.84915	0.1141	25.658	33278.1	36165.2	213.160	57.29	71.56	326
400.000	1.135	0.88086	0.1090	26.965	33888.4	36883.3	214.979	58.44	72.13	333
410.000	1.097	0.91194	0.1045	28.231	34507.1	37607.7	216.768	59.61	72.81	339
420.000	1.061	0.94248	0.1005	29.462	35134.9	38339.3	218.531	60.79	73.57	344
430.000	1.028	0.97254	0.0968	30.663	35772.2	39078.9	220.272	61.98	74.39	350
440.000	0.998	1.00219	0.0934	31.836	36420.2	39827.6	221.992	63.17	75.27	355
450.000	0.969	1.03147	0.0903	32.985	37077.6	40584.6	223.694	64.36	76.18	360
460.000	0.943	1.06042	0.0874	34.112	37745.5	41350.9	225.378	65.54	77.12	365
470.000	0.918	1.08909	0.0847	35.221	38423.9	42126.8	227.047	66.72	78.08	370
480.000	0.895	1.11749	0.0822	36.312	39112.8	42912.3	228.702	67.90	79.06	375
490.000	0.873	1.14566	0.0799	37.387	39812.5	43707.7	230.342	69.07	80.06	380
500.000	0.852	1.17362	0.0778	38.449	40522.8	44513.1	231.969	70.23	81.06	384
520.000	0.814	1.22896	0.0738	40.534	41975.6	46154.0	235.188	72.51	83.07	393
540.000	0.779	1.28366	0.0703	42.576	43471.6	47836.1	238.360	74.76	85.08	401
560.000	0.747	1.33780	0.0671	44.581	45009.0	49557.5	241.491	76.96	87.09	410
580.000	0.719	1.39147	0.0643	46.555	46587.8	51318.8	244.581	79.11	89.07	418
600.000	0.692	1.44473	0.0617	48.501	48207.5	53119.6	247.634	81.21	91.03	425

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 36.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DP/CT BAR/K	DP/DO BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	M M/SEC
90.460	21.697	0.04609	34.8515	968.063	5312.1	5478.0	76.645	44.35	68.46	2229
100.000	21.355	0.04683	31.1300	873.552	5963.0	6131.5	83.513	44.23	68.52	2122
110.000	21.000	0.04762	27.8649	784.422	6646.4	6817.9	90.055	44.03	68.72	2018
120.000	20.644	0.04844	25.0851	703.953	7331.8	7506.1	96.043	43.78	68.95	1920
130.000	20.287	0.04929	22.6761	630.989	8019.7	8197.2	101.574	43.53	69.27	1827
140.000	19.925	0.05019	20.5572	564.636	8711.2	8891.8	106.722	43.29	69.68	1739
150.000	19.558	0.05113	18.6703	504.151	9407.1	9591.1	111.546	43.08	70.20	1653
160.000	19.184	0.05213	16.9725	448.901	10108.5	10296.2	116.096	42.94	70.84	1569
170.000	18.801	0.05319	15.4314	398.335	10816.8	11008.3	120.413	42.86	71.61	1488
180.000	18.408	0.05432	14.0222	351.961	11533.4	11729.0	124.532	42.87	72.54	1407
190.000	18.004	0.05554	12.7252	309.341	12259.8	12459.8	128.483	42.96	73.65	1328
200.000	17.585	0.05687	11.5247	270.079	12997.9	13202.6	132.293	43.15	74.96	1249
210.000	17.149	0.05831	10.4076	233.814	13749.9	13959.8	135.987	43.44	76.52	1170
220.000	16.693	0.05990	9.3627	200.233	14519.4	14734.0	139.588	43.82	78.38	1091
230.000	16.212	0.06168	8.3798	169.051	15306.7	15528.7	143.121	44.29	80.64	1012
240.000	15.699	0.06370	7.4490	140.015	16119.3	16348.6	146.609	44.85	83.44	931
250.000	15.144	0.06603	6.5601	112.900	16962.4	17200.1	150.085	45.48	87.03	848
260.000	14.530	0.06882	5.7006	87.498	17845.8	18093.6	153.588	46.20	91.93	761
270.000	13.828	0.07232	4.8530	63.602	18786.4	19046.8	157.185	46.99	99.28	668
280.000	12.973	0.07709	3.9853	40.946	19820.2	20097.7	161.006	47.91	112.45	565
290.000	11.763	0.08501	3.0064	18.899	21059.8	21364.9	165.449	49.17	149.41	437
291.089	11.581	0.08635	2.8806	16.449	21221.6	21532.4	166.025	49.37	158.85	420
291.089	2.677	0.37352	0.3504	4.703	26745.9	28090.6	188.581	54.08	160.10	215
300.000	2.255	0.44349	0.2713	8.341	27595.5	29192.1	192.314	51.43	103.49	236
310.000	2.000	0.49999	0.2285	11.228	30130.7	30130.7	195.394	50.89	86.92	253
320.000	1.827	0.54729	0.2013	13.600	28989.0	30959.2	198.025	51.08	79.64	266
330.000	1.696	0.58947	0.1818	15.675	29612.4	31734.5	200.411	51.61	75.79	277
340.000	1.592	0.62831	0.1668	17.549	30218.7	32480.6	202.638	52.34	73.62	287
350.000	1.504	0.66476	0.1548	19.277	30816.7	33209.9	204.753	53.21	72.43	295
360.000	1.430	0.69943	0.1448	20.891	31412.6	33930.5	206.784	54.17	71.85	304
370.000	1.365	0.73269	0.1364	22.416	32010.4	34648.1	208.750	55.19	71.68	311
380.000	1.307	0.76483	0.1291	23.868	32611.6	35365.0	210.663	56.27	71.80	318
390.000	1.256	0.79605	0.1228	25.259	33218.6	36084.4	212.532	57.39	72.14	325
400.000	1.210	0.82650	0.1172	26.599	33832.5	36807.9	214.364	58.53	72.64	331
410.000	1.168	0.85629	0.1122	27.895	34455.1	37537.7	216.165	59.69	73.26	337
420.000	1.129	0.88552	0.1077	29.153	35085.7	38273.6	217.939	60.86	73.97	343
430.000	1.094	0.91427	0.1037	30.377	35725.6	39017.0	219.689	62.04	74.75	349
440.000	1.061	0.94259	0.1000	31.573	36375.1	39768.4	221.417	63.22	75.59	354
450.000	1.030	0.97054	0.0966	32.742	37034.6	40528.5	223.125	64.41	76.47	360
460.000	1.002	0.99816	0.0934	33.889	37704.3	41297.6	224.816	65.59	77.39	365
470.000	0.975	1.02548	0.0905	35.015	38385.0	42076.8	226.491	66.77	78.33	370
480.000	0.950	1.05254	0.0878	36.122	39075.5	42864.7	228.150	67.94	79.29	374
490.000	0.926	1.07936	0.0853	37.213	39776.6	43662.3	229.795	69.10	80.27	379
500.000	0.904	1.10596	0.0830	38.289	40488.3	44469.7	231.426	70.26	81.25	384
520.000	0.863	1.15859	0.0787	40.400	41943.3	46114.3	234.651	72.54	83.24	393
540.000	0.826	1.21056	0.0749	42.464	43440.6	47798.7	237.830	74.78	85.23	401
560.000	0.792	1.26198	0.0715	44.490	44980.6	49523.7	240.966	76.98	87.22	409
580.000	0.762	1.31292	0.0684	46.482	46561.0	51287.5	244.061	79.13	89.19	417
600.000	0.733	1.36346	0.0656	48.445	48182.1	53090.5	247.117	81.23	91.14	425

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 36.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	CP/CT BAR/K	DP/DO BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	W M/SEC
90.491	21.698	0.04609	34.8396	968.377	5312.8	5487.9	76.653	44.36	68.46	2229
100.000	21.358	0.04682	31.1330	874.238	5961.4	6139.3	83.498	44.25	68.55	2122
110.000	21.002	0.04761	27.8692	785.151	6644.7	6825.6	90.038	44.04	68.71	2018
120.000	20.647	0.04843	25.0907	704.719	7329.8	7513.8	96.026	43.80	68.94	1921
130.000	20.290	0.04929	22.6627	631.788	8017.5	8204.8	101.557	43.54	69.26	1828
140.000	19.929	0.05018	20.5649	565.465	8708.6	8899.3	106.703	43.30	69.67	1739
150.000	19.562	0.05112	18.6751	505.007	9404.2	9598.4	111.527	43.10	70.18	1654
160.000	19.188	0.05212	16.9823	449.783	10105.3	10303.3	116.076	42.95	70.82	1570
170.000	18.806	0.05317	15.4423	399.243	10813.2	11015.2	120.391	42.88	71.59	1489
180.000	18.414	0.05431	14.0341	352.895	11529.2	11735.6	124.508	42.88	72.51	1403
190.000	18.010	0.05552	12.7383	310.302	12255.1	12466.0	128.458	42.98	73.61	1329
200.000	17.592	0.05684	11.5390	271.069	12992.5	13208.5	132.265	43.17	74.91	1251
210.000	17.152	0.05828	10.4232	234.836	13743.6	13965.1	135.957	43.46	76.46	1172
220.000	16.703	0.05987	9.3799	201.292	14511.1	14738.6	139.555	43.84	78.30	1093
230.000	16.224	0.06164	8.3988	170.152	15298.2	15532.4	143.083	44.31	80.53	1014
240.000	15.713	0.06364	7.4702	141.165	16109.2	16351.0	146.566	44.86	83.29	934
250.000	15.162	0.06596	6.5841	114.110	16950.1	17200.7	150.035	45.50	86.81	851
260.000	14.553	0.06872	5.7284	88.787	17830.2	18091.4	153.527	46.21	91.58	765
270.000	13.859	0.07216	4.8866	64.996	18765.7	19039.9	157.106	47.00	98.65	674
280.000	13.021	0.07680	4.0295	42.507	19789.4	20081.2	160.892	47.91	111.00	572
290.000	11.864	0.08429	3.0797	20.825	20997.8	21318.1	165.229	49.13	142.97	449
293.582	11.245	0.08892	2.6631	12.914	21544.5	21882.4	167.163	49.82	177.32	391
293.582	2.925	0.34188	0.3912	4.001	26657.1	27956.3	187.877	55.27	186.51	212
300.000	2.516	0.35747	0.3125	7.001	27364.2	28874.6	190.974	52.46	118.58	229
310.000	2.187	0.45730	0.2556	10.210	28169.4	29907.2	194.363	51.45	92.92	248
320.000	1.979	0.50530	0.2221	12.751	28860.7	30780.8	197.138	51.45	83.07	262
330.000	1.827	0.54731	0.1989	14.939	29503.8	31583.6	199.610	51.89	78.08	273
340.000	1.708	0.59558	0.1815	16.898	30123.9	32349.1	201.895	52.56	75.29	284
350.000	1.610	0.64125	0.1677	18.694	30732.3	33093.0	204.053	53.39	73.71	293
360.000	1.527	0.68501	0.1564	20.365	31336.6	33825.6	206.116	54.32	72.87	301
370.000	1.455	0.68728	0.1469	21.938	31940.4	34552.0	208.107	55.32	72.53	309
380.000	1.392	0.71837	0.1388	23.432	32547.5	35277.3	210.041	56.38	72.52	317
390.000	1.336	0.74850	0.1318	24.860	33158.9	36003.2	211.927	57.48	72.75	323
400.000	1.286	0.77782	0.1256	26.233	33776.7	36732.4	213.774	58.61	73.17	330
410.000	1.240	0.80648	0.1201	27.558	34402.0	37466.6	215.587	59.76	73.72	335
420.000	1.198	0.83455	0.1152	28.843	35036.1	38207.4	217.371	60.93	74.38	342
430.000	1.160	0.86213	0.1107	30.092	35678.6	38954.7	219.130	62.10	75.12	348
440.000	1.125	0.88927	0.1067	31.310	36330.4	39709.7	220.866	63.28	75.92	353
450.000	1.092	0.91604	0.1030	32.500	36992.0	40473.0	222.582	64.46	76.78	359
460.000	1.061	0.94246	0.0996	33.666	37663.6	41244.9	224.279	65.63	77.66	364
470.000	1.032	0.96858	0.0964	34.809	38345.4	42026.0	225.959	66.81	78.58	369
480.000	1.006	0.99444	0.0935	35.933	39037.4	42816.3	227.623	67.98	79.52	374
490.000	0.980	1.02005	0.0908	37.039	39740.7	43616.8	229.273	69.14	80.48	379
500.000	0.957	1.04544	0.0882	38.129	40453.6	44426.3	230.908	70.29	81.45	383
520.000	0.913	1.09565	0.0836	40.266	41911.1	46074.5	234.141	72.57	83.41	392
540.000	0.873	1.14519	0.0795	42.354	43410.4	47762.1	237.326	74.81	85.38	401
560.000	0.837	1.19417	0.0759	44.399	44951.3	49489.2	240.467	77.00	87.35	409
580.000	0.805	1.24267	0.0726	46.410	46533.3	51255.5	243.566	79.15	89.31	417
600.000	0.775	1.29076	0.0696	48.389	48156.7	53061.6	246.626	81.25	91.24	425

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 40.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	OF/CT BAR/K	DF/DO BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CF J/MOL/K	W M/SEC
90.522	21.699	0.04609	34.8277	968.692	5313.6	5497.9	76.662	44.38	68.45	2229
100.000	21.360	0.04682	31.1359	874.923	5959.9	6147.1	83.482	44.26	68.55	2123
110.000	21.005	0.04761	27.8735	785.879	6642.9	6833.4	90.022	44.06	68.71	2019
120.000	20.650	0.04843	25.0962	705.484	7327.8	7521.5	96.010	43.81	68.94	1921
130.000	20.293	0.04928	22.6854	632.586	8015.3	8212.4	101.539	43.56	69.25	1829
140.000	19.937	0.05017	20.5727	566.293	8706.1	8906.8	106.685	43.32	69.65	1740
150.000	19.566	0.05111	18.6879	505.863	9401.3	9605.8	111.507	43.11	70.16	1655
160.000	19.193	0.05210	16.9922	450.665	10102.1	10310.5	116.055	42.97	70.80	1571
170.000	18.811	0.05316	15.4532	400.150	10809.5	11022.2	120.369	42.89	71.56	1490
180.000	18.420	0.05429	14.0461	353.828	11525.1	11742.2	124.485	42.90	72.48	1410
190.000	18.017	0.05550	12.7513	311.262	12250.3	12472.3	128.430	43.00	73.57	1331
200.000	17.600	0.05682	11.5533	272.057	12987.1	13214.3	132.238	43.19	74.87	1252
210.000	17.166	0.05825	10.4389	235.856	13737.4	13970.4	135.927	43.47	76.40	1174
220.000	16.713	0.05983	9.3970	202.348	14503.9	14743.3	139.521	43.85	78.22	1096
230.000	16.236	0.06159	8.4177	171.249	15289.8	15536.2	143.046	44.32	80.43	1017
240.000	15.728	0.06358	7.4913	142.311	16099.1	16353.5	146.524	44.88	83.14	936
250.000	15.179	0.06588	6.6078	115.316	16937.9	17201.4	149.985	45.51	86.60	854
260.000	14.575	0.06861	5.7559	90.067	17814.9	18089.4	153.467	46.22	91.24	769
270.000	13.889	0.07200	4.9196	66.379	18745.4	19033.3	157.028	47.02	98.05	678
280.000	13.067	0.07653	4.0724	44.044	19759.6	20065.8	160.782	47.92	109.67	579
290.000	11.956	0.08364	3.1478	22.677	20941.8	21276.3	165.027	49.09	137.74	460
295.974	10.881	0.09191	2.4458	9.734	21877.0	22244.6	168.330	50.35	203.98	362
295.974	3.203	0.31225	0.4380	3.288	26544.8	27793.8	187.104	56.61	225.02	208
300.000	2.836	0.35261	0.3655	5.523	27084.7	28495.1	189.459	53.83	144.04	222
310.000	2.393	0.41782	0.2865	9.162	27992.5	29663.8	193.295	52.07	100.54	243
320.000	2.141	0.46699	0.2449	11.893	28724.2	30592.1	196.244	51.86	87.06	258
330.000	1.964	0.50906	0.2174	14.201	29390.9	31427.1	198.814	52.19	80.63	270
340.000	1.828	0.54693	0.1971	16.247	30026.1	32213.8	201.164	52.79	77.11	281
350.000	1.718	0.58196	0.1813	18.112	30646.1	32973.9	203.368	53.58	75.09	291
360.000	1.626	0.61493	0.1685	19.840	31258.5	33718.3	205.466	54.47	73.96	299
370.000	1.547	0.64633	0.1579	21.462	31869.6	34455.0	207.484	55.46	73.42	307
380.000	1.478	0.67650	0.1489	22.997	32481.8	35187.8	209.439	56.50	73.26	315
390.000	1.417	0.70566	0.1411	24.462	33097.9	35920.6	211.343	57.58	73.39	322
400.000	1.362	0.73399	0.1343	25.868	33720.3	36656.2	213.205	58.70	73.72	329
410.000	1.313	0.76163	0.1282	27.222	34349.0	37395.5	215.031	59.84	74.20	335
420.000	1.268	0.78867	0.1228	28.534	34985.6	38140.2	216.826	60.99	74.81	341
430.000	1.227	0.81520	0.1180	29.807	35630.7	38891.5	218.594	62.16	75.50	347
440.000	1.189	0.84128	0.1135	31.047	36285.5	39650.7	220.338	63.33	76.26	353
450.000	1.153	0.86698	0.1095	32.258	36949.2	40417.2	222.061	64.51	77.08	358
460.000	1.121	0.89233	0.1058	33.443	37622.7	41192.1	223.765	65.68	77.94	363
470.000	1.090	0.91738	0.1024	34.604	38306.2	41975.8	225.450	66.85	78.84	368
480.000	1.061	0.94215	0.0992	35.744	38999.9	42768.5	227.120	68.02	79.76	373
490.000	1.034	0.96668	0.0963	36.865	39703.9	43570.6	228.774	69.18	80.70	378
500.000	1.009	0.99098	0.0936	37.970	40418.2	44382.1	230.414	70.33	81.65	383
520.000	0.962	1.03901	0.0886	40.132	41878.8	46034.8	233.654	72.60	83.58	392
540.000	0.921	1.08636	0.0842	42.243	43380.2	47725.6	236.845	74.83	85.53	401
560.000	0.882	1.13315	0.0803	44.309	44922.9	49455.5	239.990	77.02	87.48	409
580.000	0.848	1.17946	0.0768	46.338	46506.5	51224.4	243.094	79.17	89.43	417
600.000	0.816	1.22535	0.0736	48.334	48130.5	53031.9	246.158	81.26	91.35	425

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 44.0 BAR

T	DEN	VOL	DP/DT	BAR	DF/DD	E	H	S	CV	CF	M/SEC
DEG K	MOL/L	L/MOL	BAR/K	BAR-L/MCL	J/MOL	J/MOL	J/MOL	J/MCL/K	J/MOL/K	J/MOL/K	
90.584	21.701	0.04608	34.8041	969.322	5315.1	5517.8	76.678	44.41	68.45	2229	
100.000	21.365	0.04681	31.1418	876.294	5956.8	6162.7	83.451	44.29	68.54	2124	
110.000	21.010	0.04760	27.8822	787.335	6639.4	6848.9	89.990	44.09	68.70	2020	
120.000	20.656	0.04841	25.1073	707.015	7323.9	7536.9	95.976	43.84	68.92	1923	
130.000	20.299	0.04926	22.7028	634.182	8010.8	8227.6	101.504	43.59	69.23	1830	
140.000	19.939	0.05015	20.5881	567.948	8701.1	8921.7	106.649	43.35	69.63	1742	
150.000	19.574	0.05109	18.7054	507.572	9395.6	9620.4	111.469	43.14	70.13	1656	
160.000	19.202	0.05208	17.0117	452.426	10095.6	10324.8	116.014	43.00	70.76	1573	
170.000	18.821	0.05313	15.4748	401.961	10802.2	11036.0	120.326	42.92	71.51	1492	
180.000	18.431	0.05426	14.0659	355.691	11516.8	11755.5	124.438	42.93	72.42	1413	
190.000	18.029	0.05546	12.7774	313.178	12240.9	12485.0	128.382	43.03	73.50	1334	
200.000	17.614	0.05677	11.5818	274.030	12976.3	13226.1	132.183	43.22	74.77	1255	
210.000	17.183	0.05820	10.4700	237.891	13725.1	13981.2	135.867	43.50	76.28	1178	
220.000	16.733	0.05976	9.4311	204.453	14489.7	14752.6	139.455	43.88	78.07	1100	
230.000	16.259	0.06150	8.4552	173.435	15273.1	15543.7	142.971	44.36	80.22	1021	
240.000	15.755	0.06347	7.5329	144.592	16079.3	16359.6	146.439	44.91	82.85	942	
250.000	15.213	0.06573	6.6548	117.711	16913.9	17203.1	149.886	45.55	86.18	861	
260.000	14.619	0.06840	5.8099	92.605	17784.9	18085.9	153.348	46.25	90.60	777	
270.000	13.948	0.07169	4.9841	69.108	18705.9	19021.3	156.877	47.04	96.93	688	
280.000	13.155	0.07602	4.1548	47.054	19702.9	20037.4	160.572	47.93	107.29	592	
290.000	12.119	0.08251	3.2720	26.209	20841.3	21204.3	164.664	49.04	129.69	480	
300.000	10.194	0.09810	2.0882	5.535	22472.4	22904.0	170.415	51.51	278.95	316	
300.478	9.997	0.10003	1.9937	4.414	22606.7	23046.8	170.891	51.90	322.65	302	
300.478	3.911	0.25570	0.5622	1.794	26209.0	27334.1	185.182	60.25	406.36	201	
310.000	2.892	0.34574	0.3648	6.938	27573.9	29095.1	190.968	53.61	124.67	232	
320.000	2.505	0.39920	0.2981	10.147	28423.2	30179.7	194.414	52.76	97.42	250	
330.000	2.262	0.44211	0.2586	12.721	29148.4	31093.7	197.229	52.82	86.74	264	
340.000	2.085	0.47962	0.2313	14.952	29820.6	31930.9	199.728	53.28	81.26	275	
350.000	1.947	0.51373	0.2107	16.957	30466.1	32726.5	202.035	53.96	78.15	286	
360.000	1.833	0.54546	0.1945	18.799	31097.7	33497.8	204.209	54.79	76.34	295	
370.000	1.738	0.57544	0.1812	20.517	31723.8	34255.7	206.285	55.73	75.33	304	
380.000	1.655	0.60405	0.1701	22.135	32348.1	35005.9	208.287	56.73	74.84	312	
390.000	1.583	0.63158	0.1606	23.673	32974.7	35753.7	210.228	57.78	74.72	319	
400.000	1.519	0.65821	0.1523	25.143	33605.0	36501.2	212.122	58.87	74.86	326	
410.000	1.462	0.68411	0.1451	26.556	34241.0	37251.1	213.974	59.99	75.20	333	
420.000	1.410	0.70938	0.1386	27.920	34883.9	38005.2	215.792	61.13	75.68	339	
430.000	1.362	0.73411	0.1329	29.241	35535.1	38765.2	217.579	62.28	76.28	345	
440.000	1.319	0.75838	0.1277	30.525	36194.3	39531.2	219.341	63.44	76.96	351	
450.000	1.278	0.78225	0.1230	31.777	36862.4	40304.3	221.078	64.61	77.71	357	
460.000	1.241	0.80576	0.1187	32.999	37539.8	41085.2	222.795	65.77	78.51	362	
470.000	1.206	0.82895	0.1147	34.195	38226.9	41874.3	224.493	66.94	79.36	367	
480.000	1.174	0.85186	0.1110	35.368	38924.5	42672.7	226.172	68.09	80.23	372	
490.000	1.143	0.87452	0.1076	36.520	39631.5	43479.4	227.836	69.25	81.14	377	
500.000	1.115	0.89695	0.1045	37.652	40348.6	44295.1	229.484	70.39	82.06	382	
520.000	1.062	0.94121	0.0988	39.867	41813.3	45954.6	232.739	72.66	83.93	391	
540.000	1.015	0.98479	0.0938	42.024	43318.9	47652.0	235.942	74.88	85.84	400	
560.000	0.973	1.02780	0.0893	44.131	44866.1	49388.4	239.099	77.07	87.76	409	
580.000	0.934	1.07032	0.0853	46.197	46452.9	51162.3	242.212	79.21	89.67	417	
600.000	0.899	1.11424	0.0817	48.226	48079.8	52974.5	245.284	81.30	91.57	425	

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 48.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DP/DT BAR/K	DF/DO BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CF J/MOL/K	W M/SEC
90.646	21.703	0.04608	34.7806	969.954	5316.6	5537.7	76.694	44.44	68.44	2229
100.000	21.369	0.04680	31.1477	877.664	5953.7	6178.4	83.420	44.33	68.53	2124
110.000	21.015	0.04758	27.8908	788.790	6636.0	6864.4	89.958	44.12	68.68	2021
120.000	20.661	0.04840	25.1184	708.544	7319.9	7552.3	95.430	43.87	68.90	1924
130.000	20.306	0.04925	22.7161	635.777	8006.4	8242.7	101.470	43.62	69.21	1832
140.000	19.946	0.05014	20.6036	569.601	8696.0	8936.7	106.612	43.38	69.60	1743
150.000	19.582	0.05107	18.7229	509.279	9390.0	9635.1	111.430	43.17	70.10	1658
160.000	19.210	0.05206	17.0313	454.184	10089.2	10335.1	115.974	43.03	70.72	1576
170.000	18.831	0.05310	15.4964	403.769	10795.0	11049.9	120.282	42.95	71.47	1495
180.000	18.442	0.05422	14.0936	357.549	11508.6	11768.9	124.392	42.96	72.36	1415
190.000	18.042	0.05543	12.8033	315.088	12231.6	12497.6	128.332	43.06	73.42	1337
200.000	17.629	0.05673	11.6101	275.996	12965.7	13238.0	132.129	43.25	74.68	1259
210.000	17.200	0.05814	10.5009	239.919	13712.9	13992.0	135.807	43.53	76.16	1181
220.000	16.752	0.05969	9.4649	206.549	14475.6	14762.1	139.390	43.92	77.92	1104
230.000	16.282	0.06142	8.4923	175.609	15256.6	15551.4	142.898	44.39	80.02	1026
240.000	15.783	0.06336	7.5741	146.857	16059.8	16364.0	146.356	44.94	82.58	947
250.000	15.247	0.06559	6.7010	120.085	16890.3	17205.1	149.789	45.58	85.79	867
260.000	14.662	0.06821	5.8628	95.114	17755.6	18083.0	153.232	46.28	89.99	784
270.000	14.005	0.07140	5.0467	71.792	18667.9	19010.6	156.732	47.07	95.90	697
280.000	13.237	0.07555	4.2333	49.987	19649.5	20012.1	160.373	47.94	105.23	604
290.000	12.263	0.08155	3.3839	29.559	20752.5	21143.9	164.343	49.00	123.71	498
300.000	10.712	0.09336	2.3649	10.196	22178.0	22626.1	169.361	50.79	194.21	360
304.629	8.441	0.11846	1.4139	0.559	23675.1	24243.7	174.701	57.73	1586.21	226
304.629	5.319	0.18801	0.8207	0.272	25398.6	26301.1	181.474	71.86	2741.74	186
310.000	3.605	0.27740	0.4839	4.409	27000.0	28331.5	188.102	55.90	182.61	219
320.000	2.339	0.34029	0.3647	8.349	28073.3	29706.7	192.474	53.82	112.86	241
330.000	2.596	0.38519	0.3071	11.243	28881.4	30730.3	195.625	53.52	94.60	257
340.000	2.365	0.42289	0.2701	13.673	29599.8	31629.7	198.312	53.79	86.23	270
350.000	2.191	0.45647	0.2433	15.823	30276.0	32467.0	200.739	54.37	81.66	281
360.000	2.052	0.48731	0.2228	17.780	30929.7	33268.7	202.999	55.12	78.99	291
370.000	1.937	0.51618	0.2063	19.592	31572.5	34050.2	205.140	56.00	77.42	300
380.000	1.840	0.54355	0.1927	21.291	32210.2	34819.3	207.192	56.96	76.55	308
390.000	1.755	0.56976	0.1813	22.899	32847.8	35582.6	209.174	57.99	76.15	316
400.000	1.681	0.59501	0.1714	24.432	33487.2	36343.3	211.101	59.05	76.08	324
410.000	1.614	0.61947	0.1628	25.902	34131.0	37104.5	212.981	60.15	76.25	330
420.000	1.555	0.64328	0.1552	27.317	34781.1	37868.9	214.822	61.27	76.60	337
430.000	1.500	0.66653	0.1485	28.685	35437.7	38637.0	216.630	62.41	77.09	343
440.000	1.451	0.68930	0.1424	30.012	36102.0	39410.6	218.409	63.56	77.69	349
450.000	1.405	0.71165	0.1369	31.303	36774.7	40190.6	220.163	64.71	78.36	355
460.000	1.363	0.73362	0.1319	32.562	37456.9	40978.2	221.893	65.87	79.10	361
470.000	1.324	0.75528	0.1274	33.792	38147.7	41773.0	223.603	67.02	79.89	366
480.000	1.288	0.77664	0.1232	34.997	38848.0	42575.9	225.293	68.17	80.72	371
490.000	1.254	0.79775	0.1193	36.178	39558.1	43387.3	226.966	69.32	81.59	376
500.000	1.222	0.81862	0.1157	37.339	40278.0	44207.3	228.624	70.46	82.47	381
510.000	1.193	0.83975	0.1122	38.495	41000.3	45032.2	230.276	71.51	83.36	386
520.000	1.163	0.85975	0.1092	39.605	41748.3	45875.2	231.893	72.71	84.29	391
530.000	1.131	0.87909	0.1065	40.665	42518.3	46739.2	233.509	73.93	85.26	396
540.000	1.104	0.89794	0.1040	41.685	43308.6	47599.2	235.109	75.19	86.35	401
550.000	1.079	0.91645	0.1017	42.665	44120.2	48480.5	236.624	76.51	87.49	406
560.000	1.054	0.93405	0.0995	43.605	44954.5	49380.7	238.076	77.87	88.67	411
570.000	1.029	0.95141	0.0974	44.505	45814.5	50300.8	239.476	79.24	89.91	416
580.000	1.004	0.96841	0.0954	45.365	46700.5	51243.8	240.836	80.64	91.24	421
590.000	0.979	0.98491	0.0935	46.185	47613.8	52219.7	242.166	82.09	92.61	426
600.000	0.954	1.00191	0.0917	47.055	48556.5	53230.6	243.476	83.57	94.02	431

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 52.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DP/CT BAR/K	OF/DD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	W M/SEC
90.000	21.705	0.04607	34.7573	970.588	5318.1	5557.6	76.711	44.47	68.44	2229
100.000	21.374	0.04679	31.1537	879.034	5550.7	6194.0	83.389	44.36	68.52	2125
110.000	21.020	0.04757	27.8955	790.245	6632.5	6879.9	89.926	44.15	68.67	2022
120.000	20.667	0.04839	25.1295	710.072	7316.0	7567.6	95.910	43.90	68.89	1925
130.000	20.312	0.04923	22.7294	637.369	8001.9	8257.9	101.435	43.65	69.19	1833
140.000	19.953	0.05012	20.6190	571.252	8691.0	8951.7	106.576	43.40	69.58	1745
150.000	19.589	0.05105	18.7403	510.984	9384.3	9649.8	111.392	43.20	70.07	1660
160.000	19.219	0.05203	17.0507	455.939	10082.8	10353.4	115.933	43.06	70.68	1578
170.000	18.841	0.05308	15.5179	405.574	10787.8	11063.8	120.239	42.98	71.42	1497
180.000	18.453	0.05419	14.1172	359.604	11500.4	11782.2	124.346	42.99	72.30	1418
190.000	18.055	0.05539	12.8291	316.994	12222.3	12510.3	128.282	43.09	73.35	1340
200.000	17.643	0.05668	11.6382	277.957	12955.1	13249.9	132.075	43.28	74.59	1262
210.000	17.217	0.05808	10.5315	241.939	13700.8	14002.8	135.748	43.57	76.04	1185
220.000	16.772	0.05962	9.4984	208.636	14461.6	14771.6	139.325	43.95	77.77	1108
230.000	16.305	0.06133	8.5291	177.772	15240.3	15559.3	142.825	44.42	79.82	1031
240.000	15.810	0.06325	7.6148	149.108	16040.6	16369.5	146.273	44.97	82.31	953
250.000	15.280	0.06544	6.7465	122.440	16867.2	17207.5	149.694	45.61	85.41	873
260.000	14.703	0.06801	5.9147	97.596	17727.1	18080.8	153.118	46.31	89.42	792
270.000	14.060	0.07113	5.1075	74.437	18631.2	19001.0	156.591	47.09	94.96	707
280.000	13.315	0.07510	4.3083	52.853	19598.9	19989.5	160.184	47.96	103.42	616
290.000	12.391	0.08070	3.4864	32.768	20672.6	21092.2	164.053	48.98	119.04	515
300.000	11.042	0.09056	2.5575	14.143	21985.7	22456.6	168.674	50.50	164.29	391
310.000	5.105	0.19588	0.7494	1.449	25891.7	26910.2	183.207	60.85	521.92	203
320.000	3.481	0.28729	0.4522	6.471	27650.3	29144.1	190.324	55.10	138.55	233
330.000	2.978	0.33584	0.3649	9.763	28583.2	30329.6	193.975	54.28	105.06	251
340.000	2.672	0.37431	0.3144	12.416	29361.6	31308.0	196.897	54.34	92.26	265
350.000	2.453	0.40769	0.2797	14.718	30074.4	32194.4	199.468	54.79	85.71	277
360.000	2.284	0.43790	0.2538	16.790	30754.0	33031.0	201.825	55.46	81.96	287
370.000	2.146	0.46591	0.2335	18.695	31415.7	33838.5	204.037	56.28	79.71	297
380.000	2.031	0.49229	0.2171	20.473	32068.2	34628.1	206.144	57.20	78.39	305
390.000	1.933	0.51740	0.2033	22.150	32717.6	35408.1	208.170	58.19	77.67	314
400.000	1.847	0.54150	0.1916	23.743	33366.9	36182.7	210.132	59.23	77.36	321
410.000	1.771	0.56477	0.1815	25.266	34019.5	36956.3	212.041	60.31	77.35	328
420.000	1.703	0.58735	0.1726	26.730	34676.2	37730.4	213.907	61.41	77.56	335
430.000	1.641	0.60935	0.1648	28.143	35338.9	38507.6	215.736	62.53	77.93	342
440.000	1.585	0.63095	0.1577	29.512	36009.2	39289.6	217.534	63.67	78.44	348
450.000	1.534	0.65192	0.1514	30.841	36686.7	40076.7	219.303	64.81	79.03	354
460.000	1.487	0.67261	0.1457	32.135	37372.6	40870.1	221.047	65.96	79.71	359
470.000	1.443	0.69296	0.1405	33.398	38067.3	41670.7	222.769	67.11	80.44	365
480.000	1.402	0.71302	0.1357	34.634	38771.1	42478.8	224.471	68.25	81.23	370
490.000	1.365	0.73281	0.1313	35.844	39484.9	43295.5	226.154	69.39	82.05	375
500.000	1.329	0.75237	0.1272	37.032	40207.7	44120.0	227.820	70.52	82.89	380
520.000	1.264	0.79086	0.1199	39.348	41682.6	45795.0	231.105	72.77	84.65	390
540.000	1.207	0.82864	0.1135	41.594	43196.9	47505.9	234.334	74.98	86.47	399
560.000	1.155	0.86584	0.1078	44.783	44751.6	49253.9	237.512	77.15	88.31	408
580.000	1.108	0.90253	0.1028	45.921	46345.1	51038.2	240.643	79.28	90.16	417
600.000	1.065	0.93880	0.0983	48.017	47977.8	52859.6	243.730	81.37	92.01	425

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 56.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DF/CT BAR/K	DF/OD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CF J/MOL/K	W M/SEC
90.770	21.706	0.04607	34.7340	971.224	5319.6	5577.5	76.727	44.50	68.44	2229
100.000	21.378	0.04678	31.1596	880.402	5947.6	6209.6	83.358	44.39	68.52	2125
110.000	21.025	0.04756	27.9082	791.698	6625.1	6895.4	89.894	44.18	68.66	2023
120.000	20.673	0.04837	25.1406	711.598	7312.1	7583.0	95.877	43.93	68.87	1926
130.000	20.318	0.04922	22.7427	638.961	7997.5	8273.1	101.401	43.67	69.17	1834
140.000	19.960	0.05010	20.6344	572.902	8686.1	8966.6	106.540	43.43	69.55	1747
150.000	19.597	0.05103	18.7577	512.686	9378.7	9664.5	111.354	43.23	70.04	1662
160.000	19.228	0.05201	17.0701	457.692	10076.5	10367.8	115.893	43.01	70.64	1580
170.000	18.851	0.05305	15.5393	407.376	10780.6	11077.7	120.196	43.01	71.37	1499
180.000	18.465	0.05416	14.1407	361.254	11492.3	11795.6	124.300	43.02	72.24	1420
190.000	18.067	0.05535	12.8548	318.895	12213.1	12523.1	128.232	43.12	73.28	1343
200.000	17.658	0.05663	11.6661	279.911	12944.6	13261.8	132.021	43.31	74.50	1265
210.000	17.233	0.05803	10.5620	243.953	13688.8	14013.8	135.690	43.60	75.93	1189
220.000	16.791	0.05956	9.5316	210.714	14447.8	14781.3	139.260	43.98	77.62	1112
230.000	16.327	0.06125	8.5655	179.923	15224.3	15567.3	142.754	44.45	79.63	1035
240.000	15.837	0.06315	7.6550	151.344	16021.7	16375.3	146.192	45.00	82.06	958
250.000	15.312	0.06531	6.7913	124.775	16844.6	17210.3	149.600	45.64	85.05	879
260.000	14.744	0.06783	5.9655	100.052	17699.3	18079.1	153.007	46.34	88.88	799
270.000	14.113	0.07086	5.1667	77.043	18595.7	18992.5	156.454	47.11	94.09	715
280.000	13.389	0.07469	4.3803	55.658	19550.8	19969.1	160.005	47.97	101.82	627
290.000	12.508	0.07955	3.5816	35.861	20599.5	21047.2	163.787	48.97	115.27	530
300.000	11.594	0.08854	2.7133	17.738	21837.1	22333.0	168.143	50.33	147.94	416
310.000	8.551	0.11695	1.4924	2.392	23911.5	24566.4	175.445	54.19	448.90	257
320.000	4.214	0.23730	0.5760	4.564	27105.0	28433.9	187.776	56.69	187.68	224
330.000	3.422	0.29233	0.4351	8.281	28245.5	29882.0	192.238	55.13	119.55	244
340.000	3.011	0.33212	0.3653	11.181	29103.5	30963.3	195.468	54.92	99.66	260
350.000	2.735	0.36562	0.3202	13.645	29861.2	31908.7	198.209	55.22	90.39	273
360.000	2.529	0.39542	0.2878	15.834	30570.2	32784.6	200.677	55.81	85.26	284
370.000	2.365	0.42276	0.2630	17.832	31253.2	33620.6	202.968	56.57	82.21	294
380.000	2.231	0.44831	0.2431	19.687	31921.9	34432.5	205.134	57.44	80.37	303
390.000	2.116	0.47251	0.2267	21.429	32584.2	35230.3	207.206	58.40	79.28	311
400.000	2.018	0.49563	0.2129	23.080	33244.1	36019.6	209.206	59.41	78.71	319
410.000	1.931	0.51789	0.2011	24.655	33905.4	36805.6	211.146	60.47	78.50	326
420.000	1.854	0.53943	0.1908	26.166	34569.7	37590.5	213.038	61.55	78.56	333
430.000	1.785	0.56036	0.1817	27.621	35239.3	38377.4	214.889	62.66	78.81	340
440.000	1.722	0.58078	0.1737	29.029	35914.8	39167.1	216.705	63.78	79.21	346
450.000	1.665	0.60075	0.1665	30.394	36597.3	39961.5	218.491	64.91	79.72	352
460.000	1.612	0.62033	0.1600	31.722	37287.6	40761.5	220.249	66.05	80.33	358
470.000	1.564	0.63957	0.1540	33.017	37986.8	41568.4	221.984	67.19	81.01	364
480.000	1.519	0.65851	0.1486	34.282	38694.2	42381.9	223.697	68.33	81.74	369
490.000	1.477	0.67718	0.1436	35.520	39410.7	43202.9	225.390	69.46	82.51	375
500.000	1.438	0.69561	0.1390	36.734	40136.5	44031.9	227.065	70.59	83.32	380
510.000	1.366	0.73183	0.1308	39.098	41617.2	45715.5	230.366	72.83	85.02	390
520.000	1.303	0.76734	0.1237	41.388	43136.1	47433.2	233.608	75.03	86.79	399
530.000	1.246	0.80225	0.1174	43.615	44693.9	49186.6	236.797	77.20	88.59	408
540.000	1.195	0.83666	0.1118	45.789	46291.5	50976.8	239.937	79.32	90.40	417
600.000	1.149	0.87064	0.1068	47.917	47927.3	52802.8	243.032	81.40	92.23	425

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 60.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DP/DT BAR/K	DP/DD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	M M/SEC
90.831	21.708	0.04607	34.7109	971.862	5321.1	5597.5	76.743	44.54	68.43	2228
100.000	21.383	0.04677	31.1656	881.770	5944.6	6225.2	83.327	44.42	68.51	2127
110.000	21.030	0.04755	27.9169	793.150	6625.6	6910.9	89.862	44.21	68.65	2024
120.000	20.678	0.04836	25.1517	713.124	7308.2	7598.4	95.844	43.96	68.86	1927
130.000	20.324	0.04920	22.7560	640.551	7993.1	8288.4	101.366	43.70	69.15	1836
140.000	19.967	0.05008	20.6497	574.549	8681.1	8981.6	106.504	43.46	69.52	1748
150.000	19.605	0.05101	18.7751	514.386	9373.1	9679.2	111.316	43.26	70.01	1664
160.000	19.237	0.05190	17.0895	459.442	10070.2	10382.1	115.852	43.12	70.60	1582
170.000	18.861	0.05302	15.5607	409.174	10773.5	11091.6	120.153	43.04	71.32	1502
180.000	18.476	0.05413	14.1641	363.100	11484.3	11809.0	124.254	43.05	72.19	1423
190.000	18.080	0.05531	12.8803	320.791	12204.0	12535.9	128.183	43.15	73.21	1345
200.000	17.672	0.05659	11.6939	281.860	12934.3	13273.8	131.968	43.34	74.41	1269
210.000	17.249	0.05797	10.5923	245.959	13676.9	14024.8	135.632	43.63	75.82	1192
220.000	16.810	0.05949	9.5646	212.784	14434.1	14791.1	139.196	44.01	77.48	1116
230.000	16.349	0.06117	8.6016	182.064	15208.4	15575.4	142.683	44.48	79.45	1040
240.000	15.863	0.06304	7.6947	153.566	16003.1	16381.3	146.112	45.04	81.81	963
250.000	15.344	0.06517	6.8355	127.093	16822.3	17213.4	149.508	45.67	84.70	885
260.000	14.783	0.06765	6.0154	102.483	17672.1	18078.0	152.899	46.37	88.38	806
270.000	14.164	0.07060	5.2244	79.615	18561.3	18984.9	156.321	47.14	93.28	724
280.000	13.459	0.07430	4.4496	58.409	19505.0	19950.8	159.833	47.99	100.39	637
290.000	12.615	0.07927	3.6708	38.858	20532.1	21007.7	163.541	48.96	112.15	544
300.000	11.500	0.08695	2.8471	21.106	21713.9	22335.6	167.701	50.22	137.34	438
310.000	9.560	0.10460	1.8502	6.065	23348.6	23976.2	173.400	52.65	244.09	306
320.000	5.294	0.18889	0.7675	3.091	26358.0	27491.4	184.564	58.46	276.06	220
330.000	3.953	0.25297	0.5225	6.845	27856.1	29374.0	190.368	56.04	140.26	239
340.000	3.390	0.29502	0.4242	9.976	28822.6	30592.8	194.009	55.52	108.89	255
350.000	3.040	0.32894	0.3656	12.605	29634.7	31608.4	196.955	55.67	95.83	269
360.000	2.789	0.35852	0.3251	14.914	30378.1	32529.2	199.549	56.16	88.96	280
370.000	2.595	0.38534	0.2948	17.005	31084.9	33396.9	201.927	56.86	84.94	291
380.000	2.438	0.41021	0.2710	18.935	31771.4	34232.7	204.157	57.68	82.48	300
390.000	2.306	0.43363	0.2516	20.741	32447.7	35049.4	206.278	58.60	80.99	309
400.000	2.193	0.45592	0.2355	22.447	33119.1	35854.7	208.317	59.59	80.13	317
410.000	2.095	0.47730	0.2217	24.071	33789.4	36653.2	210.289	60.62	79.70	324
420.000	2.008	0.49793	0.2099	25.626	34461.6	37449.2	212.208	61.69	79.59	332
430.000	1.931	0.51794	0.1995	27.122	35138.0	38245.7	214.082	62.78	79.71	338
440.000	1.861	0.53742	0.1903	28.567	35819.3	39043.9	215.917	63.89	80.00	345
450.000	1.797	0.55644	0.1821	29.966	36507.5	39846.1	217.719	65.02	80.43	351
460.000	1.739	0.57506	0.1747	31.327	37202.4	40652.8	219.493	66.14	80.96	357
470.000	1.685	0.59334	0.1680	32.651	37905.2	41465.3	221.241	67.27	81.58	363
480.000	1.636	0.61131	0.1619	33.945	38616.4	42284.2	222.965	68.40	82.26	368
490.000	1.590	0.62900	0.1563	35.209	39336.7	43110.7	224.669	69.53	82.99	374
500.000	1.547	0.64645	0.1512	36.448	40065.6	43944.3	226.353	70.66	83.76	379
520.000	1.469	0.68071	0.1420	38.858	41551.1	45635.3	229.670	72.89	85.39	389
540.000	1.400	0.71424	0.1341	41.189	43074.5	47360.0	232.924	75.08	87.11	399
560.000	1.338	0.74718	0.1271	43.454	44636.9	49120.0	236.124	77.24	88.87	408
580.000	1.283	0.77960	0.1210	45.663	46237.3	50914.9	239.274	79.36	90.65	416
600.000	1.232	0.81159	0.1154	47.822	47876.1	52745.6	242.377	81.44	92.45	425

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 65.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	OF/IT BAR/K	DF/DO BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	W M/SEC
90.909	21.711	0.04606	34.6821	972.661	5322.9	5622.3	76.763	44.57	68.43	2228
100.000	21.388	0.04675	31.1731	883.480	5540.8	6244.7	83.288	44.46	68.50	2128
110.000	21.037	0.04754	27.5277	794.964	6621.3	6930.3	89.823	44.25	68.63	2025
120.000	20.685	0.04834	25.1655	715.029	7303.4	7617.6	95.803	44.00	68.84	1929
130.000	20.332	0.04918	22.7725	642.536	7987.7	8307.4	101.323	43.74	69.12	1838
140.000	19.976	0.05006	20.6688	576.606	8675.0	9000.3	106.459	43.50	69.49	1750
150.000	19.615	0.05098	18.7967	516.508	9366.2	9697.6	111.269	43.30	69.97	1666
160.000	19.248	0.05195	17.1136	461.626	10062.4	10400.1	115.802	43.15	70.55	1584
170.000	18.873	0.05299	15.5672	411.417	10764.6	11109.0	120.100	43.08	71.26	1504
180.000	18.489	0.05409	14.1932	365.403	11474.3	11825.8	124.197	43.09	72.12	1426
190.000	18.095	0.05526	12.9120	323.155	12192.7	12551.9	128.122	43.19	73.12	1349
200.000	17.690	0.05653	11.7285	284.288	12921.4	13288.8	131.902	43.38	74.30	1273
210.000	17.270	0.05791	10.6298	248.457	13662.2	14038.6	135.560	43.66	75.69	1197
220.000	16.833	0.05941	9.6055	215.358	14417.2	14803.4	139.117	44.05	77.31	1121
230.000	16.376	0.06106	8.6462	184.725	15188.9	15585.8	142.595	44.52	79.23	1046
240.000	15.895	0.06291	7.7437	156.325	15980.2	16389.1	146.013	45.07	81.51	970
250.000	15.383	0.06501	6.8898	129.965	16795.1	17217.6	149.395	45.70	84.29	893
260.000	14.831	0.06743	6.0764	105.490	17639.0	18077.3	152.766	46.40	87.78	815
270.000	14.225	0.07030	5.2945	82.783	18519.8	18976.7	156.160	47.17	92.35	734
280.000	13.542	0.07384	4.5329	61.779	19450.4	19930.4	159.628	48.01	98.79	650
290.000	12.738	0.07850	3.7754	42.400	20454.2	20964.5	163.256	48.95	108.91	561
300.000	11.717	0.08535	2.9940	25.089	21583.0	22137.7	167.231	50.13	128.20	462
310.000	10.182	0.09821	2.1254	10.334	22996.0	23634.4	172.134	51.98	182.68	348
320.000	7.018	0.14248	1.1141	3.100	25334.9	26261.1	180.459	54.97	315.05	243
330.000	4.782	0.20912	0.6657	5.382	27278.1	28637.4	187.786	57.18	176.01	235
340.000	3.931	0.25440	0.5121	8.565	28433.3	30086.9	192.118	56.28	123.65	250
350.000	3.458	0.28919	0.4303	11.364	29331.7	31211.5	195.379	56.23	103.92	264
360.000	3.138	0.31872	0.3769	13.818	30125.4	32197.1	198.156	56.60	94.19	277
370.000	2.898	0.34505	0.3383	16.023	30866.0	33108.8	200.655	57.22	88.68	287
380.000	2.708	0.36923	0.3086	18.046	31577.4	33977.5	202.972	57.99	85.33	297
390.000	2.552	0.39184	0.2849	19.929	32272.6	34819.5	205.160	58.86	83.25	306
400.000	2.420	0.41323	0.2654	21.702	32958.9	35644.9	207.250	59.81	81.98	315
410.000	2.306	0.43367	0.2490	23.384	33641.9	36460.8	209.265	60.82	81.26	322
420.000	2.206	0.45333	0.2349	24.991	34324.5	37271.2	211.218	61.86	80.92	330
430.000	2.117	0.47234	0.2227	26.535	35009.8	38080.0	213.121	62.94	80.86	337
440.000	2.037	0.49080	0.2119	28.023	35698.8	38889.0	214.981	64.03	81.02	343
450.000	1.965	0.50880	0.2024	29.463	36393.7	39700.8	216.805	65.14	81.33	350
460.000	1.900	0.52638	0.1938	30.860	37094.6	40516.1	218.597	66.26	81.77	356
470.000	1.840	0.54361	0.1861	32.220	37882.7	41336.2	220.362	67.38	82.31	362
480.000	1.784	0.56053	0.1791	33.546	38519.1	42162.5	222.101	68.50	82.92	367
490.000	1.733	0.57717	0.1727	34.842	39243.2	42994.8	223.817	69.62	83.59	373
500.000	1.685	0.59356	0.1668	36.110	39976.0	43834.2	225.513	70.74	84.31	378
510.000	1.638	0.60970	0.1598	37.354	40709.9	44680.9	227.181	71.86	85.07	383
520.000	1.598	0.62570	0.1564	38.575	41468.9	45535.9	228.850	72.96	85.87	389
530.000	1.562	0.64211	0.1522	40.955	42298.1	46426.3	230.521	74.04	86.72	394
540.000	1.528	0.65711	0.1474	43.265	43186.0	47369.3	232.121	75.14	87.52	398
550.000	1.494	0.67190	0.1396	45.514	44170.3	48368.5	233.655	76.26	88.39	402
560.000	1.460	0.68640	0.1326	47.711	45154.4	49428.9	235.129	77.41	89.31	406
570.000	1.426	0.70064	0.1264	49.864	46144.4	50548.9	236.565	78.56	90.27	410
580.000	1.392	0.71489	0.1212	51.981	47132.9	51725.2	238.000	79.71	91.27	414
590.000	1.357	0.72824	0.1160	54.054	48118.9	52967.5	239.431	80.86	92.31	418
600.000	1.322	0.74084	0.1118	56.087	49102.9	54267.8	240.852	81.99	93.39	422

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 70.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	OP/CT BAR/K	OP/PO BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	W M/SEC
90.986	21.713	0.04605	34.6536	973.463	5324.8	5647.2	76.784	44.61	68.42	2228
100.000	21.394	0.04674	31.1806	885.188	5937.0	6264.2	83.250	44.49	68.49	2129
110.000	21.043	0.04752	27.9386	796.777	6617.1	6949.7	89.783	44.28	68.62	2026
120.000	20.692	0.04833	25.1793	716.932	7298.6	7636.9	95.762	44.03	68.82	1930
130.000	20.340	0.04916	22.7891	644.518	7982.2	8326.4	101.280	43.78	69.10	1839
140.000	19.984	0.05004	20.6879	578.659	8668.8	9019.1	106.414	43.54	69.48	1752
150.000	19.624	0.05096	18.8183	518.627	9359.3	9716.0	111.221	43.33	69.93	1668
160.000	19.258	0.05193	17.1376	463.805	10054.6	10418.0	115.752	43.19	70.51	1587
170.000	18.885	0.05295	15.6137	413.655	10755.8	11126.5	120.047	43.12	71.21	1507
180.000	18.503	0.05405	14.2221	367.699	11464.3	11842.7	124.140	43.12	72.05	1429
190.000	18.111	0.05522	12.9436	325.511	12181.4	12567.9	128.061	43.22	73.04	1352
200.000	17.707	0.05647	11.7627	286.708	12908.6	13303.9	131.836	43.41	74.20	1277
210.000	17.290	0.05784	10.6670	250.944	13647.7	14052.5	135.488	43.70	75.56	1201
220.000	16.856	0.05933	9.6459	217.920	14400.5	14815.8	139.039	44.08	77.14	1126
230.000	16.403	0.06096	8.6904	187.369	15169.6	15596.3	142.508	44.56	79.01	1051
240.000	15.927	0.06279	7.7920	159.063	15957.7	16397.2	145.916	45.11	81.22	976
250.000	15.421	0.06485	6.9432	132.811	16768.4	17222.3	149.284	45.74	83.90	900
260.000	14.878	0.06721	6.1362	108.461	17606.8	18077.3	152.637	46.44	87.22	823
270.000	14.284	0.07001	5.3626	85.903	18479.8	18969.9	156.005	47.20	91.50	744
280.000	13.621	0.07342	4.6127	65.080	19390.6	19912.5	159.432	48.03	97.37	662
290.000	12.851	0.07781	3.8735	46.013	20382.3	20927.0	162.992	48.96	106.21	576
300.000	11.903	0.08401	3.1248	28.882	21469.9	22058.0	166.824	50.07	121.66	483
310.000	10.591	0.09442	2.3310	14.318	22761.0	23421.1	171.291	51.65	156.53	380
320.000	8.344	0.11985	1.4556	4.903	24569.2	25408.2	177.591	54.28	252.93	276
330.000	5.784	0.17289	0.8525	4.777	26623.6	27833.9	185.062	58.02	208.10	239
340.000	4.560	0.21932	0.6194	7.432	27998.9	29534.1	190.144	57.01	141.44	240
350.000	3.922	0.25499	0.5052	10.242	29004.9	30789.8	193.786	56.79	113.50	261
360.000	3.514	0.28460	0.4350	12.798	29858.6	31850.8	196.776	57.04	100.16	273
370.000	3.220	0.31060	0.3861	15.104	30637.9	32812.1	199.411	57.57	92.81	285
380.000	2.992	0.33422	0.3495	17.214	31377.0	33716.6	201.823	58.28	88.41	295
390.000	2.808	0.35613	0.3207	19.171	32092.6	34595.5	204.081	59.12	85.66	304
400.000	2.654	0.37677	0.2974	21.008	32795.4	35432.8	206.226	60.03	83.93	313
410.000	2.523	0.39646	0.2779	22.746	33491.6	36266.4	208.285	61.01	82.88	321
420.000	2.408	0.41521	0.2613	24.402	34185.2	37091.7	210.274	62.04	82.30	328
430.000	2.308	0.43336	0.2470	25.990	34879.8	37913.4	212.207	63.09	82.05	335
440.000	2.218	0.45095	0.2346	27.519	35576.9	38733.5	214.093	64.17	82.06	342
450.000	2.137	0.46805	0.2235	28.996	36278.7	39555.1	215.939	65.26	82.25	349
460.000	2.063	0.48474	0.2137	30.428	36985.8	40379.0	217.750	66.37	82.59	355
470.000	1.996	0.50107	0.2049	31.821	37695.8	41207.3	219.531	67.48	83.05	361
480.000	1.934	0.51709	0.1969	33.177	38420.6	42040.3	221.285	68.59	83.59	367
490.000	1.877	0.53282	0.1896	34.502	39149.2	42879.0	223.015	69.71	84.20	372
500.000	1.824	0.54830	0.1830	35.798	39886.0	43724.1	224.723	70.82	84.87	378
510.000	1.768	0.56381	0.1772	38.313	41385.9	45436.2	228.080	73.02	86.34	388
520.000	1.644	0.60819	0.1611	40.739	42921.1	47178.4	231.368	75.20	87.92	398
530.000	1.569	0.63715	0.1523	43.091	44493.5	48953.6	234.595	77.35	89.58	407
540.000	1.502	0.66560	0.1445	45.379	46102.7	50761.9	237.768	79.46	91.26	416
550.000	1.442	0.69361	0.1376	47.612	47749.2	52604.5	240.892	81.52	93.01	425

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 75.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DP/DT BAR/K	DP/DD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	W M/SEC
91.063	21.716	0.04605	34.6252	974.268	5326.7	5672.1	76.804	44.65	68.41	2228
100.000	21.400	0.04673	31.1882	886.895	5933.3	6283.8	83.211	44.53	68.48	2130
110.000	21.049	0.04751	27.5455	798.589	6612.8	6969.1	89.743	44.32	68.61	2028
120.000	20.699	0.04831	25.1932	718.833	7293.8	7656.1	95.721	44.07	68.80	1932
130.000	20.348	0.04915	22.8056	646.499	7976.8	8345.4	101.238	43.81	69.07	1841
140.000	19.993	0.05002	20.7070	580.710	8662.7	9037.9	106.369	43.57	69.43	1754
150.000	19.634	0.05093	18.8398	520.742	9352.4	9734.4	111.174	43.37	69.89	1671
160.000	19.269	0.05190	17.1615	465.980	10046.8	10436.1	115.703	43.23	70.46	1589
170.000	18.897	0.05292	15.6400	415.888	10747.1	11144.0	119.994	43.15	71.15	1510
180.000	18.517	0.05401	14.2509	369.990	11454.5	11859.5	124.084	43.16	71.98	1432
190.000	18.126	0.05517	12.9749	327.861	12170.3	12584.0	128.001	43.26	72.95	1356
200.000	17.724	0.05642	11.7968	289.118	12896.0	13319.1	131.771	43.45	74.09	1280
210.000	17.309	0.05777	10.7039	253.421	13633.3	14066.6	135.418	43.74	75.43	1206
220.000	16.879	0.05925	9.6860	220.469	14384.1	14828.4	138.961	44.12	76.98	1131
230.000	16.430	0.06087	8.7340	189.998	15150.6	15607.1	142.422	44.59	78.80	1057
240.000	15.958	0.06266	7.8397	161.782	15935.5	16405.5	145.820	45.15	80.95	982
250.000	15.458	0.06469	6.9958	135.633	16742.3	17227.5	149.175	45.78	83.53	907
260.000	14.923	0.06701	6.1947	111.400	17575.4	18078.0	152.511	46.47	86.69	831
270.000	14.342	0.06973	5.4289	88.980	18441.2	18964.1	155.854	47.23	90.71	754
280.000	13.696	0.07302	4.6896	68.318	19349.1	19896.8	159.245	48.05	96.11	674
290.000	12.956	0.07719	3.9662	49.443	20315.3	20894.2	162.745	48.96	103.93	591
300.000	12.066	0.08288	3.2437	32.526	21369.7	21991.3	166.463	50.03	116.69	502
310.000	10.900	0.09174	2.5006	18.097	22578.8	23266.9	170.643	51.45	141.59	407
320.000	9.150	0.10929	1.7207	7.807	24111.7	24931.3	175.923	53.64	198.59	310
330.000	6.801	0.14703	1.0662	5.219	26016.7	27119.4	182.655	55.72	211.10	256
340.000	5.267	0.18988	0.7476	6.823	27531.8	28955.8	188.143	57.61	158.02	249
350.000	4.434	0.22554	0.5919	9.348	28655.0	30346.5	192.177	57.30	124.02	259
360.000	3.919	0.25515	0.5003	11.895	29577.7	31491.3	195.403	57.46	106.78	271
370.000	3.560	0.28087	0.4388	14.253	30400.9	32507.5	198.188	57.92	97.33	282
380.000	3.289	0.30402	0.3939	16.445	31170.1	33450.2	200.703	58.57	91.71	293
390.000	3.074	0.32534	0.3592	18.469	31908.4	34348.4	203.036	59.36	88.21	302
400.000	2.896	0.34531	0.3314	20.365	32628.6	35218.4	205.239	60.25	85.97	311
410.000	2.745	0.36423	0.3085	22.156	33338.8	36070.6	207.343	61.20	94.57	319
420.000	2.616	0.38232	0.2892	23.859	34044.0	36911.4	209.370	62.20	83.72	327
430.000	2.502	0.39971	0.2726	25.489	34748.3	37746.1	211.334	63.24	83.27	334
440.000	2.401	0.41653	0.2582	27.056	35453.7	38577.7	213.246	64.30	83.12	341
450.000	2.318	0.43285	0.2456	28.568	36162.8	39409.2	215.115	65.39	83.19	348
460.000	2.228	0.44876	0.2344	30.033	36876.2	40241.9	216.945	66.48	83.43	354
470.000	2.154	0.46430	0.2243	31.456	37595.8	41118.1	218.743	67.58	83.75	360
480.000	2.085	0.47953	0.2153	32.841	38321.7	41958.1	220.512	68.69	84.27	365
490.000	2.022	0.49446	0.2071	34.192	39054.9	42763.3	222.255	69.79	84.82	372
500.000	1.964	0.50915	0.1996	35.513	39796.1	43614.8	223.975	70.90	85.44	377
510.000	1.909	0.52387	0.1864	36.875	40502.7	44488.2	225.657	72.09	86.82	388
520.000	1.859	0.53787	0.1751	38.075	41302.7	45336.7	227.352	73.09	88.34	398
530.000	1.767	0.55684	0.1653	40.545	42044.4	46180.6	229.066	74.40	89.94	407
540.000	1.686	0.59321	0.1567	42.936	42821.5	47088.2	230.898	75.50	91.60	416
550.000	1.613	0.62006	0.1491	45.260	43635.1	48005.6	232.883	76.50	93.29	425
600.000	1.547	0.64648		47.526	47686.2	52534.7	240.217	81.57		

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 80.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DP/DT BAR/K	DP/DD BAR/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	W M/SEC
91.140	21.718	0.04604	34.5971	975.076	5328.6	5696.9	76.824	44.69	68.41	2228
100.000	21.405	0.04672	31.1957	888.601	5929.5	6303.3	83.173	44.57	68.47	2131
110.000	21.055	0.04749	27.9604	800.398	6609.6	6988.5	89.704	44.36	68.59	2029
120.000	20.706	0.04830	25.2070	720.733	7289.0	7675.4	95.680	44.11	68.78	1933
130.000	20.355	0.04913	22.8221	648.477	7971.4	8364.5	101.195	43.85	69.05	1843
140.000	20.002	0.05000	20.7260	582.758	8656.7	9056.6	106.325	43.61	69.40	1756
150.000	19.644	0.05091	18.8612	522.854	9345.6	9752.8	111.128	43.41	69.85	1673
160.000	19.280	0.05187	17.1853	468.151	10039.1	10454.1	115.653	43.26	70.42	1592
170.000	18.909	0.05288	15.6662	418.116	10738.4	11161.5	119.942	43.19	71.10	1513
180.000	18.530	0.05397	14.2796	372.275	11444.7	11876.4	124.028	43.20	71.91	1436
190.000	18.141	0.05512	13.0061	330.203	12159.2	12600.2	127.941	43.30	72.87	1360
200.000	17.742	0.05636	11.8306	291.521	12883.5	13334.4	131.706	43.49	73.99	1284
210.000	17.329	0.05771	10.7406	255.890	13619.0	14080.7	135.347	43.78	75.30	1210
220.000	16.901	0.05917	9.7257	223.006	14367.8	14841.1	138.885	44.16	76.82	1136
230.000	16.456	0.06077	8.7771	192.612	15131.9	15618.0	142.338	44.63	78.60	1062
240.000	15.989	0.06254	7.8868	164.482	15913.8	16414.2	145.726	45.18	80.69	988
250.000	15.495	0.06454	7.0475	138.430	16716.8	17233.1	149.068	45.81	83.17	914
260.000	14.968	0.06681	6.2521	114.308	17544.9	18079.4	152.387	46.51	86.19	839
270.000	14.397	0.06946	5.4935	92.015	18403.8	18959.5	155.708	47.26	89.90	763
280.000	13.767	0.07264	4.7639	71.501	19301.9	19883.0	159.066	48.08	94.97	685
290.000	13.054	0.07661	4.0543	52.792	20252.5	20865.4	162.513	48.97	101.96	605
300.000	12.212	0.08189	3.3534	36.049	21279.4	21934.6	166.137	50.00	112.75	520
310.000	11.152	0.08967	2.6476	21.721	22429.7	23147.1	170.111	51.31	131.75	431
320.000	9.688	0.10322	1.9305	10.976	23804.8	24630.6	174.818	53.23	169.00	340
330.000	7.684	0.13015	1.2816	6.265	25497.2	26538.4	180.685	55.56	202.10	275
340.000	6.005	0.16653	0.8926	6.815	27064.8	28397.0	186.237	57.96	168.19	256
350.000	4.987	0.20054	0.6905	8.817	28289.8	29894.1	190.579	57.73	133.86	261
360.000	4.353	0.22970	0.5734	11.184	29284.5	31122.1	194.041	57.84	113.68	270
370.000	3.920	0.25507	0.4967	13.535	30155.3	32195.9	196.984	58.24	102.13	281
380.000	3.600	0.27777	0.4420	15.754	30957.4	33179.6	199.608	58.85	95.21	291
390.000	3.349	0.29857	0.4005	17.830	31720.0	34108.5	202.021	59.60	90.88	301
400.000	3.145	0.31795	0.3677	19.777	32458.8	35002.4	204.284	60.46	88.10	310
410.000	2.974	0.33625	0.3409	21.615	33183.7	35873.7	206.436	61.39	86.31	318
420.000	2.827	0.35368	0.3185	23.362	33901.0	36730.4	208.501	62.37	85.18	326
430.000	2.700	0.37040	0.2994	25.031	34615.4	37578.6	210.497	63.39	84.52	333
440.000	2.587	0.38653	0.2830	26.634	35329.8	38422.0	212.436	64.44	84.20	340
450.000	2.486	0.40217	0.2686	28.180	36046.0	39263.3	214.327	65.51	84.14	347
460.000	2.396	0.41739	0.2559	29.675	36766.3	40105.4	216.177	66.59	84.27	353
470.000	2.314	0.43223	0.2445	31.126	37491.3	40949.2	217.992	67.68	84.55	360
480.000	2.238	0.44675	0.2343	32.537	38222.3	41796.3	219.776	68.78	84.95	366
490.000	2.169	0.46099	0.2251	33.914	38960.5	42648.4	221.533	69.88	85.44	371
500.000	2.105	0.47438	0.2167	35.258	39705.5	43505.3	223.264	70.98	86.00	377
520.000	1.991	0.50229	0.2020	37.864	41219.8	45238.1	226.662	73.16	87.30	388
540.000	1.891	0.52886	0.1894	40.373	42767.1	46598.0	229.983	75.32	88.75	398
560.000	1.802	0.55482	0.1786	42.801	44349.5	48788.0	233.239	77.45	90.30	407
580.000	1.723	0.58027	0.1691	45.159	45963.1	50610.3	236.436	79.55	91.92	417
600.000	1.652	0.60528	0.1607	47.457	47622.6	52464.9	239.579	81.61	93.57	425

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 85.0 BAR

T OEG K	DEN MOL/L	VOL L/MOL	DF/CT BAR/K	DF/DD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CF J/MOL/K	W M/SEC
91.217	21.720	0.04604	34.5691	975.886	5330.5	5721.8	76.844	44.73	68.40	2228
100.000	21.411	0.04670	31.2033	890.306	5925.8	6322.8	83.135	44.61	68.46	2132
110.000	21.062	0.04748	27.5713	802.207	6604.4	7008.0	89.665	44.39	68.58	2030
120.000	20.713	0.04828	25.2208	722.630	7284.2	7694.6	95.639	44.14	68.76	1935
130.000	20.363	0.04911	22.8386	650.453	7966.1	8383.5	101.153	43.88	69.02	1845
140.000	20.010	0.04997	20.7450	584.803	8650.6	9075.4	106.280	43.64	69.37	1758
150.000	19.653	0.05088	18.8626	524.962	9338.8	9771.3	111.081	43.44	69.82	1675
160.000	19.290	0.05184	17.2090	470.318	10031.5	10472.1	115.604	43.30	70.37	1594
170.000	18.921	0.05285	15.6924	420.340	10729.8	11179.1	119.889	43.22	71.04	1516
180.000	18.543	0.05393	14.3081	374.554	11435.0	11893.4	123.972	43.23	71.84	1439
190.000	18.156	0.05508	13.0371	332.538	12148.3	12616.4	127.881	43.33	72.79	1363
200.000	17.759	0.05631	11.8642	293.915	12871.1	13349.7	131.642	43.52	73.89	1288
210.000	17.349	0.05764	10.7770	258.347	13605.0	14094.9	135.278	43.81	75.18	1214
220.000	16.924	0.05909	9.7651	225.531	14351.7	14854.0	138.809	44.19	76.67	1141
230.000	16.482	0.06067	8.8198	195.211	15113.4	15629.1	142.254	44.67	78.40	1068
240.000	16.019	0.06243	7.9332	167.164	15892.4	16423.1	145.633	45.22	80.43	994
250.000	15.531	0.06439	7.0983	141.204	16691.7	17239.0	148.963	45.85	82.83	921
260.000	15.011	0.06662	6.3083	117.187	17515.1	18081.3	152.266	46.54	85.72	847
270.000	14.450	0.06920	5.5564	95.012	18367.6	18955.8	155.566	47.29	89.31	772
280.000	13.836	0.07228	4.8357	74.630	19256.5	19870.9	158.894	48.10	93.93	696
290.000	13.146	0.07607	4.1384	56.068	20193.3	20839.9	162.294	48.98	100.24	618
300.000	12.344	0.08101	3.4557	39.471	21196.9	21885.5	165.837	49.98	109.54	536
310.000	11.365	0.08799	2.7787	25.220	22302.1	23050.0	169.654	51.22	124.69	452
320.000	10.087	0.09913	2.1058	14.190	23574.8	24417.5	173.994	52.95	151.23	367
330.000	8.390	0.11918	1.4829	8.064	25089.4	26102.4	179.176	55.26	183.09	298
340.000	6.713	0.14897	1.0458	7.408	26633.7	27900.0	184.544	58.09	169.49	268
350.000	5.560	0.17987	0.7993	8.705	27923.2	29452.1	189.045	58.05	141.16	265
360.000	4.811	0.20787	0.6540	10.744	28983.4	30750.3	192.705	58.17	120.11	272
370.000	4.298	0.23265	0.5600	12.969	29902.9	31880.4	195.802	58.54	106.97	281
380.000	3.924	0.25486	0.4940	15.167	30739.8	32906.2	198.538	59.11	98.82	290
390.000	3.634	0.27515	0.4447	17.265	31527.7	33866.5	201.033	59.83	93.65	300
400.000	3.401	0.29399	0.4062	19.248	32286.0	34784.9	203.359	60.66	90.29	309
410.000	3.208	0.31172	0.3751	21.126	33026.4	35676.0	205.559	61.56	88.09	317
420.000	3.044	0.32856	0.3493	22.912	33756.5	36549.2	207.664	62.53	86.67	325
430.000	2.901	0.34468	0.3275	24.617	34481.3	37411.1	209.692	63.53	85.79	332
440.000	2.776	0.36020	0.3088	26.253	35204.6	38266.3	211.658	64.56	85.30	340
450.000	2.665	0.37523	0.2925	27.830	35928.4	39117.8	213.572	65.62	85.10	346
460.000	2.565	0.38982	0.2781	29.353	36655.4	39968.9	215.442	66.70	85.12	353
470.000	2.475	0.40404	0.2654	30.831	37386.3	40820.7	217.274	67.78	85.31	359
480.000	2.393	0.41794	0.2540	32.267	38122.9	41675.4	219.074	68.87	85.63	365
490.000	2.317	0.43155	0.2437	33.667	38865.4	42533.6	220.843	69.96	86.06	371
500.000	2.248	0.44491	0.2343	35.033	39614.7	43396.5	222.587	71.05	86.57	377
520.000	2.123	0.47097	0.2180	37.679	41136.3	45139.5	226.005	73.23	87.77	388
540.000	2.015	0.49629	0.2041	40.225	42689.8	46908.3	229.343	75.38	89.16	398
560.000	1.919	0.52101	0.1922	42.687	44277.9	48706.5	232.612	77.50	90.66	407
580.000	1.834	0.54521	0.1818	45.077	45900.7	50534.9	235.821	79.59	92.23	417
600.000	1.758	0.56897	0.1726	47.404	47558.6	52395.9	238.975	81.65	93.85	426

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 90.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DF/CT BAR/K	DF/DO L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CF J/MOL/K	W M/SEC
91.294	21.723	0.04603	34.5413	976.700	5332.3	5746.7	76.865	44.76	68.40	2228
100.000	21.417	0.04669	31.2110	892.010	5922.1	6342.3	83.097	44.64	68.45	2133
110.000	21.068	0.04747	27.9822	804.014	6600.2	7027.4	89.625	44.43	68.57	2031
120.000	20.720	0.04826	25.2346	724.526	7279.5	7713.9	95.598	44.18	68.75	1936
130.000	20.371	0.04909	22.8550	652.426	7960.7	8402.6	101.111	43.92	69.00	1846
140.000	20.019	0.04995	20.7639	586.846	8644.6	9094.2	106.236	43.68	69.34	1760
150.000	19.663	0.05086	18.9039	527.067	9332.0	9789.7	111.034	43.48	69.78	1677
160.000	19.301	0.05181	17.2327	472.481	10023.9	10490.2	115.555	43.33	70.33	1597
170.000	18.933	0.05282	15.7183	422.558	10721.3	11196.7	119.837	43.26	70.92	1519
180.000	18.557	0.05389	14.3364	376.827	11425.4	11910.4	123.917	43.27	71.78	1442
190.000	18.171	0.05503	13.0679	334.867	12137.4	12632.7	127.822	43.37	72.71	1366
200.000	17.776	0.05626	11.8975	296.301	12858.8	13365.1	131.578	43.56	73.80	1292
210.000	17.368	0.05758	10.8130	260.794	13591.0	14109.2	135.209	43.85	75.06	1218
220.000	16.946	0.05901	9.8041	228.044	14335.9	14867.0	138.733	44.23	76.52	1145
230.000	16.507	0.06058	8.8620	197.796	15095.2	15640.4	142.171	44.70	78.22	1073
240.000	16.048	0.06231	7.9791	169.828	15871.4	16432.2	145.541	45.25	80.19	1000
250.000	15.566	0.06424	7.1485	143.957	16667.2	17245.3	148.860	45.88	82.51	928
260.000	15.053	0.06643	6.3635	120.038	17486.0	18083.8	152.148	46.57	85.28	855
270.000	14.502	0.06895	5.6179	97.972	18332.4	18953.0	155.428	47.32	88.68	781
280.000	13.9501	0.07194	4.9053	77.712	19213.0	19860.4	158.727	48.12	92.99	707
290.000	13.232	0.07557	4.2189	59.280	20137.3	20817.5	162.085	48.99	98.72	630
300.000	12.466	0.08022	3.5519	42.806	21120.8	21842.8	165.561	49.97	106.86	552
310.000	11.551	0.08657	2.8980	28.614	22189.9	22969.0	169.252	51.15	119.34	471
320.000	10.405	0.09611	2.2581	17.388	23390.1	24255.1	173.334	52.76	139.43	391
330.000	8.939	0.11187	1.6623	10.327	24774.8	25781.7	178.029	54.96	165.47	322
340.000	7.353	0.13601	1.1959	8.274	26253.6	27477.6	183.092	58.04	167.49	282
350.000	6.127	0.16321	0.9152	8.982	27570.5	29039.4	187.621	58.23	145.18	273
360.000	5.280	0.18940	0.7413	10.616	28682.2	30386.7	191.419	58.43	125.28	275
370.000	4.690	0.21323	0.6285	12.616	29646.7	31565.7	194.650	58.80	111.47	282
380.000	4.259	0.23482	0.5499	14.720	30518.3	32631.7	197.494	59.35	102.39	291
390.000	3.928	0.25457	0.4918	16.795	31332.6	33623.8	200.071	60.04	96.45	300
400.000	3.664	0.27289	0.4470	18.791	32111.1	34567.1	202.460	60.85	92.52	308
410.000	3.447	0.29009	0.4111	20.694	32867.5	35478.3	204.710	61.73	89.91	317
420.000	3.264	0.30639	0.3816	22.510	33610.6	36368.1	206.855	62.68	88.18	325
430.000	3.106	0.32196	0.3568	24.247	34346.3	37244.0	208.916	63.67	87.07	332
440.000	2.968	0.33694	0.3356	25.913	35078.6	38111.0	210.909	64.69	86.40	339
450.000	2.846	0.35140	0.3173	27.518	35810.3	38972.9	212.846	65.74	86.06	346
460.000	2.736	0.36543	0.3012	29.068	36544.1	39833.0	214.736	66.80	85.97	353
470.000	2.638	0.37909	0.2870	30.570	37281.0	40692.8	216.586	67.87	86.07	359
480.000	2.548	0.39243	0.2743	32.030	38022.9	41554.8	218.400	68.96	86.31	365
490.000	2.466	0.40548	0.2628	33.451	38770.2	42419.5	220.184	70.04	86.68	371
500.000	2.391	0.41827	0.2525	34.838	39524.1	43288.6	221.939	71.13	87.13	377
520.000	2.256	0.44321	0.2344	37.522	41052.8	45041.7	225.378	73.29	88.25	388
540.000	2.139	0.46741	0.2192	40.103	42613.0	46819.7	228.732	75.44	89.57	398
560.000	2.037	0.49101	0.2061	42.596	44205.9	48625.0	232.016	77.55	91.01	408
580.000	1.945	0.51409	0.1947	45.015	45833.7	50460.6	235.236	79.64	92.54	417
600.000	1.863	0.53675	0.1846	47.369	47496.3	52327.0	238.400	81.69	94.13	426

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 95.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DP/CT BAR/K	DP/DD BAR-L/MOL	F J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CF J/MOL/K	W M/SEC
91.371	21.725	0.04603	34.5137	977.515	5334.2	5771.5	76.885	44.80	68.39	2228
100.000	21.422	0.04668	31.2186	893.713	5918.4	6361.9	83.058	44.68	68.44	2134
110.000	21.074	0.04745	27.9932	805.820	6596.0	7046.8	89.586	44.47	68.55	2033
120.000	20.727	0.04825	25.2484	726.420	7274.8	7733.1	95.558	44.21	68.73	1938
130.000	20.378	0.04907	22.8714	654.398	7955.4	8421.6	101.068	43.95	68.98	1848
140.000	20.027	0.04993	20.7828	588.886	8638.6	9113.0	106.192	43.71	69.31	1762
150.000	19.672	0.05083	18.9252	529.169	9325.3	9808.2	110.988	43.51	69.75	1680
160.000	19.312	0.05178	17.2563	474.641	10016.3	10508.3	115.506	43.37	70.28	1599
170.000	18.945	0.05279	15.7442	424.772	10712.8	11214.3	119.786	43.29	70.94	1521
180.000	18.570	0.05385	14.3647	379.095	11415.8	11927.4	123.862	43.30	71.71	1445
190.000	18.186	0.05499	13.0985	337.189	12126.6	12649.0	127.763	43.40	72.63	1370
200.000	17.793	0.05620	11.9306	298.679	12846.6	13380.5	131.515	43.60	73.70	1296
210.000	17.387	0.05751	10.8488	263.231	13577.2	14123.6	135.140	43.88	74.94	1223
220.000	16.968	0.05894	9.8427	230.545	14320.2	14880.1	138.659	44.27	76.38	1150
230.000	16.532	0.06049	8.9038	200.367	15077.3	15651.9	142.090	44.74	78.03	1078
240.000	16.078	0.06220	8.0244	172.476	15850.7	16441.6	145.450	45.29	79.95	1006
250.000	15.600	0.06410	7.1979	146.688	16643.1	17252.0	148.758	45.91	82.20	935
260.000	15.094	0.06625	6.4177	122.862	17457.5	18086.9	152.032	46.60	84.86	863
270.000	14.553	0.06872	5.6780	100.899	18298.3	18951.1	155.293	47.35	88.09	790
280.000	13.964	0.07161	4.9729	80.750	19171.0	19851.3	158.567	48.15	92.12	717
290.000	13.314	0.07511	4.2964	62.434	20084.0	20797.5	161.887	49.01	97.37	642
300.000	12.578	0.07950	3.6429	46.065	21050.0	21805.2	165.302	49.96	104.59	566
310.000	11.717	0.08335	3.0081	31.921	22089.4	22900.2	168.892	51.10	115.11	489
320.000	10.669	0.09373	2.3937	20.546	23235.1	24125.5	172.780	52.62	131.02	412
330.000	9.373	0.10669	1.8217	12.834	24525.4	25538.9	177.128	54.72	151.86	344
340.000	7.917	0.12631	1.3513	9.545	25923.6	27123.5	181.858	57.91	161.68	298
350.000	6.666	0.15003	1.0344	9.643	27243.7	28668.9	186.340	58.31	145.72	283
360.000	5.748	0.17396	0.8338	10.779	28388.3	30041.0	190.206	58.61	128.87	281
370.000	5.088	0.19652	0.7015	12.504	29390.8	31257.8	193.541	59.01	115.26	285
380.000	4.602	0.21730	0.6095	14.446	30295.1	32359.5	196.480	59.56	105.70	292
390.000	4.229	0.23645	0.5419	16.447	31135.4	33381.7	199.136	60.24	99.17	300
400.000	3.933	0.25424	0.4901	18.421	31934.6	34349.8	201.587	61.03	94.74	308
410.000	3.691	0.27093	0.4490	20.330	32707.3	35281.1	203.887	61.89	91.73	317
420.000	3.488	0.28672	0.4154	22.163	33463.7	36187.6	206.072	62.82	89.70	324
430.000	3.314	0.30179	0.3874	23.923	34210.4	37077.4	208.166	63.80	88.36	332
440.000	3.162	0.31625	0.3636	25.615	34952.1	37956.5	210.187	64.81	87.52	339
450.000	3.028	0.33021	0.3430	27.244	35691.7	38828.7	212.147	65.84	87.03	346
460.000	2.909	0.34373	0.3251	28.818	36432.5	39697.9	214.057	66.90	86.83	353
470.000	2.802	0.35688	0.3092	30.344	37175.5	40565.8	215.925	67.97	86.83	359
480.000	2.705	0.36971	0.2951	31.825	37922.8	41435.0	217.754	69.04	87.00	365
490.000	2.616	0.38225	0.2825	33.267	38674.8	42306.2	219.551	70.12	87.30	371
500.000	2.535	0.39453	0.2711	34.673	39433.1	43181.2	221.318	71.20	87.70	377
520.000	2.390	0.41845	0.2512	37.392	40969.6	44944.9	224.777	73.35	88.73	388
540.000	2.264	0.44164	0.2345	40.005	42535.7	46731.3	228.148	75.49	89.97	398
560.000	2.154	0.46423	0.2202	42.528	44134.5	48444.6	231.445	77.60	91.37	408
580.000	2.056	0.48631	0.2078	44.974	45766.5	50386.4	234.677	79.68	92.85	417
600.000	1.969	0.50796	0.1969	47.354	47433.5	52259.1	237.851	81.73	94.41	427

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 100.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DP/CT BAR/K	OF/DD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	W M/SEC
91.448	21.728	0.04602	34.4863	978.334	5336.1	5796.4	76.905	44.84	68.39	2229
100.000	21.428	0.04667	31.2263	895.416	5914.7	6381.4	83.020	44.72	68.43	2135
110.000	21.080	0.04744	28.0041	807.624	6591.9	7066.2	89.547	44.50	68.54	2034
120.000	20.734	0.04823	25.2622	728.313	7270.1	7752.4	95.518	44.25	68.71	1939
130.000	20.386	0.04905	22.8879	656.367	7950.2	8440.7	101.026	43.99	68.96	1850
140.000	20.036	0.04991	20.8017	590.923	8632.7	9131.8	106.148	43.75	69.29	1764
150.000	19.682	0.05081	18.9464	531.267	9318.6	9826.7	110.942	43.55	69.71	1682
160.000	19.322	0.05175	17.2797	476.796	10008.8	10526.4	115.457	43.40	70.24	1602
170.000	18.956	0.05275	15.7700	426.982	10704.4	11231.9	119.734	43.33	70.88	1524
180.000	18.583	0.05361	14.3927	381.357	11406.3	11944.4	123.807	43.34	71.65	1448
190.000	18.201	0.05494	13.1290	339.505	12115.9	12665.4	127.704	43.44	72.56	1373
200.000	17.809	0.05615	11.9636	301.050	12834.6	13396.1	131.452	43.63	73.61	1300
210.000	17.406	0.05745	10.8843	265.659	13563.6	14138.1	135.072	43.92	74.83	1227
220.000	16.989	0.05886	9.8810	233.035	14304.7	14893.3	138.585	44.30	76.24	1155
230.000	16.557	0.06040	8.9452	202.925	15059.6	15663.5	142.009	44.77	77.85	1083
240.000	16.106	0.06209	8.0692	175.106	15830.3	16451.2	145.361	45.32	79.72	1012
250.000	15.634	0.06396	7.2465	149.359	16619.4	17259.0	148.658	45.95	81.90	941
260.000	15.134	0.06607	6.4710	125.661	17429.7	18090.5	151.919	46.64	84.46	870
270.000	14.601	0.06849	5.7368	103.793	18265.1	18950.0	155.162	47.38	87.54	799
280.000	14.025	0.07130	5.0386	83.747	19130.6	19843.6	158.412	48.17	91.32	727
290.000	13.393	0.07467	4.3710	65.534	20033.2	20779.9	161.697	49.02	96.16	654
300.000	12.683	0.07885	3.7294	49.257	20983.6	21772.1	165.060	49.96	102.62	580
310.000	11.866	0.08428	3.1106	35.151	21998.1	22840.8	168.563	51.06	111.67	506
320.000	10.896	0.09178	2.5169	23.659	23101.0	24018.8	172.302	52.52	124.69	432
330.000	9.727	0.10280	1.9648	15.466	24320.5	25348.5	176.393	54.53	141.59	365
340.000	8.401	0.11903	1.4954	11.206	25642.8	26833.1	180.824	57.75	153.87	315
350.000	7.164	0.13959	1.1541	10.460	26946.6	28342.5	185.200	58.30	145.14	294
360.000	6.204	0.16119	0.9296	11.216	28108.0	29719.8	189.082	58.73	130.79	288
370.000	5.487	0.18225	0.7784	12.627	29139.9	30962.4	192.487	59.18	118.15	290
380.000	4.949	0.20205	0.6724	14.365	30072.9	32093.4	195.504	59.74	108.57	295
390.000	4.535	0.22049	0.5948	16.243	30937.8	33142.7	198.230	60.41	101.70	302
400.000	4.207	0.23771	0.5355	18.157	31756.9	34134.0	200.740	61.19	96.88	309
410.000	3.939	0.25388	0.4887	20.044	32546.3	35085.1	203.089	62.04	93.53	317
420.000	3.715	0.26919	0.4507	21.879	33316.2	36008.1	205.313	62.96	91.22	325
430.000	3.524	0.28378	0.4192	23.651	34074.0	36911.9	207.440	63.92	89.65	332
440.000	3.358	0.29778	0.3925	25.360	34825.1	37802.9	209.489	64.92	88.63	339
450.000	3.213	0.31126	0.3696	27.010	35572.9	38685.5	211.473	65.95	88.00	346
460.000	3.083	0.32432	0.3497	28.605	36320.6	39563.8	213.403	67.00	87.68	353
470.000	2.967	0.33700	0.3322	30.151	37070.1	40440.1	215.287	68.05	87.59	359
480.000	2.862	0.34936	0.3167	31.652	37822.5	41316.1	217.132	69.12	87.68	365
490.000	2.767	0.36143	0.3027	33.112	38579.8	42194.1	218.942	70.20	87.91	371
500.000	2.679	0.37325	0.2902	34.537	39342.1	43074.6	220.722	71.27	88.26	377
520.000	2.524	0.39625	0.2685	37.289	40886.2	44848.7	224.200	73.42	89.20	388
540.000	2.389	0.41852	0.2502	39.932	42458.9	46644.1	227.588	75.55	90.38	399
560.000	2.272	0.44019	0.2347	42.483	44062.7	48464.6	230.899	77.65	91.72	408
580.000	2.168	0.46136	0.2212	44.954	45699.7	50313.3	234.142	79.73	93.16	418
600.000	2.074	0.48211	0.2094	47.358	47370.4	52191.4	237.326	81.77	94.68	427

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 110.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DP/CT BAR/K	DP/DD BAR/K	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CF J/MOL/K	W M/SEC
91.601	21.732	0.04601	34.4320	979.979	5339.9	5846.1	76.945	44.91	68.38	2227
100.000	21.439	0.04664	31.2418	898.817	5507.4	6420.5	82.945	44.79	68.42	2137
110.000	21.093	0.04741	28.0260	811.1229	6583.6	7105.1	89.469	44.57	68.51	2036
120.000	20.747	0.04820	25.2898	732.092	7260.8	7791.0	95.437	44.32	68.60	1942
130.000	20.401	0.04902	22.9206	660.304	7939.7	8478.8	100.943	44.06	68.91	1853
140.000	20.053	0.04987	20.8392	594.989	8620.9	9169.5	106.061	43.82	69.23	1768
150.000	19.700	0.05076	18.9886	535.454	9305.4	9863.7	110.850	43.62	69.64	1686
160.000	19.343	0.05170	17.3265	481.095	9993.9	10562.6	115.361	43.47	70.16	1607
170.000	18.980	0.05269	15.8212	431.386	10687.6	11267.2	119.632	43.40	70.78	1530
180.000	18.609	0.05374	14.4485	385.865	11387.5	11978.7	123.698	43.41	71.53	1454
190.000	18.230	0.05485	13.1894	344.116	12094.8	12698.2	127.588	43.51	72.41	1380
200.000	17.842	0.05605	12.0288	305.768	12810.8	13427.3	131.328	43.70	73.43	1307
210.000	17.443	0.05733	10.9546	270.488	13536.7	14167.3	134.938	43.99	74.61	1235
220.000	17.032	0.05871	9.9567	237.983	14274.2	14920.1	138.440	44.37	75.96	1164
230.000	16.606	0.06022	9.0267	208.000	15024.8	15687.3	141.850	44.84	77.51	1094
240.000	16.163	0.06187	8.1572	180.320	15790.5	16471.1	145.185	45.39	79.29	1023
250.000	15.700	0.06370	7.3419	154.763	16573.4	17274.0	148.463	46.01	81.34	954
260.000	15.212	0.06574	6.5749	131.187	17375.9	18099.9	151.698	46.70	83.72	884
270.000	14.695	0.06805	5.8509	109.493	18201.3	18949.9	154.909	47.44	86.53	815
280.000	14.141	0.07072	5.1651	89.628	19053.6	19831.5	158.115	48.22	89.90	745
290.000	13.539	0.07386	4.5131	71.593	19938.0	20750.5	161.339	49.05	94.06	676
300.000	12.874	0.07767	3.8913	55.465	20862.1	21716.5	164.614	49.96	99.38	606
310.000	12.127	0.08246	3.2982	41.4415	21836.6	22743.6	167.981	51.01	106.38	536
320.000	11.272	0.08872	2.7357	29.746	22876.1	23852.0	171.499	52.37	115.74	468
330.000	10.282	0.09726	2.2143	20.886	23997.1	25066.9	175.237	54.26	127.54	404
340.000	9.167	0.10909	1.7563	15.251	25200.0	26400.0	179.216	57.44	139.27	351
350.000	8.033	0.12448	1.3898	12.811	26436.1	27805.4	183.290	58.16	139.93	320
360.000	7.043	0.14198	1.1248	12.714	27603.2	29165.0	187.121	58.79	130.99	307
370.000	6.257	0.15982	0.9395	13.493	28666.2	30424.2	190.572	59.37	121.19	303
380.000	5.639	0.17794	0.8062	14.758	29641.4	31592.1	193.687	60.00	112.63	304
390.000	5.152	0.19411	0.7077	16.312	30547.6	32682.8	196.520	60.69	105.81	308
400.000	4.761	0.21003	0.6325	18.008	31403.6	33713.9	199.131	61.46	100.66	313
410.000	4.442	0.22512	0.5734	19.768	32224.1	34700.4	201.568	62.30	96.87	320
420.000	4.176	0.23946	0.5258	21.540	33020.5	35654.6	203.867	63.20	94.12	327
430.000	3.950	0.25315	0.4866	23.291	33800.8	36585.4	206.058	64.15	92.17	334
440.000	3.756	0.26627	0.4537	25.004	34570.9	37498.8	208.160	65.13	90.82	340
450.000	3.586	0.27890	0.4256	26.672	35335.3	38403.2	210.190	66.14	89.92	347
460.000	3.435	0.29111	0.4014	28.293	36096.9	39299.2	212.160	67.18	89.38	354
470.000	3.301	0.30296	0.3802	29.869	36858.8	40191.4	214.079	68.22	89.10	360
480.000	3.180	0.31449	0.3615	31.401	37622.5	41081.9	215.953	69.28	89.03	366
490.000	3.070	0.32575	0.3448	32.893	38389.3	41972.5	217.790	70.34	89.13	372
500.000	2.970	0.33675	0.3299	34.349	39160.7	42865.3	219.593	71.41	89.37	378
510.000	2.792	0.35812	0.3041	37.161	40720.0	44659.3	223.112	73.54	90.13	389
520.000	2.640	0.37878	0.2826	39.858	42305.1	46471.7	226.532	75.65	91.17	400
530.000	2.507	0.39884	0.2644	42.459	43920.0	48307.3	229.870	77.75	92.41	410
540.000	2.390	0.41842	0.2487	44.977	45566.3	50169.0	233.136	79.81	93.77	419
550.000	2.285	0.43758	0.2350	47.424	47245.1	52058.5	236.339	81.84	95.22	428

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 120.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DF/DT BAR/K	DP/DD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	W M/SEC
91.754	21.737	0.04600	34.3784	981.635	5343.7	5895.7	76.985	44.99	68.37	2227
100.000	21.450	0.04662	31.2574	902.215	5900.1	6459.6	82.869	44.86	68.40	2139
110.000	21.105	0.04738	28.0480	814.829	6575.4	7144.0	89.392	44.65	68.49	2039
120.000	20.761	0.04817	25.3174	735.865	7251.5	7829.6	95.357	44.39	68.64	1945
130.000	20.416	0.04898	22.9533	664.226	7929.3	8517.0	100.860	44.13	68.87	1857
140.000	20.069	0.04983	20.8766	599.044	8609.2	9207.2	105.974	43.89	69.17	1772
150.000	19.719	0.05071	19.0305	539.629	9292.3	9900.8	110.759	43.68	69.57	1691
160.000	19.364	0.05164	17.3729	485.378	9979.2	10599.0	115.265	43.54	70.07	1612
170.000	19.003	0.05262	15.8720	435.773	10671.1	11302.6	119.531	43.47	70.68	1535
180.000	18.635	0.05366	14.5037	390.352	11369.0	12013.0	123.591	43.48	71.41	1460
190.000	18.259	0.05477	13.2451	348.703	12074.0	12731.2	127.474	43.58	72.26	1387
200.000	17.875	0.05595	12.0931	310.456	12787.4	13458.7	131.205	43.77	73.26	1315
210.000	17.480	0.05721	11.0238	275.282	13510.4	14196.9	134.806	44.06	74.40	1243
220.000	17.073	0.05857	10.0310	242.889	14244.4	14947.2	138.297	44.44	75.71	1173
230.000	16.653	0.06005	9.1066	213.026	14991.0	15711.6	141.694	44.91	77.19	1104
240.000	16.217	0.06166	8.2432	185.473	15751.9	16491.8	145.014	45.46	78.89	1035
250.000	15.763	0.06344	7.4347	160.053	16528.9	17290.2	148.273	46.08	80.83	966
260.000	15.287	0.06542	6.6755	136.624	17324.3	18109.3	151.485	46.76	83.05	898
270.000	14.784	0.06764	5.9606	115.083	18140.7	18952.3	154.667	47.49	85.63	831
280.000	14.249	0.07018	5.2856	95.373	18981.2	19823.4	157.834	48.27	88.67	763
290.000	13.673	0.07314	4.6467	77.4486	19850.1	20727.7	161.007	49.09	92.32	696
300.000	13.045	0.07666	4.0411	61.473	20752.6	21672.5	164.210	49.97	96.80	629
310.000	12.353	0.08095	3.4675	47.460	21696.2	22667.6	167.472	50.99	102.46	563
320.000	11.578	0.08637	2.9278	35.659	22690.4	23726.8	170.835	52.28	109.67	499
330.000	10.707	0.09340	2.4288	26.353	23745.9	24866.6	174.341	54.08	118.52	438
340.000	9.742	0.10265	1.9839	19.811	24865.7	26097.6	178.015	57.20	128.38	385
350.000	8.731	0.11453	1.6104	16.087	26029.8	27404.2	181.803	57.96	131.97	349
360.000	7.776	0.12860	1.3192	14.759	27170.8	28713.9	185.493	58.72	128.91	328
370.000	6.961	0.14366	1.1044	15.007	28243.4	29967.4	188.928	59.43	121.49	319
380.000	6.296	0.15883	0.9466	15.801	29240.1	31146.1	192.072	60.14	114.50	316
390.000	5.754	0.17378	0.8278	16.966	30174.8	32260.1	194.966	60.88	108.44	317
400.000	5.312	0.18825	0.7363	18.387	31059.6	33318.6	197.646	61.67	103.47	320
410.000	4.947	0.20215	0.6643	19.940	31907.2	34333.1	200.151	62.51	99.60	325
420.000	4.641	0.21548	0.6063	21.569	32727.6	35313.5	202.514	63.41	96.05	331
430.000	4.381	0.22827	0.5587	23.229	33529.2	36268.5	204.762	64.35	94.46	337
440.000	4.157	0.24057	0.5189	24.892	34317.8	37204.6	206.914	65.32	92.87	343
450.000	3.962	0.25242	0.4852	26.538	35098.3	38127.3	208.987	66.32	91.75	349
460.000	3.790	0.26388	0.4561	28.155	35874.2	39040.8	210.995	67.34	91.01	356
470.000	3.636	0.27500	0.4309	29.739	36648.3	39948.2	212.947	68.38	90.56	362
480.000	3.499	0.28581	0.4087	31.286	37423.0	40852.7	214.851	69.42	90.35	368
490.000	3.374	0.29635	0.3890	32.798	38199.9	41756.0	216.714	70.48	90.33	374
500.000	3.261	0.30665	0.3714	34.276	38979.9	42659.6	218.540	71.53	90.45	380
520.000	3.062	0.32662	0.3412	37.134	40554.3	44473.8	222.098	73.65	91.04	391
540.000	2.891	0.34591	0.3162	39.878	42152.5	46303.3	225.550	75.75	91.96	401
560.000	2.743	0.36461	0.2951	42.522	43778.1	48153.5	228.914	77.84	93.09	411
580.000	2.612	0.38284	0.2770	45.081	45433.4	50027.5	232.202	79.89	94.37	421
600.000	2.496	0.40067	0.2613	47.566	47120.6	51928.5	235.425	81.92	95.75	430

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 130.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DF/CT BAR/K	DF/DD BAR/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	W M/SEC
91.907	21.742	0.04599	34.3255	983.301	5347.5	5945.4	77.025	45.06	68.36	2227
100.000	21.461	0.04660	31.2731	905.610	5892.9	6498.7	82.794	44.94	68.38	2141
110.000	21.117	0.04735	28.0700	818.424	6567.2	7182.9	89.315	44.72	68.46	2041
120.000	20.775	0.04814	25.3450	739.631	7242.4	7868.2	95.277	44.46	68.61	1948
130.000	20.431	0.04894	22.9859	668.140	7919.0	8555.2	100.777	44.20	68.82	1860
140.000	20.086	0.04979	20.9139	603.089	8597.7	9244.9	105.887	43.95	69.12	1776
150.000	19.737	0.05067	19.0723	543.791	9279.3	9937.9	110.669	43.75	69.51	1695
160.000	19.384	0.05159	17.4120	489.648	9964.7	10635.4	115.170	43.61	69.99	1617
170.000	19.026	0.05256	15.9224	440.143	10654.9	11338.2	119.430	43.53	70.59	1541
180.000	18.660	0.05359	14.5584	394.819	11350.8	12047.5	123.464	43.54	71.29	1466
190.000	18.288	0.05468	13.3082	353.265	12053.6	12764.4	127.360	43.64	72.13	1393
200.000	17.907	0.05585	12.1567	315.116	12764.4	13490.4	131.084	43.84	73.09	1322
210.000	17.516	0.05709	11.0920	280.043	13484.5	14226.7	134.676	44.12	74.20	1251
220.000	17.114	0.05843	10.1043	247.757	14215.2	14974.4	138.156	44.51	75.46	1182
230.000	16.699	0.05988	9.1851	218.004	14958.0	15736.4	141.541	44.97	76.89	1113
240.000	16.271	0.06146	8.3274	190.570	15714.3	16513.3	144.847	45.52	78.51	1045
250.000	15.825	0.06319	7.5253	165.276	16485.9	17307.4	148.089	46.14	80.35	978
260.000	15.359	0.06511	6.7732	141.978	17274.7	18121.1	151.280	46.82	82.44	912
270.000	14.869	0.06725	6.0664	120.574	18082.8	18957.1	154.435	47.55	84.82	846
280.000	14.351	0.06968	5.4010	100.999	18912.9	19818.8	157.568	48.32	87.59	780
290.000	13.797	0.07248	4.7733	83.235	19768.2	20710.4	160.697	49.13	90.83	715
300.000	13.201	0.07575	4.1810	67.314	20652.6	21637.4	163.839	49.99	94.70	651
310.000	12.551	0.07967	3.6230	53.325	21571.4	22607.2	167.018	50.98	99.42	588
320.000	11.838	0.08447	3.1007	41.418	22531.3	23629.4	170.263	52.23	105.23	527
330.000	11.052	0.09048	2.6186	31.784	23539.7	24715.9	173.606	53.97	112.25	469
340.000	10.194	0.09810	2.1853	24.601	24600.3	25875.5	177.067	57.02	120.54	416
350.000	9.290	0.10764	1.8119	19.923	25704.3	27103.7	180.627	57.77	124.60	378
360.000	8.399	0.11906	1.5067	17.529	26806.1	28353.9	184.149	58.59	124.68	352
370.000	7.590	0.13175	1.2632	16.883	27870.6	29583.3	187.518	59.40	120.67	338
380.000	6.901	0.14491	1.0893	17.326	28877.1	30760.9	190.659	60.18	114.83	332
390.000	6.326	0.15808	0.9520	18.132	29827.6	31882.7	193.573	60.98	109.70	329
400.000	5.845	0.17109	0.8449	19.226	30732.8	32957.0	196.294	61.81	105.28	330
410.000	5.442	0.18377	0.7599	20.548	31601.5	33990.5	198.846	62.67	101.58	333
420.000	5.101	0.19606	0.6913	21.991	32442.4	34991.1	201.257	63.57	98.65	337
430.000	4.809	0.20794	0.6349	23.509	33262.5	35965.7	203.551	64.51	96.39	342
440.000	4.558	0.21942	0.5878	25.070	34068.2	36920.6	205.746	65.48	94.67	347
450.000	4.338	0.23052	0.5479	26.648	34863.9	37860.7	207.959	66.47	93.41	353
460.000	4.145	0.24128	0.5137	28.224	35653.4	38790.1	209.902	67.49	92.53	359
470.000	3.973	0.25172	0.4841	29.786	36439.8	39712.2	211.885	68.52	91.95	365
480.000	3.818	0.26189	0.4581	31.326	37225.1	40629.6	213.817	69.55	91.61	370
490.000	3.679	0.27180	0.4352	32.840	38011.6	41545.0	215.704	70.60	91.48	376
500.000	3.553	0.28147	0.4148	34.325	38800.6	42459.8	217.552	71.65	91.50	382
520.000	3.331	0.30024	0.3799	37.211	40390.2	44293.3	221.148	73.75	91.93	393
540.000	3.141	0.31833	0.3511	39.989	42001.0	46139.2	224.631	75.85	92.72	403
560.000	2.977	0.33586	0.3269	42.669	43637.3	48003.5	228.021	77.92	93.75	413
580.000	2.833	0.35293	0.3063	45.262	45301.8	49889.8	231.331	79.97	94.94	423
600.000	2.706	0.36960	0.2885	47.780	46997.0	51801.8	234.572	81.99	96.26	432

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 140.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DP/DT BAR/K	DP/DO BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	W M/SEC
92.060	21.747	0.04598	34.2734	984.978	5351.3	5995.0	77.064	45.13	68.35	2227
100.000	21.472	0.04657	31.2089	909.001	5005.0	6537.0	82.719	45.01	68.37	2143
110.000	21.129	0.04733	28.0921	822.013	5559.2	7221.0	89.238	44.79	68.44	2044
120.000	20.780	0.04810	25.3725	743.390	7233.3	7906.0	95.198	44.53	68.57	1951
130.000	20.446	0.04891	23.0104	672.046	7908.8	8593.5	100.695	44.26	68.78	1864
140.000	20.103	0.04974	20.9510	607.125	8506.2	9202.7	105.802	44.02	69.07	1780
150.000	19.756	0.05062	19.1138	547.941	9266.5	9975.1	110.579	43.82	69.44	1699
160.000	19.405	0.05153	17.4648	493.902	9950.4	10671.0	115.075	43.67	69.91	1622
170.000	19.040	0.05250	15.9724	444.495	10638.0	11373.0	119.331	43.60	70.49	1546
180.000	18.666	0.05352	14.6127	399.265	11332.0	12082.0	123.379	43.61	71.18	1472
190.000	18.316	0.05460	13.3667	357.804	12033.4	12797.0	127.248	43.71	71.99	1400
200.000	17.938	0.05575	12.2196	319.748	12741.0	13522.3	130.964	43.90	72.93	1329
210.000	17.551	0.05698	11.1594	284.770	13459.2	14256.0	134.548	44.19	74.00	1259
220.000	17.154	0.05830	10.1783	252.584	14106.7	15002.0	138.018	44.57	75.22	1191
230.000	16.745	0.05972	9.2621	222.936	14925.7	15761.0	141.392	45.04	76.60	1123
240.000	16.322	0.06127	8.4099	195.613	15677.0	16535.5	144.664	45.59	78.16	1056
250.000	15.884	0.06296	7.6136	170.434	16444.2	17325.6	147.909	46.20	79.90	990
260.000	15.420	0.06482	6.8681	147.257	17226.0	18134.3	151.081	46.88	81.87	925
270.000	14.950	0.06689	6.1688	125.973	18027.4	18963.9	154.211	47.60	84.09	860
280.000	14.447	0.06922	5.5117	106.516	18840.2	19817.2	157.314	48.37	86.63	797
290.000	13.913	0.07187	4.8938	88.856	19691.5	20697.7	160.404	49.16	89.54	734
300.000	13.343	0.07494	4.3120	73.309	20560.4	21609.6	163.495	50.01	92.94	672
310.000	12.730	0.07856	3.7675	59.036	21458.0	22558.6	166.607	50.88	96.97	611
320.000	12.065	0.08209	3.2508	47.039	22391.4	23551.9	169.780	52.19	101.83	552
330.000	11.343	0.08616	2.7900	37.151	23364.0	24590.4	172.980	53.89	107.63	497
340.000	10.565	0.09065	2.3666	29.489	24300.5	25705.7	176.284	56.89	114.75	445
350.000	9.746	0.10261	1.9958	24.087	25437.0	26873.5	179.669	57.62	118.55	406
360.000	8.923	0.11207	1.6835	20.016	26499.0	28068.0	183.037	58.46	120.02	377
370.000	8.145	0.12277	1.4307	19.320	27544.5	29263.3	186.310	59.32	118.41	358
380.000	7.451	0.13421	1.2322	19.107	28550.5	30429.4	189.420	60.17	114.56	348
390.000	6.856	0.14586	1.0777	19.667	29510.0	31552.1	192.337	61.02	110.03	343
400.000	6.350	0.15749	0.9562	20.483	30427.6	32632.5	195.072	61.89	106.17	342
410.000	5.910	0.16899	0.8587	21.524	31311.6	33677.4	197.653	62.78	102.89	343
420.000	5.540	0.18025	0.7796	22.770	32160.4	34691.9	200.097	63.70	100.11	345
430.000	5.229	0.19122	0.7143	24.4127	33004.2	35681.3	202.426	64.64	97.09	349
440.000	4.953	0.20190	0.6598	25.555	33824.7	36651.3	204.656	65.61	96.16	353
450.000	4.711	0.21227	0.6136	27.029	34634.1	37605.9	206.801	66.60	94.84	358
460.000	4.497	0.22236	0.5740	28.529	35436.2	38549.2	208.875	67.61	93.88	363
470.000	4.307	0.23217	0.5397	30.030	36234.0	39484.4	210.886	68.64	93.21	368
480.000	4.137	0.24174	0.5098	31.543	37029.0	40414.1	212.844	69.67	92.78	374
490.000	3.983	0.25107	0.4833	33.036	37825.7	41340.7	214.754	70.71	92.56	379
500.000	3.843	0.26019	0.4599	34.512	38623.0	42265.6	216.623	71.76	92.50	385
520.000	3.599	0.27787	0.4159	37.399	40227.6	44117.8	220.295	73.85	92.78	395
540.000	3.391	0.29491	0.3872	40.194	41850.8	45979.5	223.768	75.93	93.45	406
560.000	3.211	0.31141	0.3598	42.898	43497.5	47857.2	227.183	78.00	94.39	415
580.000	3.054	0.32746	0.3364	45.4519	45171.4	49755.8	230.514	80.04	95.51	425
600.000	2.914	0.34313	0.3163	48.065	46874.5	51678.4	233.773	82.05	96.76	434

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 150.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DF/CT BAR/K	DF/DD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CF J/MOL/K	W M/SEC
92.212	21.752	0.04597	34.2219	986.666	5355.1	6044.7	77.104	45.20	68.34	2227
100.000	21.483	0.04655	31.3048	912.388	5878.7	6576.9	82.645	45.08	68.35	2145
110.000	21.142	0.04730	28.1142	825.598	6551.2	7260.7	89.162	44.85	68.42	2046
120.000	20.801	0.04807	25.4001	747.143	7224.3	7945.4	95.119	44.60	68.54	1954
130.000	20.461	0.04887	23.0508	675.944	7898.7	8631.8	100.613	44.33	68.74	1867
140.000	20.119	0.04970	20.9820	611.150	8574.9	9320.5	105.717	44.09	69.02	1784
150.000	19.774	0.05057	19.1551	552.079	9253.8	10012.4	110.490	43.88	69.38	1704
160.000	19.425	0.05148	17.5102	498.143	9936.2	10708.4	114.982	43.74	69.84	1626
170.000	19.071	0.05244	16.0220	448.831	10622.9	11409.5	119.232	43.67	70.40	1551
180.000	18.710	0.05345	14.6664	403.692	11315.1	12116.8	123.274	43.68	71.07	1478
190.000	18.344	0.05451	13.4245	362.320	12013.6	12831.3	127.138	43.77	71.86	1406
200.000	17.969	0.05565	12.2816	324.353	12719.6	13554.4	130.846	43.97	72.77	1336
210.000	17.586	0.05686	11.2258	289.467	13434.3	14287.2	134.422	44.26	73.82	1267
220.000	17.193	0.05816	10.2473	257.375	14158.7	15031.2	137.882	44.64	75.00	1199
230.000	16.789	0.05956	9.3379	227.825	14894.3	15787.7	141.245	45.10	76.33	1132
240.000	16.373	0.06108	8.4907	200.605	15642.2	16558.3	144.524	45.65	77.82	1066
250.000	15.942	0.06273	7.7000	175.533	16403.8	17344.7	147.735	46.26	79.49	1001
260.000	15.495	0.06454	6.9605	152.464	17180.7	18148.8	150.888	46.94	81.35	937
270.000	15.028	0.06654	6.2679	131.290	17974.4	18972.5	153.996	47.66	83.43	874
280.000	14.539	0.06878	5.6184	111.936	18786.5	19818.3	157.072	48.41	85.77	812
290.000	14.023	0.07131	5.0091	94.364	19619.2	20688.9	160.127	49.20	88.42	751
300.000	13.475	0.07421	4.4376	78.577	20474.7	21587.9	163.174	50.04	91.44	691
310.000	12.891	0.07757	3.9029	64.612	21355.9	22519.4	166.228	50.98	94.96	633
320.000	12.266	0.08153	3.4054	52.538	22266.3	23489.2	169.307	52.17	99.12	576
330.000	11.594	0.08625	2.9471	42.445	23210.8	24504.6	172.831	53.83	104.07	522
340.000	10.870	0.09193	2.5320	34.406	24192.9	25571.8	175.617	56.80	110.34	471
350.000	10.128	0.09874	2.1646	28.440	25211.7	26692.8	178.866	57.50	113.71	432
360.000	9.366	0.10677	1.8489	24.454	26239.9	27841.4	182.102	58.34	115.71	402
370.000	8.628	0.11590	1.5862	22.207	27261.0	28999.5	185.275	59.23	115.54	380
380.000	7.947	0.12583	1.3734	21.319	28258.0	30145.4	188.331	60.13	113.36	366
390.000	7.344	0.13617	1.2036	21.392	29220.2	31262.8	191.233	61.03	110.00	358
400.000	6.821	0.14661	1.0605	22.026	30145.6	32344.8	193.973	61.93	106.50	355
410.000	6.369	0.15701	0.9595	22.849	31039.6	33394.7	196.566	62.85	103.57	354
420.000	5.977	0.16730	0.8701	23.852	31908.3	34417.7	199.031	63.78	101.10	355
430.000	5.637	0.17741	0.7962	25.037	32756.6	35417.7	201.385	64.74	99.00	357
440.000	5.339	0.18731	0.7341	26.324	33589.5	36399.1	203.641	65.72	97.32	360
450.000	5.077	0.19697	0.6815	27.679	34410.8	37365.4	205.813	66.71	96.01	364
460.000	4.845	0.20641	0.6364	29.080	35224.0	38320.2	207.911	67.72	95.02	368
470.000	4.638	0.21563	0.5974	30.510	36032.2	39266.7	209.947	68.75	94.31	373
480.000	4.452	0.22463	0.5633	31.956	36837.7	40207.1	211.927	69.78	93.83	378
490.000	4.284	0.23342	0.5333	33.406	37642.5	41143.8	213.858	70.81	93.54	383
500.000	4.132	0.24202	0.5066	34.852	38448.1	42078.5	215.747	71.86	93.42	388
520.000	3.865	0.25872	0.4614	37.709	40066.8	43947.6	219.412	73.94	93.59	398
540.000	3.639	0.27481	0.4244	40.500	41702.2	45824.4	222.954	76.02	94.15	408
560.000	3.444	0.29040	0.3935	43.214	43359.5	47715.5	226.393	78.08	95.00	418
580.000	3.273	0.30556	0.3674	45.852	45042.3	49625.7	229.744	80.11	96.05	428
600.000	3.122	0.32034	0.3449	48.419	46753.3	51558.5	233.020	82.12	97.24	437

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 160.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DF/CT BAR/K	DF/DO BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CF J/MOL/K	W M/SEC
92.364	21.757	0.04596	34.1712	988.363	5358.9	6094.3	77.144	45.27	68.33	2227
100.000	21.494	0.04652	31.3209	915.772	5871.6	6616.0	82.571	45.15	68.34	2147
110.000	21.154	0.04727	28.1364	829.177	6543.2	7299.6	89.086	44.92	68.35	2049
120.000	20.815	0.04804	25.4276	750.889	7215.4	7984.1	95.041	44.66	68.51	1957
130.000	20.476	0.04884	23.0832	679.834	7888.6	8670.1	100.532	44.40	68.70	1870
140.000	20.135	0.04966	21.0248	615.165	8563.7	9358.3	105.632	44.15	68.97	1788
150.000	19.792	0.05053	19.1962	556.205	9241.2	10049.7	110.402	43.95	69.32	1708
160.000	19.445	0.05143	17.5954	502.370	9922.1	10745.0	114.889	43.80	69.76	1631
170.000	19.093	0.05238	16.0713	453.151	10607.3	11445.3	119.134	43.73	70.31	1557
180.000	18.735	0.05338	14.7156	408.100	11297.6	12151.6	123.171	43.74	70.97	1484
190.000	18.371	0.05443	13.4818	366.814	11994.1	12865.0	127.028	43.84	71.74	1413
200.000	18.000	0.05556	12.3430	328.932	12697.8	13586.7	130.730	44.03	72.62	1343
210.000	17.620	0.05675	11.2914	294.133	13409.8	14317.9	134.297	44.32	73.64	1275
220.000	17.232	0.05803	10.3172	262.130	14131.4	15059.9	137.749	44.70	74.79	1208
230.000	16.833	0.05941	9.4123	232.675	14863.5	15814.0	141.101	45.16	76.07	1142
240.000	16.422	0.06089	8.5700	205.548	15607.5	16581.8	144.368	45.71	77.51	1077
250.000	15.998	0.06251	7.7844	180.575	16364.6	17364.7	147.564	46.32	79.10	1013
260.000	15.559	0.06427	7.0506	157.606	17136.1	18164.4	150.700	46.99	80.87	950
270.000	15.103	0.06621	6.3641	136.529	17923.3	18982.8	153.788	47.71	82.63	889
280.000	14.626	0.06837	5.7215	117.266	18727.7	19821.7	156.839	48.46	85.00	827
290.000	14.126	0.07079	5.1196	99.771	19550.9	20683.6	159.863	49.24	87.42	769
300.000	13.598	0.07354	4.5564	84.032	20394.6	21571.2	162.872	50.07	90.15	703
310.000	13.040	0.07669	4.0307	70.070	21260.9	22487.9	165.878	51.00	93.27	653
320.000	12.447	0.08034	3.5425	57.928	22152.8	23438.3	168.895	52.16	96.91	598
330.000	11.816	0.08463	3.0929	47.662	23074.4	24428.4	171.941	53.79	101.23	545
340.000	11.150	0.08969	2.6846	39.318	24029.1	25464.1	175.033	56.73	106.86	496
350.000	10.455	0.09565	2.3207	32.898	25017.5	26547.9	178.174	57.41	109.83	458
360.000	9.746	0.10260	2.0036	28.327	26016.1	27657.8	181.301	58.24	111.95	426
370.000	9.049	0.11051	1.7344	25.428	27013.7	28781.9	184.381	59.14	112.60	401
380.000	8.390	0.11918	1.5110	23.916	27997.2	29904.2	187.374	60.07	111.60	384
390.000	7.790	0.12836	1.3287	23.449	28956.0	31009.8	190.246	61.01	109.39	374
400.000	7.258	0.13777	1.1810	23.718	29885.4	32089.8	192.981	61.94	106.59	368
410.000	6.793	0.14722	1.0609	24.401	30786.4	33141.8	195.578	62.89	103.87	366
420.000	6.385	0.15661	0.9621	25.229	31663.2	34168.9	198.054	63.84	101.63	365
430.000	6.027	0.16591	0.8797	26.203	32521.1	35175.6	200.423	64.81	99.77	366
440.000	5.712	0.17507	0.8103	27.339	33364.0	36165.2	202.698	65.80	98.19	368
450.000	5.433	0.18407	0.7514	28.570	34195.3	37140.4	204.890	66.80	96.93	371
460.000	5.184	0.19289	0.7007	29.863	35018.4	38104.7	207.009	67.81	95.96	375
470.000	4.962	0.20153	0.6569	31.201	35835.9	39060.4	209.064	68.84	95.23	379
480.000	4.762	0.21000	0.6185	32.571	36650.1	40010.1	211.064	69.87	94.73	383
490.000	4.581	0.21829	0.5847	33.959	37463.1	40955.6	213.014	70.90	94.41	389
500.000	4.417	0.22641	0.5548	35.358	38276.1	41898.6	214.919	71.94	94.25	392
510.000	4.269	0.23429	0.5240	36.763	39080.7	42838.8	216.816	73.02	94.33	402
520.000	4.129	0.24219	0.4927	38.153	39908.7	43783.8	218.616	74.09	94.82	412
530.000	3.985	0.25043	0.4627	40.515	40755.7	44744.6	220.416	75.15	95.59	421
540.000	3.844	0.25829	0.4327	42.821	41623.1	45728.2	222.216	76.15	96.57	430
550.000	3.694	0.26654	0.4028	45.164	42523.1	46749.5	224.016	77.15	97.71	439
560.000	3.549	0.27529	0.3722	47.548	43453.4	47804.2	225.816	78.15	98.84	448
570.000	3.409	0.28454	0.3422	49.972	44418.7	48904.2	227.616	79.15	100.00	457
580.000	3.272	0.29429	0.3122	52.446	45423.1	50044.2	229.416	80.15	101.15	466
590.000	3.139	0.30454	0.2822	54.969	46463.4	51214.2	231.216	81.15	102.30	475
600.000	3.010	0.31529	0.2522	57.542	47543.4	52424.2	233.016	82.15	103.45	484

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 170.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DP/CT BAR/K	BAR-L/MOL	DF/DO	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	W M/SEC
92.516	21.761	0.04595	34.1211	990.071	5362.7	6143.9	77.183	45.34	68.32	2227	
100.000	21.505	0.04650	31.3370	919.153	5864.6	6655.1	82.497	45.22	68.32	2143	
110.000	21.166	0.04725	28.1586	832.752	6535.3	7338.5	89.010	44.99	68.37	2051	
120.000	20.828	0.04801	25.4551	754.629	7206.5	8022.7	94.963	44.73	68.48	1960	
130.000	20.490	0.04880	23.1154	683.716	7878.7	8708.4	100.451	44.46	68.66	1874	
140.000	20.151	0.04962	21.0615	619.171	8552.6	9396.2	105.548	44.22	68.92	1791	
150.000	19.810	0.05048	19.2370	560.320	9228.8	10087.0	110.314	44.01	69.26	1712	
160.000	19.465	0.05138	17.6004	506.583	9908.3	10781.7	114.797	43.87	69.69	1636	
170.000	19.115	0.05232	16.1202	457.455	10591.8	11481.2	119.037	43.79	70.23	1562	
180.000	18.759	0.05331	14.7724	412.489	11280.3	12186.5	123.069	43.80	70.86	1490	
190.000	18.398	0.05435	13.5385	371.286	11974.8	12898.8	126.920	43.90	71.61	1419	
200.000	18.030	0.05546	12.4037	333.486	12676.3	13619.2	130.615	44.10	72.48	1350	
210.000	17.654	0.05664	11.3561	298.770	13385.8	14348.8	134.174	44.38	73.47	1282	
220.000	17.269	0.05791	10.3861	266.852	14104.5	15088.9	137.617	44.76	74.58	1216	
230.000	16.875	0.05926	9.4856	237.483	14833.4	15840.8	140.959	45.23	75.83	1151	
240.000	16.470	0.06072	8.6478	210.446	15573.7	16605.9	144.215	45.77	77.21	1087	
250.000	16.053	0.06229	7.8671	185.563	16326.5	17385.5	147.398	46.38	78.74	1024	
260.000	15.622	0.06401	7.1385	162.685	17093.0	18181.2	150.518	47.05	80.42	962	
270.000	15.175	0.06598	6.4577	141.697	17874.2	18994.5	153.587	47.76	82.27	901	
280.000	14.709	0.06790	5.8212	122.514	18671.5	19827.2	156.615	48.51	84.30	841	
290.000	14.223	0.07031	5.2260	105.085	19486.0	20681.2	159.612	49.28	86.54	783	
300.000	13.714	0.07292	4.6701	89.386	20319.2	21558.8	162.587	50.10	89.02	727	
310.000	13.177	0.07589	4.1521	75.423	21172.6	22462.7	165.550	51.01	91.82	672	
320.000	12.612	0.07929	3.6716	63.218	22048.7	23396.6	168.515	52.16	95.06	619	
330.000	12.016	0.08322	3.2293	52.805	22951.2	24366.0	171.498	53.77	98.91	568	
340.000	11.390	0.08780	2.8268	44.207	23883.4	25376.0	174.513	56.68	104.06	520	
350.000	10.739	0.09311	2.4661	37.412	24846.9	26429.9	177.567	57.34	106.67	481	
360.000	10.076	0.09924	2.1488	32.355	25820.4	27507.6	180.603	58.15	108.75	449	
370.000	9.418	0.10618	1.8752	28.897	26796.3	28601.4	183.600	59.06	109.82	423	
380.000	8.785	0.11382	1.6440	26.817	27764.7	29699.8	186.529	60.01	109.63	404	
390.000	8.197	0.12200	1.4516	25.835	28716.3	30790.2	189.362	60.97	108.31	391	
400.000	7.664	0.13048	1.2930	25.664	29645.4	31863.5	192.080	61.93	106.30	383	
410.000	7.189	0.13910	1.1625	26.071	30550.6	32915.2	194.677	62.90	104.02	379	
420.000	6.770	0.14771	1.0546	26.787	31433.6	33944.6	197.158	63.88	101.92	377	
430.000	6.399	0.15627	0.9643	27.621	32298.4	34954.9	199.535	64.86	100.21	377	
440.000	6.070	0.16475	0.8878	28.572	33149.0	35949.7	201.822	65.86	98.81	378	
450.000	5.776	0.17312	0.8226	29.667	33988.6	36931.7	204.029	66.87	97.63	380	
460.000	5.514	0.18136	0.7664	30.851	34819.9	37903.1	206.164	67.89	96.70	382	
470.000	5.278	0.18946	0.7177	32.094	35645.4	38866.3	208.236	68.91	95.99	386	
480.000	5.065	0.19742	0.6751	33.379	36467.4	39823.5	210.251	69.95	95.49	389	
490.000	4.873	0.20523	0.6376	34.695	37287.8	40776.6	212.217	70.98	95.16	393	
500.000	4.697	0.21290	0.6043	36.033	38108.0	41727.3	214.137	72.02	94.99	398	
520.000	4.389	0.22784	0.5479	38.739	39753.3	43626.5	217.862	74.10	95.01	406	
540.000	4.127	0.24228	0.5019	41.448	41411.5	45530.3	221.454	76.16	95.43	416	
560.000	3.902	0.25629	0.4638	44.127	43088.6	47445.5	224.937	78.21	96.14	425	
580.000	3.705	0.26991	0.4316	46.760	44788.8	49377.3	228.326	80.24	97.07	434	
600.000	3.531	0.28320	0.4041	49.339	46515.0	51329.4	231.635	82.24	98.16	443	

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 180.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DF/DT BAR/K	DF/DD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CF J/MOL/K	W M/SEC
92.668	21.766	0.04594	34.0718	991.789	5366.5	6193.5	77.222	45.441	68.31	2227
100.000	21.516	0.04648	31.3533	922.531	5857.7	6694.3	82.423	45.429	68.31	2151
110.000	21.178	0.04722	28.1809	836.323	6527.5	7377.5	88.935	45.06	68.35	2054
120.000	20.841	0.04798	25.4826	758.363	7197.8	8061.4	94.886	44.80	68.45	1963
130.000	20.505	0.04877	23.1476	687.590	7868.9	8746.7	100.371	44.53	68.62	1877
140.000	20.168	0.04958	21.0981	623.168	8541.6	9434.1	105.465	44.28	68.87	1795
150.000	19.828	0.05043	19.2777	564.424	9216.5	10124.4	110.227	44.08	69.20	1717
160.000	19.484	0.05132	17.6450	510.783	9894.6	10818.4	114.706	43.93	69.62	1641
170.000	19.136	0.05226	16.1687	461.743	10576.5	11517.1	118.941	43.86	70.14	1567
180.000	18.784	0.05324	14.8248	416.860	11263.3	12221.6	122.968	43.87	70.76	1495
190.000	18.425	0.05427	13.5947	375.737	11955.8	12932.8	126.813	43.97	71.50	1425
200.000	18.060	0.05537	12.4638	338.016	12655.1	13651.8	130.501	44.16	72.34	1357
210.000	17.687	0.05654	11.4201	303.378	13362.3	14379.9	134.053	44.44	73.30	1290
220.000	17.307	0.05778	10.4541	271.540	14078.2	15118.3	137.488	44.82	74.38	1224
230.000	16.917	0.05911	9.5577	242.253	14804.0	15868.0	140.820	45.29	75.59	1160
240.000	16.517	0.06054	8.7243	215.300	15540.8	16630.5	144.065	45.83	76.93	1096
250.000	16.106	0.06209	7.9481	190.501	16289.5	17407.1	147.235	46.44	78.40	1034
260.000	15.682	0.06377	7.2243	167.706	17051.1	18198.9	150.341	47.10	80.01	973
270.000	15.244	0.06560	6.5488	146.797	17826.8	19007.6	153.392	47.81	81.76	914
280.000	14.789	0.06762	5.9178	127.686	18617.5	19834.6	156.400	48.55	83.67	855
290.000	14.316	0.06985	5.3287	110.314	19424.2	20681.5	159.371	49.32	85.74	799
300.000	13.822	0.07235	4.7792	94.648	20247.9	21550.2	162.316	50.13	88.02	743
310.000	13.306	0.07516	4.2679	80.680	21090.0	22442.8	165.243	51.03	90.56	690
320.000	12.764	0.07835	3.7940	68.419	21952.5	23362.7	168.163	52.17	93.49	639
330.000	12.196	0.08199	3.3579	57.877	22838.7	24314.5	171.092	53.76	96.97	589
340.000	11.604	0.08617	2.9604	49.061	23752.1	25303.2	174.043	56.65	101.75	541
350.000	10.992	0.09098	2.6026	41.951	24694.8	26332.4	177.026	57.28	104.05	503
360.000	10.367	0.09646	2.2854	36.485	25647.0	27383.3	179.986	58.08	106.04	471
370.000	9.744	0.10263	2.0090	32.545	26603.4	28450.7	182.911	58.99	107.32	444
380.000	9.138	0.10943	1.7719	29.956	27556.6	29526.3	185.780	59.95	107.64	423
390.000	8.566	0.11674	1.5715	28.490	28498.8	30600.2	188.569	60.92	107.00	408
400.000	8.038	0.12441	1.4038	27.893	29424.5	31663.9	191.262	61.91	105.65	399
410.000	7.560	0.13227	1.2639	27.939	30331.0	32711.9	193.850	62.90	103.92	392
420.000	7.132	0.14020	1.1472	28.445	31218.2	33741.9	196.332	63.90	102.09	389
430.000	6.752	0.14811	1.0492	29.185	32088.5	34754.5	198.715	64.90	100.48	388
440.000	6.411	0.15597	0.9660	30.023	32944.9	35752.4	201.010	65.91	99.18	388
450.000	6.106	0.16376	0.8947	30.957	33791.1	36738.8	203.226	66.92	98.13	389
460.000	5.832	0.17146	0.8332	32.017	34629.2	37715.6	205.373	67.95	97.27	390
470.000	5.585	0.17906	0.7797	33.162	35461.8	38684.9	207.458	68.98	96.60	393
480.000	5.361	0.18654	0.7328	34.361	36290.6	39648.3	209.486	70.01	96.12	396
490.000	5.157	0.19390	0.6915	35.601	37117.5	40607.8	211.465	71.05	95.80	400
500.000	4.972	0.20115	0.6548	36.871	37944.1	41564.7	213.398	72.09	95.62	403
520.000	4.645	0.21529	0.5927	39.470	39600.9	43476.1	217.147	74.17	95.62	411
540.000	4.367	0.22900	0.5421	42.105	41269.8	45391.8	220.761	76.23	95.99	420
560.000	4.127	0.24231	0.5002	44.738	42956.2	47317.8	224.264	78.28	96.66	429
580.000	3.917	0.25527	0.4648	47.345	44664.6	49259.4	227.670	80.30	97.54	437
600.000	3.733	0.26791	0.4346	49.912	46398.1	51220.5	230.994	82.29	98.59	446

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 190.0 PAR

T DEG K	DEN MOL/L	VOL L/MOL	DF/CT BAR/K	DF/DD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CF J/MOL/K	W M/SEC
92.819	21.771	0.04593	34.0231	993.518	5370.3	6243.0	77.261	45.48	68.30	2227
100.000	21.527	0.04645	31.3697	925.906	5850.8	6733.4	82.350	45.36	68.29	2153
110.000	21.190	0.04719	28.2033	839.888	6519.8	7416.4	88.860	45.13	68.33	2057
120.000	20.854	0.04795	25.5101	762.091	7189.1	8100.1	94.808	44.86	68.42	1966
130.000	20.520	0.04873	23.1798	691.457	7859.2	8785.1	100.291	44.59	68.58	1881
140.000	20.184	0.04955	21.1345	627.155	8530.7	9472.1	105.382	44.35	68.82	1799
150.000	19.845	0.05039	19.3182	568.517	9204.4	10161.8	110.140	44.14	69.14	1721
160.000	19.504	0.05127	17.6894	514.970	9881.0	10855.2	114.615	43.99	69.55	1645
170.000	19.158	0.05220	16.2169	466.017	10561.4	11553.2	118.846	43.92	70.06	1572
180.000	18.807	0.05317	14.8767	421.214	11246.5	12256.7	122.867	43.93	70.67	1501
190.000	18.451	0.05420	13.4504	380.168	11937.1	12966.8	126.707	44.03	71.38	1432
200.000	18.089	0.05528	12.5231	342.522	12634.3	13684.7	130.389	44.22	72.21	1364
210.000	17.720	0.05643	11.4832	307.960	13339.1	14411.3	133.934	44.51	73.14	1297
220.000	17.343	0.05766	10.5211	276.197	14052.4	15147.9	137.360	44.88	74.20	1232
230.000	16.958	0.05897	9.6287	246.987	14775.2	15895.6	140.684	45.35	75.37	1168
240.000	16.563	0.06038	8.7994	220.113	15508.5	16655.7	143.918	45.89	76.66	1106
250.000	16.158	0.06189	8.0276	195.391	16253.4	17429.3	147.076	46.49	78.08	1045
260.000	15.741	0.06353	7.3083	172.673	17010.6	18217.6	150.168	47.16	79.62	985
270.000	15.311	0.06531	6.6375	151.836	17781.1	19022.0	153.203	47.86	81.28	926
280.000	14.866	0.06727	6.0117	132.788	18565.7	19843.7	156.191	48.60	83.08	869
290.000	14.405	0.06942	5.4281	115.465	19365.1	20684.1	159.140	49.36	85.02	813
300.000	13.925	0.07181	4.8842	99.826	20180.3	21544.8	162.058	50.16	87.13	759
310.000	13.426	0.07448	4.3787	85.852	21012.3	22427.5	164.952	51.05	89.46	707
320.000	12.905	0.07749	3.9106	73.537	21862.8	23335.1	167.833	52.17	92.14	657
330.000	12.362	0.08089	3.4797	62.881	22735.0	24272.0	170.716	53.75	95.33	609
340.000	11.799	0.08475	3.0865	53.877	23632.5	25242.8	173.614	56.62	99.81	562
350.000	11.218	0.08914	2.7313	46.496	24557.4	26251.1	176.537	57.24	101.86	525
360.000	10.627	0.09410	2.4146	40.679	25491.4	27279.3	179.433	58.03	103.72	492
370.000	10.035	0.09965	2.1362	36.323	26430.5	28323.9	182.295	58.93	105.09	464
380.000	9.455	0.10576	1.8947	33.282	27369.2	29378.7	185.108	59.89	105.74	442
390.000	8.900	0.11236	1.6879	31.366	28301.3	30436.0	187.854	60.88	105.60	425
400.000	8.382	0.11931	1.5125	30.359	29221.5	31488.4	190.519	61.98	104.79	413
410.000	7.905	0.12650	1.3645	30.049	30126.8	32530.2	193.092	62.89	103.54	406
420.000	7.473	0.13381	1.2397	30.256	31016.1	33558.5	195.570	63.90	102.10	401
430.000	7.085	0.14114	1.1343	30.834	31890.4	34572.2	197.955	64.92	100.66	399
440.000	6.736	0.14845	1.0445	31.593	32751.8	35572.4	200.254	65.94	99.43	398
450.000	6.422	0.15571	0.9675	32.433	33602.9	36561.5	202.477	66.97	98.45	398
460.000	6.138	0.16291	0.9007	33.354	34446.7	37542.1	204.633	68.00	97.69	399
470.000	5.881	0.17004	0.8425	34.385	35285.0	38515.8	206.727	69.03	97.09	401
480.000	5.647	0.17708	0.7914	35.496	36119.7	39484.2	208.766	70.07	96.63	403
490.000	5.434	0.18402	0.7464	36.659	36952.4	40448.8	210.755	71.11	96.33	406
500.000	5.239	0.19087	0.7063	37.860	37784.6	41411.1	212.699	72.15	96.15	410
510.000	5.062	0.20227	0.6384	40.341	39452.3	43333.4	216.469	74.23	96.15	417
520.000	4.896	0.21729	0.5831	42.887	41130.7	45259.2	220.103	76.29	96.50	425
530.000	4.749	0.22995	0.5373	45.457	42826.1	47195.2	223.623	78.33	97.13	433
540.000	4.602	0.24229	0.4987	48.023	44542.4	49146.0	227.046	80.35	97.98	441
550.000	4.467	0.25435	0.4657	50.566	46282.9	51115.4	230.384	82.34	98.99	450

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 200.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DF/CT BAR/K	DF/DD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	W M/SEC
92.971	21.776	0.04592	33.9750	995.256	5374.1	6292.6	77.300	45.55	68.29	2228
100.000	21.537	0.04643	31.3862	929.277	5843.9	6772.5	82.277	45.42	68.28	2155
110.000	21.201	0.04717	28.2257	843.450	6512.1	7455.4	88.785	45.19	68.31	2059
120.000	20.868	0.04792	25.5376	765.814	7180.4	8138.9	94.732	44.92	68.39	1969
130.000	20.534	0.04870	23.2119	695.317	7849.5	8823.5	100.212	44.66	68.55	1884
140.000	20.199	0.04951	21.1708	631.134	8519.9	9510.0	105.299	44.41	68.78	1803
150.000	19.863	0.05035	19.3585	572.600	9192.4	10199.3	110.054	44.20	69.09	1725
160.000	19.523	0.05122	17.7335	519.145	9867.6	10892.0	114.525	44.06	69.48	1650
170.000	19.179	0.05210	16.2647	470.275	10546.5	11589.3	118.752	43.98	69.98	1577
180.000	18.831	0.05310	14.9282	425.551	11229.9	12291.9	122.768	43.99	70.57	1507
190.000	18.478	0.05412	13.7055	384.579	11918.7	13001.1	126.602	44.09	71.27	1438
200.000	18.118	0.05519	12.5819	347.006	12613.8	13717.7	130.277	44.28	72.07	1371
210.000	17.752	0.05633	11.5457	312.515	13316.3	14442.9	133.816	44.57	72.99	1305
220.000	17.379	0.05754	10.5872	280.824	14027.0	15177.9	137.234	44.94	74.02	1240
230.000	16.998	0.05883	9.6986	251.686	14747.0	15923.6	140.549	45.40	75.15	1177
240.000	16.608	0.06021	8.8733	224.885	15477.1	16681.3	143.774	45.94	76.41	1115
250.000	16.208	0.06170	8.1055	200.235	16218.2	17452.1	146.920	46.55	77.77	1055
260.000	15.798	0.06330	7.3905	177.587	16971.2	18237.2	149.999	47.21	79.25	996
270.000	15.376	0.06504	6.7242	156.816	17736.8	19037.5	153.019	47.91	80.84	938
280.000	14.940	0.06693	6.1031	137.825	18515.7	19854.4	155.990	48.64	82.55	882
290.000	14.490	0.06902	5.5243	120.545	19308.6	20688.9	158.918	49.40	84.37	827
300.000	14.023	0.07131	4.9856	104.928	20116.0	21542.3	161.811	50.19	86.33	775
310.000	13.539	0.07386	4.4852	90.945	20938.9	22416.2	164.676	51.08	88.49	724
320.000	13.036	0.07671	4.0221	78.579	21778.8	23313.0	167.523	52.19	90.95	675
330.000	12.515	0.07990	3.5958	67.821	22638.8	24236.9	170.366	53.75	93.91	628
340.000	11.977	0.08350	3.2062	58.650	23522.4	25192.3	173.218	56.61	98.15	582
350.000	11.423	0.08754	2.8534	51.035	24432.2	26183.0	176.090	57.21	100.00	545
360.000	10.861	0.09208	2.5373	44.913	25350.3	27191.9	178.932	57.98	101.73	512
370.000	10.296	0.09712	2.2575	40.193	26274.1	28216.5	181.739	58.88	103.13	484
380.000	9.741	0.10266	2.0126	36.750	27199.4	29252.6	184.502	59.84	103.98	461
390.000	9.205	0.10864	1.8006	34.423	28121.1	30293.9	187.207	60.83	104.19	443
400.000	8.697	0.11498	1.6188	33.026	29034.8	31334.3	189.841	61.85	103.81	429
410.000	8.226	0.12157	1.4637	32.369	29937.1	32368.4	192.395	62.87	102.98	420
420.000	7.794	0.12831	1.3317	32.274	30826.8	33393.0	194.864	63.90	101.89	414
430.000	7.400	0.13513	1.2193	32.604	31703.5	34406.0	197.248	64.93	100.73	410
440.000	7.045	0.14195	1.1232	33.236	32568.6	35407.6	199.550	65.96	99.61	409
450.000	6.723	0.14874	1.0404	34.008	33424.1	36398.9	201.778	67.00	98.69	408
460.000	6.432	0.15548	0.9687	34.851	34272.3	37381.9	203.939	68.04	97.98	409
470.000	6.166	0.16217	0.9059	35.762	35115.5	38359.0	206.040	69.08	97.44	410
480.000	5.924	0.16880	0.8507	36.768	35955.2	39331.2	208.087	70.12	97.04	411
490.000	5.703	0.17536	0.8019	37.849	36793.0	40300.1	210.085	71.16	96.76	414
500.000	5.500	0.18183	0.7585	38.980	37630.2	41266.8	212.038	72.20	96.60	415
520.000	5.141	0.19453	0.6848	41.342	39307.5	43198.2	215.825	74.28	96.60	423
540.000	4.833	0.20691	0.6248	43.790	40994.9	45133.1	219.477	76.34	96.95	430
560.000	4.567	0.21897	0.5750	46.286	42698.5	47077.9	223.013	78.38	97.57	438
580.000	4.334	0.23074	0.5331	48.798	44422.2	49037.1	226.451	80.40	98.39	446
600.000	4.128	0.24225	0.4974	51.304	46165.4	51014.3	229.802	82.39	99.37	454

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 220.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DP/CT BAR/K	DP/DD L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	W M/SEC
93.272	21.786	0.04590	33.8810	998.762	5381.8	6391.6	77.378	45.68	68.27	2228
100.000	21.559	0.04638	31.4197	936.011	5830.4	6850.9	82.132	45.56	68.25	2159
110.000	21.225	0.04711	28.2707	850.559	6496.9	7533.4	88.637	45.32	68.27	2064
120.000	20.894	0.04786	25.5927	773.241	7163.4	8216.4	94.579	45.05	68.34	1975
130.000	20.563	0.04863	23.2759	703.014	7830.5	8900.4	100.054	44.78	68.47	1891
140.000	20.231	0.04943	21.2431	639.069	8498.6	9586.1	105.136	44.53	68.69	1811
150.000	19.897	0.05026	19.4385	580.733	9168.7	10274.3	109.884	44.33	68.98	1734
160.000	19.561	0.05112	17.8210	527.458	9841.2	10965.9	114.347	44.18	69.35	1659
170.000	19.221	0.05203	16.3594	478.750	10517.2	11661.7	118.565	44.10	69.82	1588
180.000	18.878	0.05297	15.0300	434.175	11197.3	12362.7	122.572	44.11	70.39	1518
190.000	18.529	0.05397	13.8143	393.344	11882.6	13069.9	126.395	44.21	71.06	1450
200.000	18.175	0.05502	12.6976	355.906	12573.8	13784.2	130.059	44.40	71.83	1384
210.000	17.815	0.05613	11.6684	321.549	13271.9	14506.8	133.584	44.68	72.70	1319
220.000	17.449	0.05731	10.7170	289.991	13977.7	15238.6	136.988	45.06	73.68	1256
230.000	17.076	0.05856	9.8355	260.985	14692.2	15980.6	140.287	45.52	74.75	1194
240.000	16.695	0.05990	9.0175	234.316	15416.2	16734.0	143.493	46.05	75.94	1134
250.000	16.306	0.06133	8.2572	209.797	16150.4	17499.6	146.618	46.66	77.21	1075
260.000	15.908	0.06286	7.5500	187.272	16895.6	18278.6	149.673	47.31	78.59	1017
270.000	15.499	0.06452	6.8917	166.613	17652.3	19071.7	152.666	48.01	80.05	961
280.000	15.080	0.06631	6.2789	147.719	18420.9	19879.8	155.605	48.73	81.59	907
290.000	14.649	0.06826	5.7087	130.508	19202.0	20703.8	158.466	49.48	83.23	854
300.000	14.205	0.07040	5.1786	114.923	19995.9	21544.7	161.347	50.26	84.96	804
310.000	13.747	0.07274	4.6869	100.917	20803.4	22403.4	164.162	51.13	86.83	755
320.000	13.276	0.07532	4.2321	88.460	21625.1	23282.2	166.952	52.22	88.98	708
330.000	12.791	0.07818	3.8132	77.522	22464.6	24184.6	169.729	53.75	91.59	663
340.000	12.293	0.08135	3.4296	68.070	23325.3	25115.0	172.506	56.59	95.47	618
350.000	11.784	0.08486	3.0807	60.061	24210.3	26077.3	175.295	57.16	96.99	582
360.000	11.268	0.08874	2.7660	53.435	25102.5	27054.8	178.049	57.92	98.51	550
370.000	10.751	0.09302	2.4844	48.111	26000.6	28047.0	180.767	58.80	99.87	521
380.000	10.238	0.09768	2.2347	43.989	26902.3	29051.1	183.445	59.75	100.91	497
390.000	9.737	0.10270	2.0150	40.946	27804.4	30063.8	186.076	60.76	101.54	477
400.000	9.256	0.10804	1.8232	38.842	28703.7	31080.5	188.650	61.78	101.74	461
410.000	8.800	0.11363	1.6567	37.526	29597.2	32097.2	191.160	62.83	101.55	449
420.000	8.374	0.11942	1.5126	36.846	30483.3	33110.5	193.602	63.88	101.06	440
430.000	7.980	0.12532	1.3880	36.664	31360.9	34118.0	195.973	64.93	100.41	434
440.000	7.617	0.13129	1.2802	36.866	32230.0	35118.4	198.273	65.98	99.70	430
450.000	7.284	0.13728	1.1866	37.366	33091.7	36111.8	200.505	67.03	98.99	428
460.000	6.981	0.14325	1.1051	38.068	33947.0	37098.5	202.674	68.09	98.37	428
470.000	6.703	0.14919	1.0336	38.860	34797.5	38079.6	204.784	69.14	97.90	429
480.000	6.444	0.15509	0.9705	39.706	35644.9	39056.8	206.842	70.19	97.58	428
490.000	6.213	0.16095	0.9145	40.601	36490.7	40031.5	208.851	71.24	97.38	430
500.000	5.997	0.16675	0.8645	41.568	37336.3	41004.9	210.818	72.29	97.28	431
510.000	5.611	0.17821	0.7794	43.679	38029.8	42950.4	214.633	74.37	97.34	436
520.000	5.279	0.18942	0.7099	45.927	40733.0	44900.3	218.313	76.44	97.70	442
530.000	4.990	0.20039	0.6522	48.255	42451.3	46859.9	221.876	78.48	98.30	448
540.000	4.736	0.21113	0.6036	50.463	44188.5	48833.4	225.339	80.49	99.09	455
550.000	4.512	0.22165	0.5621	53.037	45948.2	50824.5	228.714	82.48	100.04	463

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 240.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	OP/CT BAR/K	OP/DO BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL-K	CV J/MOL-K	CP J/MOL-K	W M/SEC
93.573	21.796	0.04588	33.7895	1002.307	5389.5	6490.6	77.455	45.81	68.25	2228
100.000	21.580	0.04634	31.4536	942.734	5617.1	6929.2	81.988	45.69	58.23	2164
110.000	21.248	0.04706	28.3159	857.652	5481.9	7611.4	88.490	45.45	58.23	2069
120.000	20.919	0.04780	25.6477	780.646	5146.6	8293.9	94.428	45.18	68.28	1981
130.000	20.591	0.04857	23.3397	710.684	4811.7	8977.3	99.898	44.90	68.41	1897
140.000	20.262	0.04935	21.3149	646.965	4477.8	9662.3	104.974	44.65	68.60	1819
150.000	19.932	0.05017	19.5179	588.826	4145.5	10349.6	109.716	44.45	68.87	1742
160.000	19.599	0.05102	17.5075	535.723	3815.5	11040.0	114.172	44.30	69.23	1669
170.000	19.263	0.05191	16.4528	487.169	3488.6	11734.5	118.382	44.22	69.68	1598
180.000	18.923	0.05285	15.1302	442.735	3165.6	12433.9	122.379	44.23	70.22	1529
190.000	18.579	0.05382	13.9211	402.035	2847.4	13139.2	126.193	44.32	70.86	1462
200.000	18.231	0.05485	12.8111	364.723	2534.9	13851.4	129.845	44.51	71.59	1397
210.000	17.877	0.05594	11.7884	330.487	2228.9	14571.4	133.358	44.80	72.43	1333
220.000	17.517	0.05709	10.8436	299.049	1930.2	15300.3	136.749	45.17	73.36	1271
230.000	17.151	0.05830	9.9687	270.161	1639.6	16038.9	140.032	45.63	74.39	1210
240.000	16.779	0.05960	9.1573	243.606	1357.9	16788.3	143.221	46.16	75.51	1151
250.000	16.399	0.06098	8.4038	219.199	1085.8	17549.3	146.328	46.76	76.71	1094
260.000	16.012	0.06245	7.7035	196.780	823.9	18322.8	149.361	47.41	78.00	1038
270.000	15.616	0.06404	7.0522	176.216	572.6	19105.5	152.330	48.10	79.35	983
280.000	15.211	0.06574	6.4465	157.398	332.2	19910.0	155.241	48.82	80.77	931
290.000	14.797	0.06758	5.8835	140.239	103.1	20725.1	158.101	49.56	82.25	880
300.000	14.372	0.06958	5.3606	124.671	1988.4	21555.3	160.916	50.33	83.80	831
310.000	13.937	0.07175	4.8459	110.639	20675.5	22401.6	163.690	51.18	85.48	784
320.000	13.491	0.07413	4.4276	98.098	21486.6	23265.7	166.433	52.26	87.39	733
330.000	13.034	0.07672	4.0146	87.006	22309.7	24151.0	169.158	53.78	89.76	695
340.000	12.568	0.07957	3.6356	77.322	23152.2	25061.8	171.876	56.59	93.39	651
350.000	12.094	0.08268	3.2898	68.994	24017.7	26002.1	174.602	57.15	94.68	617
360.000	11.616	0.08609	2.9762	61.964	24889.4	26955.6	177.288	57.88	96.03	585
370.000	11.135	0.08980	2.6936	56.157	25767.1	27922.4	179.937	58.75	97.30	556
380.000	10.658	0.09383	2.4406	51.485	26649.2	28901.0	182.547	59.69	98.40	531
390.000	10.189	0.09815	2.2156	47.849	27534.0	29889.5	185.114	60.69	99.23	510
400.000	9.734	0.10274	2.0166	45.136	28419.0	30884.7	187.634	61.73	99.77	493
410.000	9.297	0.10756	1.8414	43.225	29302.2	31883.7	190.101	62.78	99.99	478
420.000	8.883	0.11258	1.6877	41.991	30181.7	32883.5	192.510	63.84	99.95	468
430.000	8.494	0.11773	1.5531	41.312	31056.3	33882.0	194.859	64.91	99.71	459
440.000	8.131	0.12299	1.4353	41.076	31925.7	34877.4	197.148	65.98	99.36	454
450.000	7.795	0.12829	1.3321	41.190	32790.0	35869.0	199.376	67.05	98.96	450
460.000	7.484	0.13362	1.2415	41.579	33649.6	36856.5	201.547	68.12	98.56	447
470.000	7.197	0.13895	1.1616	42.185	34505.6	37840.3	203.663	69.18	98.20	446
480.000	6.932	0.14425	1.0909	42.928	35358.8	38820.8	205.727	70.24	97.93	446
490.000	6.688	0.14952	1.0280	43.734	36210.6	39799.2	207.744	71.30	97.77	447
500.000	6.462	0.15476	0.9717	44.582	37062.2	40776.5	209.719	72.35	97.72	447
520.000	6.056	0.16513	0.8756	46.404	38768.7	42731.8	213.553	74.44	97.87	450
540.000	5.704	0.17533	0.7967	48.435	40484.8	44692.7	217.254	76.51	98.27	455
560.000	5.395	0.18535	0.7310	50.592	42215.5	46663.9	220.838	78.56	98.88	460
580.000	5.123	0.19519	0.6757	52.823	43964.5	48649.0	224.321	80.57	99.67	466
600.000	4.882	0.20485	0.6285	55.104	45735.2	50651.5	227.715	82.56	100.60	473

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 260.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DP/CT BAR/K	DP/DD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	W M/SEC
93.872	21.806	0.04586	33.7006	1005.890	5397.2	6589.6	77.532	45.94	68.23	2229
100.000	21.601	0.04629	31.4880	949.446	5803.9	7007.5	81.845	45.82	68.20	2168
110.000	21.272	0.04701	28.3614	864.729	6467.2	7689.5	88.344	45.58	68.19	2074
120.000	20.945	0.04774	25.7028	788.029	7130.2	8371.5	94.279	45.30	68.23	1987
130.000	20.619	0.04850	23.4032	718.327	7793.4	9054.3	99.744	45.02	68.34	1904
140.000	20.293	0.04928	21.3863	654.829	8457.3	9738.6	104.815	44.77	68.52	1826
150.000	19.965	0.05009	19.5965	596.881	9122.7	10425.0	109.550	44.56	68.77	1750
160.000	19.636	0.05093	17.9931	543.943	9790.2	11114.3	113.999	44.41	69.11	1678
170.000	19.304	0.05180	16.5451	495.536	10460.6	11807.5	118.201	44.34	69.54	1608
180.000	18.968	0.05272	15.2290	451.234	11134.7	12505.4	122.190	44.34	70.06	1540
190.000	18.628	0.05368	14.0262	410.657	11813.2	13208.9	125.994	44.44	70.67	1474
200.000	18.285	0.05469	12.9224	373.461	12497.1	13919.1	129.636	44.63	71.37	1409
210.000	17.936	0.05575	11.9059	339.336	13187.2	14636.7	133.138	44.91	72.18	1347
220.000	17.583	0.05687	10.9672	308.005	13884.2	15362.9	136.515	45.28	73.07	1286
230.000	17.224	0.05806	10.0985	279.221	14588.9	16098.4	139.785	45.73	74.05	1226
240.000	16.859	0.05931	9.2932	252.767	15302.0	16844.1	142.958	46.27	75.11	1168
250.000	16.489	0.06065	8.5458	228.456	16024.1	17600.9	146.048	46.86	76.26	1112
260.000	16.111	0.06207	7.8516	206.126	16755.7	18369.5	149.062	47.51	77.47	1057
270.000	15.727	0.06359	7.2065	185.639	17497.2	19150.4	152.009	48.19	78.73	1004
280.000	15.335	0.06521	6.6070	166.883	18248.8	19944.3	154.896	48.90	80.05	953
290.000	14.935	0.06696	6.0501	149.763	19010.7	20751.6	157.729	49.63	81.41	904
300.000	14.527	0.06884	5.5332	134.204	19782.9	21572.7	160.512	50.39	82.83	856
310.000	14.110	0.07087	5.0542	120.142	20565.8	22402.5	163.253	51.24	84.35	811
320.000	13.685	0.07307	4.6113	107.523	21360.5	23260.4	165.957	52.30	86.09	767
330.000	13.253	0.07546	4.2028	96.296	22169.9	24131.8	168.638	53.80	88.27	725
340.000	12.813	0.07805	3.8275	86.414	22997.6	25026.8	171.310	56.61	91.72	692
350.000	12.367	0.08086	3.4841	77.821	23847.2	25945.5	173.985	57.14	92.84	648
360.000	11.918	0.08391	3.1715	70.456	24702.4	26883.9	176.617	57.87	94.05	617
370.000	11.468	0.08720	2.8882	64.250	25563.2	27830.4	179.210	58.72	95.24	589
380.000	11.020	0.09074	2.6329	59.124	26429.1	28788.4	181.765	59.65	96.34	564
390.000	10.579	0.09453	2.4039	54.991	27298.9	29756.7	184.280	60.65	97.27	542
400.000	10.147	0.09855	2.1994	51.757	28170.8	30733.1	186.752	61.68	97.99	523
410.000	9.730	0.10277	2.0175	49.321	29043.5	31715.6	189.178	62.74	98.48	507
420.000	9.330	0.10718	1.8562	47.579	29915.3	32701.9	191.555	63.81	98.75	495
430.000	8.950	0.11173	1.7134	46.426	30785.1	33689.9	193.880	64.89	98.83	485
440.000	8.592	0.11638	1.5872	45.762	31652.2	34678.1	196.151	65.97	98.78	477
450.000	8.257	0.12111	1.4757	45.495	32516.3	35665.2	198.370	67.05	98.64	472
460.000	7.944	0.12589	1.3769	45.547	33377.7	36650.8	200.536	68.13	98.47	468
470.000	7.652	0.13069	1.2853	45.854	34236.8	37634.6	202.652	69.20	98.30	464
480.000	7.381	0.13549	1.2113	46.367	35094.3	38616.9	204.720	70.27	98.16	464
490.000	7.129	0.14027	1.1418	47.042	35950.8	39597.9	206.743	71.34	98.06	464
500.000	6.895	0.14504	1.0794	47.810	36807.3	40578.2	208.723	72.40	98.03	464
510.000	6.673	0.15048	0.9726	49.473	38523.8	42540.2	212.571	74.50	98.23	466
520.000	6.405	0.15680	0.8846	51.266	40250.2	44509.0	216.286	76.58	98.69	469
530.000	6.105	0.16380	0.8111	53.231	41991.3	46489.0	219.886	78.62	99.34	473
540.000	5.781	0.17299	0.7491	55.314	43750.4	48483.4	223.386	80.64	100.14	478
550.000	5.493	0.18204	0.6961	57.467	45530.8	50495.2	226.796	82.62	101.07	484

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 280.0 BAR

T DEG K	DN MOL/L	VOL L/MOL	DP/CT BAR/K	DP/OD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CF J/MOL/K	W M/SEC
94.171	21.815	0.04584	33.6141	1009.512	5404.9	6688.4	77.608	46.07	68.22	2230
100.000	21.622	0.04625	31.5229	956.148	5791.0	7085.9	81.704	45.95	68.18	2172
110.000	21.295	0.04696	28.4072	871.790	6452.7	7767.6	88.200	45.70	68.15	2079
120.000	20.970	0.04769	25.7579	795.392	7114.0	8449.2	94.131	45.42	68.18	1993
130.000	20.647	0.04843	23.4666	725.944	7775.3	9131.5	99.592	45.14	68.28	1911
140.000	20.323	0.04920	21.4573	662.661	8437.2	9815.0	104.657	44.89	68.44	1833
150.000	19.999	0.05000	19.6746	604.898	9100.4	10500.5	109.386	44.68	68.68	1759
160.000	19.672	0.05083	18.0778	552.120	9765.5	11188.8	113.829	44.53	69.00	1687
170.000	19.344	0.05170	16.6362	503.853	10433.3	11880.8	118.023	44.45	69.41	1618
180.000	19.012	0.05260	15.3263	459.676	11104.5	12577.2	122.004	44.45	69.90	1550
190.000	18.677	0.05354	14.1296	419.214	11779.9	13275.1	125.799	44.55	70.49	1485
200.000	18.338	0.05453	13.0318	382.124	12460.4	13987.3	129.431	44.74	71.17	1422
210.000	17.994	0.05557	12.0211	348.099	13146.7	14702.8	132.922	45.02	71.94	1360
220.000	17.647	0.05667	11.0881	316.865	13839.7	15426.4	136.288	45.38	72.80	1300
230.000	17.295	0.05782	10.2250	288.173	14539.9	16159.0	139.544	45.84	73.74	1242
240.000	16.937	0.05904	9.4253	261.809	15248.2	16901.3	142.704	46.37	74.75	1185
250.000	16.574	0.06033	8.6835	237.580	15964.9	17654.3	145.777	46.96	75.84	1130
260.000	16.206	0.06171	7.9948	215.325	16690.6	18418.4	148.774	47.60	76.99	1076
270.000	15.832	0.06316	7.3552	194.902	17425.6	19194.2	151.701	48.28	78.18	1024
280.000	15.451	0.06472	6.7611	176.195	18170.0	19982.1	154.567	48.99	79.42	975
290.000	15.064	0.06638	6.2095	159.103	18923.9	20782.6	157.376	49.71	80.68	927
300.000	14.671	0.06816	5.6977	143.545	19687.3	21595.9	160.133	50.46	81.99	881
310.000	14.270	0.07008	5.2235	129.451	20460.5	22422.6	162.843	51.30	83.38	837
320.000	13.864	0.07213	4.7849	116.758	21244.5	23264.2	165.515	52.35	85.00	794
330.000	13.451	0.07434	4.3802	105.411	22042.3	24124.0	168.161	53.84	87.04	753
340.000	13.033	0.07673	4.0078	95.356	22857.5	25005.9	170.794	56.63	90.34	711
350.000	12.611	0.07930	3.6663	86.535	23693.9	25914.2	173.426	57.15	91.34	673
360.000	12.186	0.08206	3.3544	78.887	24535.4	26833.1	176.015	57.86	92.44	647
370.000	11.761	0.08503	3.0706	72.345	25382.4	27763.1	178.563	58.70	93.56	619
380.000	11.338	0.08820	2.8135	66.835	26234.6	28704.2	181.072	59.63	94.63	594
390.000	10.920	0.09157	2.5813	62.281	27091.4	29655.4	183.543	60.62	95.60	572
400.000	10.510	0.09514	2.3725	58.599	27951.7	30615.7	185.975	61.65	96.43	552
410.000	10.111	0.09890	2.1853	55.703	28814.3	31583.4	188.364	62.71	97.09	536
420.000	9.727	0.10281	2.0178	53.504	29678.1	32556.8	190.710	63.78	97.57	522
430.000	9.358	0.10686	1.8684	51.910	30542.1	33534.2	193.010	64.87	97.89	510
440.000	9.007	0.11102	1.7351	50.835	31405.4	34514.1	195.262	65.96	98.08	501
450.000	8.675	0.11527	1.6163	50.195	32267.9	35495.4	197.468	67.05	98.17	494
460.000	8.363	0.11957	1.5104	49.912	33129.2	36477.2	199.625	68.13	98.20	483
470.000	8.070	0.12391	1.4159	49.920	33989.6	37459.1	201.737	69.22	98.20	485
480.000	7.796	0.12828	1.3313	50.166	34849.4	38441.2	203.805	70.29	98.20	483
490.000	7.539	0.13264	1.2554	50.605	35709.2	39423.2	205.830	71.37	98.22	481
500.000	7.299	0.13700	1.1872	51.203	36569.4	40405.5	207.814	72.43	98.26	481
520.000	6.865	0.14566	1.0699	52.707	38294.2	42372.8	211.672	74.54	98.51	481
540.000	6.484	0.15423	0.9731	54.376	40029.0	44347.4	215.398	76.63	99.00	483
560.000	6.147	0.16269	0.8921	56.146	41778.6	46333.9	219.011	78.68	99.69	486
580.000	5.846	0.17104	0.8234	58.058	43546.4	48335.6	222.523	80.70	100.51	490
600.000	5.576	0.17928	0.7647	60.079	45335.2	50355.2	225.946	82.68	111.45	495

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 300.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DF/CT BAR/K	DF/DD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CF J/MOL/K	W M/SEC
94.469	21.825	0.04582	33.5302	1013.170	5412.7	6787.2	77.684	46.19	68.20	2230
100.000	21.643	0.04620	31.5582	962.840	5778.2	7164.3	81.563	46.08	68.16	2176
110.000	21.318	0.04691	28.4532	878.836	6438.4	7845.7	88.057	45.82	68.12	2084
120.000	20.995	0.04763	25.8130	802.735	7098.0	8526.9	93.984	45.54	68.14	1999
130.000	20.674	0.04837	23.5298	733.536	7757.5	9208.6	99.441	45.26	68.22	1917
140.000	20.353	0.04913	21.5278	670.463	8417.5	9891.5	104.501	45.00	68.36	1840
150.000	20.032	0.04992	19.7520	612.880	9078.5	10576.2	109.225	44.79	68.59	1767
160.000	19.708	0.05074	18.1617	560.255	9741.3	11263.5	113.661	44.64	68.89	1696
170.000	19.383	0.05159	16.7263	512.121	10406.5	11954.3	117.848	44.56	69.28	1627
180.000	19.055	0.05248	15.4223	468.063	11075.0	12649.4	121.821	44.56	69.76	1561
190.000	18.724	0.05341	14.2314	427.707	11747.4	13349.7	125.607	44.66	70.32	1497
200.000	18.389	0.05438	13.1392	390.716	12424.7	14056.1	129.230	44.84	70.97	1434
210.000	18.051	0.05540	12.1340	356.783	13107.5	14769.4	132.711	45.12	71.72	1373
220.000	17.709	0.05647	11.2064	325.635	13796.6	15490.7	136.066	45.49	72.54	1314
230.000	17.363	0.05759	10.3486	297.026	14492.7	16220.5	139.310	45.94	73.45	1257
240.000	17.012	0.05878	9.5541	270.738	15196.4	16959.8	142.456	46.46	74.42	1201
250.000	16.657	0.06003	8.8174	246.581	15908.1	17709.2	145.515	47.05	75.46	1147
260.000	16.297	0.06136	8.1337	224.389	16628.4	18465.2	148.496	47.69	76.55	1094
270.000	15.932	0.06277	7.4989	204.019	17357.4	19240.4	151.406	48.37	77.69	1044
280.000	15.562	0.06426	6.9096	185.349	18095.3	20023.0	154.252	49.07	78.85	995
290.000	15.186	0.06585	6.3626	168.277	18842.0	20817.4	157.040	49.78	80.03	949
300.000	14.806	0.06754	5.8552	152.714	19597.6	21623.8	159.774	50.53	81.25	904
310.000	14.420	0.06935	5.3850	138.585	20362.2	22442.7	162.459	51.35	82.55	861
320.000	14.029	0.07128	4.9500	125.823	21137.0	23275.5	165.103	52.40	84.06	819
330.000	13.633	0.07335	4.5483	114.368	21924.8	24125.4	167.718	53.88	85.99	779
340.000	13.234	0.07557	4.1782	104.159	22729.4	24996.4	170.318	56.65	89.19	738
350.000	12.831	0.07794	3.8383	95.139	23554.6	25892.7	172.916	57.17	90.09	706
360.000	12.427	0.08047	3.5269	87.246	24384.5	26798.6	175.467	57.87	91.10	676
370.000	12.023	0.08317	3.2427	80.414	25219.7	27714.9	177.978	58.69	92.16	648
380.000	11.621	0.08605	2.9840	74.576	26060.3	28641.7	180.450	59.61	93.21	623
390.000	11.224	0.08910	2.7453	69.659	26905.9	29578.8	182.884	60.59	94.19	600
400.000	10.833	0.09231	2.5370	65.589	27755.8	30525.2	185.280	61.62	95.07	580
410.000	10.451	0.09569	2.3454	62.288	28609.2	31479.8	187.637	62.68	95.83	563
420.000	10.080	0.09920	2.1729	59.679	29465.3	32441.4	189.954	63.76	96.46	548
430.000	9.723	0.10285	2.0178	57.683	30322.3	33408.5	192.230	64.85	96.95	536
440.000	9.381	0.10660	1.8785	56.223	31182.2	34380.0	194.463	65.94	97.32	525
450.000	9.055	0.11043	1.7536	55.221	32041.7	35354.6	196.654	67.04	97.60	517
460.000	8.746	0.11433	1.6414	54.609	32901.7	36331.7	198.801	68.13	97.80	511
470.000	8.454	0.11828	1.5406	54.321	33761.9	37310.5	200.906	69.22	97.96	506
480.000	8.179	0.12226	1.4500	54.300	34622.8	38290.7	202.970	70.31	98.09	502
490.000	7.920	0.12626	1.3683	54.500	35484.4	39272.3	204.994	71.39	98.23	499
500.000	7.677	0.13027	1.2946	54.881	36347.2	40255.2	206.979	72.46	98.37	498
510.000	7.443	0.13433	1.2285	55.071	38078.4	42226.0	210.844	74.58	98.73	497
520.000	7.233	0.13825	1.1673	56.071	39820.4	44205.5	214.580	76.73	99.25	498
530.000	7.041	0.14217	1.1099	57.616	41577.2	46197.2	218.201	78.73	99.95	500
540.000	6.863	0.14617	1.0593	59.288	43352.2	48204.7	221.723	80.75	100.81	503
550.000	6.703	0.15020	1.0153	61.041	45149.2	50230.3	225.157	82.74	101.77	507
560.000	6.556	0.15433	0.9773	62.907						
570.000	6.422	0.15856	0.9438							
580.000	6.298	0.16288	0.9138							
590.000	6.184	0.16730	0.8869							
600.000	6.080	0.17182	0.8630							

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 320.0 BAR

T	DEN	VOL	DF/CT	DF/DD	E	H	S	CV	CF	W
DES K	MOL/L	L/MOL	BAR/K	BAR-L/MOL	J/MOL	J/MOL	J/MOL/K	J/MOL/K	J/MOL/K	M/SEC
94.766	21.835	0.04580	33.4486	1016.866	5420.5	6886.0	77.760	46.31	68.18	2231
100.000	21.664	0.04616	31.5941	969.522	5765.6	7242.8	81.424	46.20	68.14	2181
110.000	21.340	0.04686	28.4995	885.869	6424.3	7923.8	87.915	45.94	68.09	2090
120.000	21.020	0.04757	25.8682	810.059	7082.3	8604.7	93.839	45.66	68.09	2004
130.000	20.701	0.04831	23.5929	741.105	7740.1	9285.9	99.292	45.37	68.16	1924
140.000	20.383	0.04906	21.5980	678.237	8398.1	9968.1	104.347	45.12	68.25	1848
150.000	20.064	0.04984	19.8289	620.831	9057.1	10652.0	109.065	44.90	68.50	1775
160.000	19.744	0.05065	18.2448	568.350	9717.6	11338.4	113.495	44.75	68.79	1705
170.000	19.422	0.05149	16.8153	520.344	10390.4	12028.0	117.676	44.67	69.16	1637
180.000	19.097	0.05236	15.5171	476.398	11046.2	12721.8	121.641	44.67	69.62	1571
190.000	18.770	0.05328	14.3317	436.141	11715.8	13420.6	125.419	44.76	70.16	1508
200.000	18.440	0.05423	13.2448	399.240	12389.9	14125.3	129.033	44.95	70.79	1446
210.000	18.107	0.05523	12.2448	365.391	13069.4	14836.7	132.504	45.22	71.51	1386
220.000	17.770	0.05628	11.3222	334.320	13754.9	15555.7	135.849	45.59	72.30	1328
230.000	17.429	0.05737	10.4694	305.784	14447.0	16283.0	139.082	46.04	73.18	1271
240.000	17.085	0.05853	9.6797	279.564	15146.4	17019.4	142.216	46.56	74.12	1217
250.000	16.737	0.05975	8.9476	255.468	15853.5	17765.5	145.261	47.14	75.11	1163
260.000	16.384	0.06103	8.2685	233.329	16568.7	18521.8	148.227	47.78	76.16	1112
270.000	16.028	0.06239	7.6381	213.002	17292.3	19288.8	151.122	48.45	77.24	1063
280.000	15.667	0.06383	7.0530	194.361	18024.2	20066.7	153.951	49.15	78.34	1015
290.000	15.302	0.06535	6.5100	177.301	18764.5	20855.7	156.719	49.86	79.46	969
300.000	14.933	0.06697	6.0064	161.728	19513.0	21656.0	159.432	50.59	80.61	926
310.000	14.559	0.06868	5.5396	147.562	20270.1	22468.0	162.095	51.41	81.83	884
320.000	14.182	0.07051	5.1076	134.734	21036.8	23293.1	164.715	52.45	83.25	843
330.000	13.801	0.07246	4.7084	123.178	21815.9	24134.4	167.303	53.92	85.10	804
340.000	13.418	0.07451	4.3403	112.832	22611.2	24996.1	169.875	56.68	88.21	764
350.000	13.032	0.07673	4.0015	103.636	23426.8	25882.2	172.444	57.19	89.03	732
360.000	12.646	0.07908	3.6905	95.527	24246.7	26777.1	174.965	57.88	89.97	703
370.000	12.260	0.08156	3.4058	88.443	25071.8	27681.9	177.444	58.70	90.98	675
380.000	11.877	0.08420	3.1458	82.318	25902.4	28596.8	179.883	59.61	91.99	650
390.000	11.497	0.08698	2.9090	77.084	26738.2	29521.6	182.286	60.58	92.98	627
400.000	11.122	0.08991	2.6937	72.673	27579.0	30456.1	184.652	61.61	93.89	607
410.000	10.756	0.09297	2.4985	69.015	28424.1	31399.2	186.980	62.66	94.72	589
420.000	10.399	0.09616	2.3217	66.041	29272.9	32350.1	189.272	63.74	95.44	573
430.000	10.053	0.09947	2.1619	63.679	30124.6	33307.7	191.525	64.83	96.06	560
440.000	9.720	0.10288	2.0175	61.861	30978.9	34270.9	193.739	65.93	96.57	549
450.000	9.401	0.10637	1.8871	60.519	31835.0	35238.7	195.914	67.03	96.99	540
460.000	9.097	0.10993	1.7694	59.588	32692.8	36210.4	198.050	68.13	97.34	532
470.000	8.808	0.11354	1.6631	59.006	33552.0	37185.2	200.147	69.23	97.63	526
480.000	8.533	0.11719	1.5671	58.720	34412.8	38162.9	202.205	70.32	97.89	521
490.000	8.274	0.12086	1.4801	58.680	35275.2	39142.9	204.226	71.40	98.13	518
500.000	8.029	0.12456	1.4013	58.846	36139.5	40125.3	206.210	72.48	98.36	515
520.000	7.579	0.13194	1.2645	59.660	37875.4	42097.6	210.078	74.61	98.87	513
540.000	7.179	0.13930	1.1507	60.961	39623.2	44080.8	213.820	76.71	99.47	513
560.000	6.822	0.14659	1.0549	62.533	41386.1	46076.9	217.450	78.77	100.18	514
580.000	6.502	0.15380	0.9735	64.207	43167.4	48089.0	220.980	80.79	101.05	517
600.000	6.214	0.16094	0.9036	65.945	44969.5	50119.5	224.422	82.78	102.02	520

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 340.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DP/CT BAR/K	DF/DO BAR-L/MOL	E J/MOL	H J/MCL	S J/MCL/K	CV J/MCL/K	CP J/MOL/K	W M/SEC
95.062	21.845	0.04578	33.3693	1020.596	5428.3	6984.7	77.835	46.43	68.17	2232
100.000	21.684	0.04612	31.6305	976.197	5753.3	7321.2	81.285	46.32	68.12	2185
110.000	21.363	0.04681	28.5461	892.887	6410.5	8002.0	87.774	46.06	68.06	2095
120.000	21.044	0.04752	25.9235	817.365	7066.9	8682.5	93.695	45.77	68.05	2010
130.000	20.728	0.04824	23.6559	748.650	7722.9	9363.2	99.144	45.49	68.10	1931
140.000	20.412	0.04899	21.6679	685.982	8379.1	10044.8	104.194	45.23	68.22	1855
150.000	20.096	0.04976	19.9051	628.745	9036.0	10727.9	108.907	45.01	68.42	1783
160.000	19.779	0.05056	18.3271	576.407	9694.4	11413.4	113.331	44.86	68.69	1713
170.000	19.460	0.05139	16.9034	528.523	10354.8	12102.0	117.505	44.77	69.04	1646
180.000	19.139	0.05225	15.48106	484.682	11018.0	12794.5	121.464	44.77	69.48	1582
190.000	18.816	0.05315	14.4305	444.519	11684.9	13491.9	125.234	44.87	70.01	1519
200.000	18.490	0.05408	13.3487	407.701	12356.0	14194.9	128.840	45.05	70.62	1458
210.000	18.161	0.05506	12.3536	373.927	13032.3	14904.5	132.302	45.32	71.31	1393
220.000	17.829	0.05609	11.4358	342.926	13714.3	15621.4	135.637	45.69	72.08	1341
230.000	17.494	0.05716	10.5876	314.454	14402.7	16346.3	138.859	46.13	72.92	1286
240.000	17.155	0.05829	9.8024	288.292	15098.1	17080.0	141.982	46.65	73.83	1232
250.000	16.814	0.05948	9.0746	264.249	15800.9	17823.1	145.015	47.23	74.79	1180
260.000	16.469	0.06072	8.3996	242.154	16511.5	18576.0	147.968	47.87	75.80	1129
270.000	16.120	0.06203	7.7732	221.861	17229.9	19339.1	150.848	48.53	76.83	1081
280.000	15.768	0.06342	7.1919	203.242	17956.4	20112.7	153.661	49.22	77.88	1034
290.000	15.412	0.06488	6.6524	186.186	18690.8	20896.8	156.412	49.93	78.95	989
300.000	15.053	0.06643	6.1520	170.599	19433.0	21691.7	159.107	50.66	80.03	947
310.000	14.691	0.06807	5.6882	156.397	20183.3	22497.7	161.750	51.47	81.15	906
320.000	14.326	0.06980	5.2588	143.506	20942.7	23316.0	164.348	52.50	82.54	866
330.000	13.958	0.07164	4.8616	131.855	21714.1	24149.9	166.914	53.96	84.32	829
340.000	13.589	0.07359	4.4950	121.384	22501.5	25003.5	169.461	56.72	87.37	789
350.000	13.218	0.07565	4.1572	112.029	23308.5	25880.8	172.004	57.21	88.12	757
360.000	12.847	0.07784	3.8464	103.729	24119.8	26766.3	174.499	57.89	89.01	728
370.000	12.477	0.08015	3.5613	96.421	24936.1	27661.2	176.951	58.70	89.97	701
380.000	12.109	0.08259	3.3001	90.042	25757.9	28565.8	179.363	59.61	90.96	676
390.000	11.744	0.08515	3.0614	84.529	26585.2	29480.3	181.738	60.58	91.93	653
400.000	11.385	0.08784	2.8436	79.817	27417.9	30404.3	184.078	61.60	92.86	633
410.000	11.032	0.09064	2.6452	75.841	28255.4	31337.3	186.382	62.65	93.73	614
420.000	10.688	0.09356	2.4647	72.539	29097.4	32278.6	188.650	63.73	94.52	598
430.000	10.353	0.09659	2.3008	69.846	29943.4	33227.5	190.883	64.82	95.23	584
440.000	10.029	0.09971	2.1519	67.699	30792.8	34182.8	193.079	65.92	95.84	572
450.000	9.718	0.10290	2.0169	66.038	31645.2	35144.0	195.239	67.03	96.38	562
460.000	9.419	0.10617	1.8943	64.802	32500.3	36110.1	197.362	68.13	96.84	553
470.000	9.133	0.10949	1.7831	63.936	33358.0	37080.7	199.450	69.23	97.25	547
480.000	8.861	0.11285	1.6821	63.387	34217.9	38055.0	201.501	70.32	97.61	541
490.000	8.602	0.11625	1.5904	63.108	35080.4	39032.8	203.517	71.41	97.95	537
500.000	8.357	0.11966	1.5069	63.057	35945.5	40014.0	205.499	72.49	98.28	533
520.000	7.904	0.12652	1.3613	63.497	37684.2	41985.9	209.366	74.63	98.92	529
540.000	7.498	0.13337	1.2394	64.485	39436.5	43971.2	213.113	76.74	99.62	528
560.000	7.133	0.14018	1.1365	65.866	41204.8	45971.1	216.749	78.80	100.38	528
580.000	6.806	0.14693	1.0489	67.457	42991.4	47987.1	220.286	80.83	101.26	530
600.000	6.510	0.15361	0.9735	69.130	44799.1	50021.9	223.735	82.83	102.24	533

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 360.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DF/CT BAR/K	DF/DD L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CF J/MOL/K	W M/SEC
95.357	21.855	0.04576	33.2924	1024.364	5436.1	7083.3	77.909	46.55	68.15	2233
100.000	21.705	0.04607	31.6674	982.862	5741.0	7399.7	81.148	46.44	68.10	2189
110.000	21.385	0.04676	28.5930	899.893	6396.8	8080.3	87.635	46.18	68.03	2100
120.000	20.069	0.04746	25.9788	824.653	7051.7	8760.4	93.553	45.88	68.01	2016
130.000	20.755	0.04818	23.7187	756.173	7706.1	9440.6	98.997	45.60	68.05	1937
140.000	20.441	0.04892	21.7375	693.701	8360.4	10121.6	104.044	45.33	68.16	1862
150.000	20.128	0.04968	19.9809	636.627	9015.4	10804.0	108.752	45.12	68.34	1791
160.000	19.813	0.05047	18.4087	584.427	9671.6	11488.6	113.170	44.96	68.59	1722
170.000	19.497	0.05129	16.9905	536.659	10329.7	12176.1	117.338	44.88	68.93	1656
180.000	19.180	0.05214	15.7030	492.918	10990.5	12867.5	121.289	44.88	69.35	1592
190.000	18.860	0.05302	14.5280	452.842	11654.7	13563.5	125.052	44.97	69.86	1530
200.000	18.538	0.05394	13.4510	416.100	12323.0	14265.0	128.650	45.15	70.45	1469
210.000	18.214	0.05490	12.4606	382.396	12996.2	14972.8	132.104	45.42	71.12	1411
220.000	17.886	0.05591	11.5473	351.457	13675.0	15687.7	135.429	45.78	71.87	1355
230.000	17.556	0.05696	10.7034	323.041	14359.9	16410.4	138.642	46.22	72.69	1300
240.000	17.224	0.05806	9.9223	296.930	15051.5	17141.6	141.753	46.74	73.57	1247
250.000	16.888	0.05921	9.1985	272.930	15750.2	17881.9	144.775	47.32	74.50	1195
260.000	16.550	0.06042	8.5273	250.872	16456.4	18631.6	147.716	47.95	75.46	1146
270.000	16.208	0.06170	7.9045	230.605	17170.2	19391.2	150.582	48.61	76.46	1098
280.000	15.864	0.06304	7.3265	212.001	17891.6	20160.9	153.381	49.30	77.47	1053
290.000	15.517	0.06444	6.7902	194.946	18620.6	20940.6	156.117	50.00	78.48	1009
300.000	15.168	0.06593	6.2926	179.341	19357.1	21730.6	158.795	50.72	79.52	967
310.000	14.816	0.06750	5.8314	165.101	20101.3	22531.1	161.420	51.53	80.62	927
320.000	14.461	0.06915	5.4041	152.147	20854.2	23343.6	164.000	52.55	81.92	888
330.000	14.105	0.07090	5.0087	140.410	21618.7	24170.9	166.545	54.00	83.64	850
340.000	13.748	0.07274	4.6433	129.823	22398.9	25017.4	169.072	56.76	86.63	812
350.000	13.390	0.07468	4.3062	120.324	23198.5	25887.1	171.593	57.24	87.33	781
360.000	13.033	0.07673	3.9956	111.851	24002.1	26764.4	174.064	57.92	88.17	753
370.000	12.676	0.07889	3.7100	104.343	24810.7	27650.7	176.493	58.72	89.09	726
380.000	12.322	0.08116	3.4477	97.737	25624.8	28546.4	178.881	59.62	90.06	701
390.000	11.971	0.08354	3.2073	91.575	26444.6	29451.8	181.233	60.58	91.02	678
400.000	11.625	0.08602	2.9873	86.993	27269.9	30366.7	183.549	61.60	91.96	657
410.000	11.285	0.08862	2.7861	82.734	28100.7	31290.8	185.831	62.65	92.86	639
420.000	10.952	0.09131	2.6025	79.136	28936.5	32223.7	188.079	63.72	93.69	622
430.000	10.627	0.09410	2.4349	76.142	29776.9	33164.4	190.293	64.82	94.46	607
440.000	10.313	0.09697	2.2821	73.694	30621.7	34112.6	192.473	65.92	95.16	595
450.000	10.000	0.09992	2.1429	71.735	31470.3	35067.3	194.618	67.02	95.78	584
460.000	9.715	0.10293	2.0160	70.213	32322.5	36028.0	196.729	68.13	96.34	575
470.000	9.434	0.10600	1.9004	69.073	33178.0	36993.9	198.807	69.23	96.84	567
480.000	9.165	0.10911	1.7950	68.268	34036.7	37964.7	200.851	70.33	97.30	560
490.000	8.908	0.11226	1.6989	67.753	34898.6	38939.8	202.861	71.42	97.73	555
500.000	8.664	0.11543	1.6111	67.485	35763.7	39915.0	204.840	72.51	98.13	551
520.000	8.209	0.12181	1.4572	67.549	37504.2	41889.4	208.704	74.65	98.91	546
540.000	7.799	0.12822	1.3278	68.223	39259.8	43875.5	212.451	76.76	99.70	543
560.000	7.429	0.13460	1.2180	69.340	41032.2	45877.8	216.092	78.83	100.54	542
580.000	7.095	0.14094	1.1243	70.781	42823.7	47897.5	219.636	80.87	101.44	543
600.000	6.793	0.14722	1.0436	72.384	44636.2	49936.1	223.091	82.86	102.43	545

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 380.0 BAR

T DEG K	DEN MOL/L	VCL L/MOL	DF/CI BAR/K	DF/DO BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	W M/SEC
95.651	21.865	0.04574	33.2177	1028.166	5444.0	7191.9	77.983	46.66	68.13	2234
100.000	21.725	0.04603	31.7048	989.521	5729.0	7478.1	81.012	46.56	68.08	2194
110.000	21.407	0.04671	28.6401	906.887	6383.4	8158.5	87.436	46.29	68.00	2105
120.000	21.093	0.04741	26.0343	831.924	7036.8	8838.3	93.411	46.00	67.97	2022
130.000	20.781	0.04812	23.7814	763.675	7689.5	9518.1	98.852	45.70	68.00	1944
140.000	20.470	0.04885	21.8067	701.394	8342.1	10198.5	103.894	45.44	68.09	1870
150.000	20.159	0.04961	20.0562	644.479	8995.1	10880.2	108.597	45.22	68.26	1799
160.000	19.847	0.05038	18.4896	592.412	9649.3	11563.9	113.010	45.06	68.50	1731
170.000	19.534	0.05119	17.0767	544.755	10305.2	12250.5	117.172	44.98	68.83	1665
180.000	19.220	0.05203	15.7943	501.109	10963.6	12940.7	121.117	44.98	69.23	1602
190.000	18.904	0.05290	14.6241	461.113	11625.3	13635.4	124.873	45.06	69.72	1540
200.000	18.586	0.05380	13.5518	424.442	12290.9	14335.4	128.464	45.24	70.29	1481
210.000	18.265	0.05475	12.5658	390.800	12961.1	15041.6	131.909	45.51	70.95	1423
220.000	17.943	0.05573	11.6567	359.916	13636.7	15754.6	135.226	45.87	71.67	1369
230.000	17.618	0.05676	10.8169	331.550	14318.3	16475.2	138.429	46.31	72.47	1313
240.000	17.290	0.05784	10.0396	305.482	15006.3	17204.1	141.531	46.83	73.32	1261
250.000	16.960	0.05896	9.3195	281.519	15701.2	17941.7	144.542	47.41	74.22	1211
260.000	16.628	0.06014	8.6518	259.490	16403.3	18688.6	147.471	48.03	75.16	1162
270.000	16.293	0.06137	8.0323	239.243	17112.7	19444.9	150.325	48.69	76.12	1115
280.000	15.957	0.06267	7.4573	220.648	17829.5	20211.0	153.111	49.37	77.09	1070
290.000	15.618	0.06403	6.9238	203.588	18553.6	20986.7	155.833	50.07	78.06	1027
300.000	15.277	0.06546	6.4288	187.963	19284.8	21772.3	158.496	50.79	79.05	986
310.000	14.934	0.06696	5.9697	173.684	20023.4	22568.0	161.105	51.59	80.11	947
320.000	14.589	0.06854	5.5442	160.670	20770.4	23375.1	163.668	52.60	81.36	909
330.000	14.244	0.07021	5.1503	148.851	21528.8	24196.6	166.196	54.05	83.04	872
340.000	13.897	0.07196	4.7859	138.157	22302.5	25036.8	168.704	56.79	85.98	834
350.000	13.551	0.07380	4.4493	128.526	23095.5	25899.8	171.205	57.27	86.63	804
360.000	13.205	0.07573	4.1388	119.896	23892.3	26770.0	173.656	57.94	87.43	776
370.000	12.861	0.07776	3.8526	112.206	24694.1	27648.8	176.064	58.74	88.33	749
380.000	12.519	0.07988	3.5894	105.396	25501.3	28536.7	178.432	59.63	89.27	724
390.000	12.180	0.08210	3.3474	99.409	26314.4	29434.2	180.763	60.59	90.22	702
400.000	11.846	0.08442	3.1254	94.185	27133.2	30341.1	183.059	61.60	91.16	681
410.000	11.517	0.08683	2.9218	89.669	27957.8	31257.3	185.322	62.65	92.08	662
420.000	11.194	0.08933	2.7353	85.804	28788.0	32182.5	187.551	63.72	92.95	645
430.000	10.880	0.09192	2.5645	82.535	29623.2	33116.0	189.748	64.81	93.76	630
440.000	10.573	0.09458	2.4083	79.810	30463.5	34057.5	191.912	65.91	94.51	617
450.000	10.276	0.09731	2.2653	77.577	31308.3	35006.1	194.044	67.02	95.21	605
460.000	9.989	0.10011	2.1346	75.785	32157.4	35961.4	196.143	68.13	95.84	595
470.000	9.713	0.10295	2.0151	74.386	33010.6	36922.8	198.211	69.23	96.43	587
480.000	9.448	0.10585	1.9057	73.334	33867.6	37889.7	200.247	70.34	96.96	580
490.000	9.193	0.10877	1.8055	72.587	34728.6	38862.0	202.251	71.43	97.47	574
500.000	8.950	0.11173	1.7137	72.104	35593.3	39839.0	204.225	72.52	97.94	569
520.000	8.497	0.11769	1.5522	71.791	37334.5	41806.9	208.084	74.67	98.84	562
540.000	8.084	0.12369	1.4156	72.151	39092.2	43792.6	211.831	76.79	99.73	558
560.000	7.711	0.12969	1.2993	73.001	40868.0	45796.3	215.475	78.86	100.64	557
580.000	7.371	0.13566	1.1997	74.218	42663.5	47818.7	219.023	80.90	101.60	557
600.000	7.063	0.14159	1.1136	75.702	44489.2	49860.5	222.484	82.90	102.60	558

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 400.0 BAR

T DEG K	OEN MOL/L	VOL L/MOL	DP/CT BAR/K	DP/OD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	W M/SEC
95.944	21.875	0.04571	33.1452	1032.003	5451.9	7280.4	78.057	46.78	58.12	2236
100.000	21.745	0.04599	31.7427	996.172	5717.1	7556.6	80.877	46.68	68.07	2198
110.000	21.429	0.04667	28.6875	913.868	6370.2	8236.8	87.359	46.40	57.97	2110
120.000	21.117	0.04736	26.0898	839.180	7022.1	8916.3	93.271	46.10	67.93	2028
130.000	20.807	0.04806	23.8440	771.156	7673.2	9595.6	98.709	45.81	67.95	1950
140.000	20.498	0.04878	21.8757	709.063	8324.1	10275.5	103.747	45.54	68.03	1877
150.000	20.190	0.04953	20.1310	652.301	8975.2	10956.2	108.445	45.32	68.18	1807
160.000	19.881	0.05030	18.5699	600.367	9627.4	11639.4	112.853	45.16	68.41	1739
170.000	19.571	0.05110	17.1621	552.813	10281.2	12325.0	117.009	45.08	68.72	1674
180.000	19.260	0.05192	15.8845	509.255	10937.3	13014.2	120.948	45.07	69.12	1611
190.000	18.947	0.05278	14.7190	469.335	11596.5	13707.6	124.697	45.16	69.59	1551
200.000	18.632	0.05367	13.6511	432.729	12259.5	14406.2	128.281	45.34	70.15	1492
210.000	18.316	0.05460	12.6693	399.143	12926.9	15110.8	131.718	45.61	70.78	1435
220.000	17.998	0.05556	11.7643	368.308	13599.6	15822.1	135.027	45.96	71.49	1380
230.000	17.677	0.05657	10.9282	339.985	14277.9	16540.7	138.221	46.40	72.26	1327
240.000	17.355	0.05762	10.1546	313.953	14962.5	17267.4	141.314	46.91	73.09	1275
250.000	17.030	0.05872	9.4379	290.021	15653.8	18002.6	144.315	47.49	73.96	1226
260.000	16.704	0.05987	8.7734	268.014	16352.1	18746.7	147.233	48.11	74.87	1178
270.000	16.376	0.06107	8.1568	247.782	17057.4	19500.1	150.076	48.77	75.80	1132
280.000	16.046	0.06232	7.5846	229.191	17769.9	20262.8	152.850	49.44	76.74	1088
290.000	15.714	0.06364	7.0536	212.122	18489.4	21034.9	155.559	50.13	77.68	1045
300.000	15.381	0.06502	6.5608	196.474	19215.8	21816.4	158.209	50.85	78.63	1005
310.000	15.046	0.06646	6.1036	182.155	19949.3	22607.8	160.803	51.64	79.65	967
320.000	14.711	0.06798	5.6797	169.084	20690.9	23410.1	163.350	52.65	80.86	929
330.000	14.374	0.06957	5.2870	157.186	21433.7	24226.4	165.862	54.10	82.50	893
340.000	14.038	0.07124	4.9235	146.392	22211.6	25061.0	168.354	56.83	85.40	855
350.000	13.702	0.07298	4.5872	136.639	22998.7	25918.0	170.838	57.31	86.02	826
360.000	13.367	0.07481	4.2766	127.864	23789.5	26782.0	173.272	57.97	86.79	798
370.000	13.033	0.07673	3.9900	120.008	24585.0	27654.1	175.661	58.76	87.65	772
380.000	12.702	0.07873	3.7257	113.013	25386.1	28535.2	178.011	59.64	88.57	747
390.000	12.374	0.08081	3.4824	106.822	26193.1	29425.7	180.324	60.60	89.51	724
400.000	12.050	0.08299	3.2585	101.379	27006.1	30325.5	182.602	61.61	90.46	704
410.000	11.732	0.08524	3.0527	96.629	27825.1	31234.7	184.847	62.65	91.38	685
420.000	11.419	0.08757	2.8636	92.520	28650.0	32153.0	187.060	63.72	92.27	667
430.000	11.113	0.08999	2.6900	89.001	29480.6	33080.0	189.241	64.81	93.12	652
440.000	10.815	0.09247	2.5306	86.021	30316.5	34015.2	191.391	65.91	93.92	638
450.000	10.525	0.09501	2.3844	83.533	31157.6	34958.2	193.510	67.02	94.67	626
460.000	10.244	0.09762	2.2502	81.489	32003.6	35908.4	195.598	68.13	95.37	616
470.000	9.973	0.10027	2.1270	79.845	32854.4	36865.4	197.656	69.24	96.01	607
480.000	9.711	0.10297	2.0140	78.558	33709.6	37828.5	199.684	70.34	96.62	599
490.000	9.460	0.10571	1.9101	77.586	34569.2	38797.6	201.682	71.44	97.19	592
500.000	9.219	0.10847	1.8147	76.893	35433.2	39772.1	203.651	72.53	97.73	587
510.000	8.967	0.11106	1.6460	76.203	37174.3	41736.9	207.504	74.69	98.74	579
520.000	8.767	0.11370	1.5027	76.246	38933.5	43721.5	211.249	76.81	99.72	574
530.000	8.564	0.11635	1.3802	76.830	40711.8	45725.8	214.893	78.89	100.70	571
540.000	8.354	0.11900	1.2749	77.817	42510.3	47745.7	218.445	80.93	101.71	570
550.000	8.149	0.12165	1.1837	79.111	44330.8	49794.4	221.910	82.93	102.75	571
560.000	7.944	0.12430								
570.000	7.739	0.12695								
580.000	7.534	0.12960								
590.000	7.329	0.13225								
600.000	7.124	0.13490								

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 420.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DP/CT BAR/K	DP/DO BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	W M/SEC
96.236	21.885	0.04569	33.0749	1035.875	5459.8	7378.9	78.131	46.89	68.11	2237
100.000	21.765	0.04594	31.7811	1002.816	5705.4	7635.1	80.742	46.79	68.05	2202
110.000	21.451	0.04662	28.7353	920.839	6357.1	8315.1	87.223	46.51	67.95	2115
120.000	21.141	0.04730	26.1454	846.419	7007.6	8934.3	93.133	46.21	67.90	2034
130.000	20.833	0.04800	23.5065	778.618	7657.2	9673.2	98.567	45.91	67.90	1957
140.000	20.526	0.04872	21.9444	716.707	8306.3	10352.5	103.601	45.65	67.97	1884
150.000	20.220	0.04946	20.2054	660.096	8955.7	11032.9	108.295	45.42	68.11	1814
160.000	19.914	0.05022	18.6495	608.285	9605.9	11715.0	112.697	45.26	68.33	1748
170.000	19.607	0.05100	17.2467	560.833	10257.6	12399.7	116.848	45.17	68.63	1683
180.000	19.299	0.05182	15.9738	517.360	10911.5	13087.8	120.781	45.17	69.01	1621
190.000	18.989	0.05266	14.8126	477.510	11568.3	13780.1	124.524	45.25	69.47	1561
200.000	18.678	0.05354	13.7490	440.963	12228.8	14477.4	128.100	45.43	70.00	1503
210.000	18.366	0.05445	12.7712	407.428	12893.6	15180.5	131.530	45.70	70.62	1447
220.000	18.051	0.05540	11.8700	376.637	13563.4	15890.1	134.831	46.05	71.31	1393
230.000	17.735	0.05638	11.0375	348.349	14238.7	16606.8	138.017	46.49	72.06	1340
240.000	17.418	0.05741	10.2673	322.349	14920.1	17331.5	141.101	47.00	72.87	1289
250.000	17.098	0.05849	9.5538	298.440	15608.0	18064.4	144.093	47.57	73.72	1240
260.000	16.777	0.05960	8.8922	276.451	16302.6	18806.0	147.002	48.19	74.61	1193
270.000	16.455	0.06077	8.2784	256.228	17004.2	19556.6	149.834	48.84	75.51	1148
280.000	16.131	0.06199	7.7087	237.636	17712.6	20316.2	152.597	49.51	76.42	1104
290.000	15.806	0.06327	7.1759	220.556	18427.8	21085.0	155.294	50.20	77.33	1063
300.000	15.480	0.06460	6.6890	204.884	19149.7	21862.8	157.931	50.91	78.25	1023
310.000	15.153	0.06599	6.2335	190.524	19878.5	22650.2	160.513	51.70	79.23	985
320.000	14.826	0.06745	5.8110	177.395	20615.3	23448.2	163.046	52.70	80.41	949
330.000	14.498	0.06897	5.4193	165.421	21363.0	24259.9	165.544	54.14	82.01	913
340.000	14.171	0.07057	5.0564	154.534	22125.7	25089.5	168.020	56.87	84.88	876
350.000	13.844	0.07223	4.7204	144.667	22907.3	25941.1	170.489	57.34	85.47	847
360.000	13.519	0.07397	4.4097	135.759	23692.6	26799.4	172.907	58.00	86.21	819
370.000	13.195	0.07579	4.1225	127.751	24482.6	27665.7	175.280	58.78	87.05	793
380.000	12.873	0.07768	3.8573	120.586	25278.2	28540.7	177.614	59.66	87.95	769
390.000	12.555	0.07965	3.6126	114.208	26079.7	29424.9	179.910	60.61	88.89	746
400.000	12.241	0.08169	3.3870	108.564	26887.3	30318.4	182.173	61.62	89.83	725
410.000	11.931	0.08381	3.1792	103.601	27701.3	31221.4	184.402	62.66	90.76	706
420.000	11.627	0.08600	2.9878	99.269	28521.3	32133.5	186.600	63.73	91.66	689
430.000	11.330	0.08826	2.8116	95.520	29347.5	33054.5	188.767	64.82	92.54	673
440.000	11.039	0.09059	2.6494	92.305	30179.4	33984.1	190.904	65.92	93.37	659
450.000	10.756	0.09297	2.5001	89.581	31017.0	34921.8	193.011	67.02	94.16	647
460.000	10.481	0.09541	2.3628	87.302	31859.9	35867.2	195.089	68.13	94.91	636
470.000	10.215	0.09790	2.2363	85.427	32708.1	36819.8	197.138	69.24	95.61	626
480.000	9.958	0.10043	2.1199	83.915	33561.4	37779.3	199.158	70.35	96.27	618
490.000	9.710	0.10299	2.0127	82.728	34419.5	38745.1	201.150	71.45	96.90	611
500.000	9.471	0.10559	1.9139	81.830	35282.5	39717.1	203.113	72.54	97.49	605
520.000	9.022	0.11084	1.7387	80.769	37022.9	41678.2	206.959	74.70	98.61	595
540.000	8.609	0.11615	1.5890	80.492	38782.7	43661.1	210.701	76.82	99.68	589
560.000	8.231	0.12148	1.4606	80.808	40562.8	45665.2	214.345	78.91	100.73	586
580.000	7.885	0.12682	1.3498	81.567	42364.0	47690.3	217.898	80.95	101.79	584
600.000	7.569	0.13312	1.2536	82.660	44187.6	49736.8	221.367	82.96	102.87	584

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 450.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DP/DT BAR/K	DP/DD BAR/L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CF J/MOL/K	W M/SEC
96.673	21.300	0.04566	32.9735	1041.744	5471.7	7526.5	78.240	47.05	68.08	2239
100.000	21.795	0.04588	31.8396	1012.770	5688.2	7752.9	80.543	46.96	68.03	2209
110.000	21.483	0.04655	28.8075	931.274	6338.0	8432.6	87.021	46.67	67.91	2123
120.000	21.176	0.04722	26.2291	857.251	6986.3	9111.3	92.927	46.37	67.84	2042
130.000	20.871	0.04791	24.0002	789.775	7633.6	9789.7	98.356	46.07	67.83	1967
140.000	20.568	0.04862	22.0470	728.131	8280.3	10468.2	103.384	45.80	67.89	1895
150.000	20.265	0.04935	20.3161	671.737	8927.1	11147.7	108.072	45.57	68.01	1826
160.000	19.963	0.05009	18.7679	620.103	9574.5	11828.7	112.467	45.41	68.21	1760
170.000	19.660	0.05087	17.3721	572.797	10233.2	12512.1	116.610	45.32	68.49	1697
180.000	19.356	0.05166	16.1059	529.442	10873.9	13198.8	120.535	45.31	68.85	1636
190.000	19.051	0.05249	14.9511	489.689	11527.3	13889.4	124.269	45.39	69.29	1577
200.000	18.745	0.05335	13.8933	453.222	12184.2	14584.8	127.835	45.56	69.80	1520
210.000	18.438	0.05424	12.9212	419.752	12845.1	15285.7	131.255	45.83	70.40	1464
220.000	18.130	0.05516	12.0253	389.016	13510.8	15992.9	134.545	46.18	71.06	1411
230.000	17.820	0.05612	11.1979	360.774	14181.9	16707.1	137.720	46.61	71.79	1359
240.000	17.509	0.05711	10.4324	334.809	14858.7	17428.9	140.791	47.12	72.57	1309
250.000	17.197	0.05815	9.7232	310.927	15541.9	18158.6	143.770	47.69	73.39	1261
260.000	16.884	0.05923	9.0657	288.954	16231.5	18896.8	146.665	48.30	74.24	1215
270.000	16.569	0.06035	8.4555	268.736	16927.7	19643.6	149.483	48.95	75.11	1171
280.000	16.254	0.06152	7.8892	250.135	17630.5	20399.0	152.231	49.62	75.99	1129
290.000	15.939	0.06274	7.3633	233.031	18339.9	21163.2	154.913	50.30	76.86	1088
300.000	15.622	0.06401	6.8750	217.317	19055.7	21936.2	157.533	51.00	77.74	1050
310.000	15.306	0.06533	6.4216	202.897	19778.1	22718.1	160.097	51.78	78.68	1013
320.000	14.989	0.06671	6.0008	189.684	20508.3	23510.4	162.612	52.78	79.82	977
330.000	14.673	0.06815	5.6103	177.604	21249.1	24315.9	165.091	54.21	81.37	942
340.000	14.358	0.06965	5.2481	166.585	22004.7	25138.9	167.547	56.93	84.20	905
350.000	14.043	0.07121	4.9123	156.560	22779.1	25983.5	169.995	57.39	84.75	877
360.000	13.730	0.07283	4.6012	147.469	23557.1	26834.5	172.392	58.04	85.46	850
370.000	13.420	0.07452	4.3132	139.254	24339.7	27693.0	174.745	58.82	86.27	824
380.000	13.111	0.07627	4.0467	131.858	25127.9	28560.1	177.057	59.69	87.15	800
390.000	12.806	0.07809	3.8001	125.228	25922.1	29436.1	179.333	60.64	88.06	778
400.000	12.504	0.07997	3.5722	119.312	26722.7	30321.4	181.574	61.64	89.00	757
410.000	12.207	0.08192	3.3616	114.061	27529.7	31216.0	183.783	62.67	89.93	738
420.000	11.915	0.08393	3.1670	109.427	28343.3	32120.0	185.961	63.74	90.86	720
430.000	11.629	0.08599	2.9873	105.365	29163.3	33033.1	188.110	64.83	91.76	704
440.000	11.348	0.08812	2.8213	101.831	29989.7	33955.1	190.229	65.92	92.63	690
450.000	11.075	0.09030	2.6680	98.782	30822.3	34885.5	192.320	67.03	93.47	677
460.000	10.808	0.09252	2.5264	96.179	31660.8	35824.3	194.383	68.14	94.27	665
470.000	10.550	0.09479	2.3956	93.983	32505.3	36770.9	196.419	69.25	95.04	655
480.000	10.299	0.09710	2.2747	92.157	33355.4	37724.9	198.428	70.36	95.77	646
490.000	10.056	0.09944	2.1629	90.665	34211.1	38686.0	200.410	71.46	96.46	638
500.000	9.822	0.10182	2.0595	89.474	35072.2	39653.9	202.365	72.55	97.13	631
520.000	9.378	0.10663	1.8751	87.870	36810.8	41605.2	206.199	74.72	98.38	620
540.000	8.968	0.11151	1.7167	87.118	38570.7	43588.7	209.934	76.85	99.56	613
560.000	8.589	0.11642	1.5799	87.025	40352.4	45591.5	213.576	78.94	100.71	608
580.000	8.241	0.12135	1.4614	87.438	42156.4	47617.0	217.130	80.99	101.85	605
600.000	7.920	0.12626	1.3581	88.234	43983.6	49665.5	220.602	83.00	102.99	603

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 500.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DP/CT BAR/K	OF/DD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CF J/MOL/K	W M/SEC
97.397	21.925	0.04561	32.8146	1051.691	5491.7	7772.2	78.420	47.30	68.05	2243
100.000	21.844	0.04578	31.9398	1029.333	5660.3	7949.3	80.215	47.23	68.00	2220
110.000	21.537	0.04643	28.9293	948.618	6306.9	8628.5	86.689	46.94	67.86	2136
120.000	21.234	0.04710	26.3691	875.234	6951.9	9306.6	92.589	46.62	67.77	2057
130.000	20.934	0.04777	24.1560	808.282	7595.5	9984.1	98.011	46.31	67.73	1983
140.000	20.636	0.04846	22.2169	747.063	8238.4	10661.4	103.031	46.04	67.76	1912
150.000	20.339	0.04917	20.4988	691.013	8881.0	11339.4	107.709	45.81	67.86	1845
160.000	20.042	0.04990	18.9623	639.655	9524.0	12018.8	112.093	45.64	68.03	1781
170.000	19.746	0.05064	17.5776	592.574	10168.0	12700.2	116.224	45.54	68.28	1719
180.000	19.449	0.05142	16.3216	549.392	10813.7	13384.6	120.136	45.53	68.61	1659
190.000	19.151	0.05222	15.1765	509.778	11461.8	14072.6	123.856	45.61	69.01	1602
200.000	18.853	0.05304	14.1279	473.422	12113.1	14765.1	127.408	45.78	69.50	1545
210.000	18.554	0.05390	13.1644	440.039	12768.1	15462.9	130.812	46.04	70.06	1492
220.000	18.255	0.05478	12.2765	409.371	13427.6	16166.6	134.085	46.39	70.69	1440
230.000	17.955	0.05570	11.4565	381.180	14092.1	16876.9	137.243	46.81	71.38	1390
240.000	17.654	0.05664	10.6979	355.251	14762.1	17594.4	140.296	47.31	72.12	1342
250.000	17.352	0.05763	9.9951	331.390	15438.0	18319.4	143.256	47.87	72.90	1295
260.000	17.051	0.05865	9.3433	309.423	16120.1	19052.5	146.131	48.48	73.71	1251
270.000	16.749	0.05971	8.7384	289.193	16808.4	19793.7	148.928	49.12	74.53	1208
280.000	16.446	0.06080	8.1767	270.562	17533.0	20543.2	151.654	49.78	75.36	1167
290.000	16.144	0.06194	7.6548	253.406	18203.8	21300.9	154.312	50.45	76.18	1128
300.000	15.842	0.06312	7.1699	237.614	18910.7	22066.8	156.909	51.15	77.01	1091
310.000	15.541	0.06435	6.7193	223.089	19623.9	22841.2	159.448	51.92	77.90	1055
320.000	15.240	0.06562	6.3005	209.742	20344.5	23625.3	161.938	52.90	78.98	1020
330.000	14.940	0.06693	5.9114	197.495	21075.5	24422.2	164.390	54.32	80.46	986
340.000	14.641	0.06830	5.5498	186.275	21821.1	25236.1	166.819	57.04	83.26	951
350.000	14.344	0.06971	5.2140	176.016	22595.4	26071.1	169.239	57.49	83.76	924
360.000	14.049	0.07118	4.9022	166.656	23352.9	26911.9	171.608	58.12	84.42	897
370.000	13.756	0.07269	4.6127	158.138	24125.2	27760.0	173.931	58.89	85.20	872
380.000	13.466	0.07426	4.3439	150.408	24903.1	28616.2	176.215	59.76	86.05	849
390.000	13.179	0.07588	4.0946	143.414	25687.1	29481.1	178.461	60.69	86.94	827
400.000	12.895	0.07755	3.8632	137.108	26477.6	30355.1	180.674	61.68	87.87	806
410.000	12.615	0.07927	3.6485	131.444	27275.0	31238.4	182.855	62.71	88.80	787
420.000	12.340	0.08104	3.4493	126.376	28079.3	32131.2	185.006	63.77	89.74	769
430.000	12.070	0.08285	3.2646	121.864	28890.5	33033.2	187.129	64.85	90.67	753
440.000	11.804	0.08471	3.0931	117.668	29708.7	33944.4	189.224	65.95	91.58	738
450.000	11.545	0.08662	2.9340	114.350	30533.8	34864.7	191.292	67.05	92.47	724
460.000	11.291	0.08856	2.7863	111.273	31365.5	35793.7	193.334	68.16	93.33	712
470.000	11.044	0.09055	2.6492	108.603	32204.4	36731.2	195.350	69.27	94.17	701
480.000	10.804	0.09256	2.5218	106.307	33048.9	37677.0	197.341	70.38	94.98	691
490.000	10.570	0.09461	2.4035	104.354	33900.3	38630.8	199.308	71.48	95.76	682
500.000	10.343	0.09668	2.2934	102.714	34758.0	39592.2	201.250	72.58	96.51	674
520.000	9.911	0.10090	2.0958	100.260	36491.8	41536.9	205.064	74.75	97.95	661
540.000	9.507	0.10519	1.9243	98.739	38250.0	43509.5	208.786	76.89	99.30	651
560.000	9.131	0.10952	1.7751	97.967	40032.4	45508.4	212.420	78.99	100.59	644
580.000	8.782	0.11388	1.6447	97.790	41839.0	47532.8	215.972	81.04	101.85	639
600.000	8.457	0.11824	1.5304	98.081	43670.1	49582.1	219.446	83.05	103.08	636

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16. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.) Thermophysical properties are tabulated at uniform temperatures over the entire range of fluid states from 90 to 600 K along isobars to 700 bar. A new, rational equation of state is employed for the first time. Thermodynamic functions in the compressed liquid at $T < T_c$ are obtained by use of specific heats $C_p(T)$ along a high pressure isobar.			
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Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 700.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DE/CT BAR/K	DP/DD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	M M/SEC
100.239	22.025	0.04540	32.2963	1093.402	5573.1	8751.3	79.119	48.22	67.93	2263
110.000	21.740	0.04600	29.4370	1017.517	6193.4	9413.3	85.421	47.89	67.71	2187
120.000	21.453	0.04661	26.5389	946.464	6826.5	10089.4	91.304	47.54	67.53	2115
130.000	21.170	0.04724	24.7790	881.391	7457.6	10764.1	96.704	47.20	67.41	2046
140.000	20.891	0.04787	22.8866	821.670	8087.0	11437.8	101.697	46.90	67.35	1981
150.000	20.613	0.04851	21.2105	766.796	8715.4	12111.3	106.343	46.65	67.36	1919
160.000	20.337	0.04917	19.7122	716.344	9343.3	12785.2	110.693	46.46	67.45	1860
170.000	20.063	0.04984	18.3627	669.943	9971.4	13437.7	114.657	46.35	67.61	1803
180.000	19.789	0.05053	17.1393	627.262	10600.3	14137.7	118.657	46.32	67.85	1748
190.000	19.516	0.05124	16.0244	587.997	11230.9	14817.7	122.333	46.38	68.17	1695
200.000	19.244	0.05196	15.0039	551.868	11863.8	15501.3	125.840	46.54	68.57	1644
210.000	18.972	0.05271	14.0662	518.614	12499.7	16189.2	129.196	46.78	69.04	1595
220.000	18.701	0.05347	13.2021	487.996	13139.2	16882.2	132.420	47.11	69.57	1548
230.000	18.431	0.05426	12.4037	459.790	13783.0	17580.9	135.525	47.52	70.17	1503
240.000	18.162	0.05506	11.6647	433.791	14431.6	18285.8	138.525	47.99	70.82	1459
250.000	17.894	0.05589	10.9793	409.809	15085.3	18997.3	141.430	48.53	71.50	1417
260.000	17.626	0.05673	10.3429	387.673	15744.5	19715.9	144.248	49.12	72.21	1377
270.000	17.360	0.05760	9.7513	367.227	16409.3	20441.5	146.987	49.73	72.93	1338
280.000	17.095	0.05850	9.2007	348.330	17079.7	21174.4	149.652	50.36	73.65	1302
290.000	16.832	0.05941	8.6880	330.853	17755.6	21914.4	152.249	51.01	74.36	1267
300.000	16.570	0.06035	8.2101	314.681	18437.1	22661.6	154.782	51.67	75.08	1233
310.000	16.310	0.06131	7.7645	299.713	19124.3	23416.2	157.256	52.42	75.86	1201
320.000	16.052	0.06230	7.3487	285.853	19818.5	24179.4	159.679	53.37	76.83	1170
330.000	15.796	0.06331	6.9606	273.020	20522.7	24954.3	162.063	54.76	78.23	1139
340.000	15.542	0.06434	6.5981	261.138	21241.2	25745.1	164.424	57.44	80.91	1106
350.000	15.291	0.06540	6.2595	250.139	21978.1	26556.1	166.774	57.86	81.31	1081
360.000	15.042	0.06648	5.9429	239.961	22718.2	27372.0	169.073	58.47	81.89	1057
370.000	14.795	0.06759	5.6470	230.549	23463.1	28194.3	171.326	59.21	82.59	1034
380.000	14.552	0.06872	5.3701	221.851	24213.7	29024.1	173.539	60.05	83.37	1012
390.000	14.311	0.06987	5.1110	213.819	24970.8	29862.0	175.715	60.96	84.22	991
400.000	14.074	0.07105	4.8684	206.410	25734.8	30708.6	177.859	61.92	85.11	971
410.000	13.840	0.07226	4.6412	199.584	26506.4	31564.3	179.972	62.93	86.03	953
420.000	13.609	0.07348	4.4283	193.303	27285.6	32429.3	182.056	63.97	86.96	935
430.000	13.382	0.07473	4.2286	187.533	28072.8	33303.9	184.114	65.04	87.93	918
440.000	13.158	0.07600	4.0414	182.240	28868.1	34188.1	186.146	66.12	88.89	903
450.000	12.938	0.07729	3.8657	177.395	29671.4	35081.8	188.155	67.21	89.86	888
460.000	12.722	0.07860	3.7007	172.969	30482.6	35985.2	190.140	68.31	90.81	874
470.000	12.510	0.07994	3.5457	168.935	31302.6	36898.0	192.103	69.41	91.76	862
480.000	12.302	0.08129	3.4000	165.268	32130.4	37820.4	194.045	70.52	92.70	850
490.000	12.099	0.08265	3.2630	161.943	32966.3	38692.9	195.966	71.62	93.63	839
500.000	11.899	0.08404	3.1340	158.943	33810.2	39692.9	197.867	72.72	94.54	829
520.000	11.514	0.08665	2.8983	153.820	35521.8	41601.5	201.610	74.89	96.31	811
540.000	11.146	0.08972	2.6887	149.743	37264.6	43545.0	205.277	77.04	98.02	796
560.000	10.796	0.09263	2.5021	146.574	39037.9	45522.1	208.872	79.15	99.67	783
580.000	10.463	0.09558	2.3355	144.186	40841.0	47531.4	212.397	81.21	101.26	773
600.000	10.147	0.09855	2.1864	142.469	42673.7	49572.0	215.856	83.24	102.79	765

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 650.0 BAR

T	DEN	VOL	DF/CT	DF/DD	E	H	S	CV	CF	M
DEG K	MOL/L	L/MOL	BAR/K	BAR-L/MOL	J/MCL	J/MOL	J/MCL/K	J/MOL/K	J/MOL/K	M/SEC
99.536	22.000	0.04545	32.4094	1082.699	5552.5	8507.0	78.947	48.01	67.96	2258
100.000	21.986	0.04548	32.2595	1078.869	5582.2	8538.6	79.264	47.99	67.95	2254
110.000	21.691	0.04610	29.3069	1000.347	6220.3	9217.0	85.729	47.66	67.74	2174
120.000	21.400	0.04673	26.7949	928.747	6856.1	9893.5	91.616	47.32	67.58	2100
130.000	21.113	0.04736	24.6230	863.233	7490.1	10568.7	97.021	46.99	67.48	2030
140.000	20.829	0.04801	22.7203	803.165	8122.6	11243.2	102.019	46.70	67.44	1964
150.000	20.547	0.04867	21.0350	748.024	8754.2	11917.7	106.672	46.45	67.47	1901
160.000	20.267	0.04934	19.5283	697.827	9385.6	12592.8	111.029	46.27	67.57	1840
170.000	19.987	0.05003	18.1712	650.827	10017.3	13269.4	115.131	46.16	67.75	1782
180.000	19.708	0.05074	16.9408	608.047	10650.0	13948.1	119.011	46.14	68.01	1726
190.000	19.430	0.05147	15.8195	568.722	11284.5	14629.9	122.696	46.20	68.35	1673
200.000	19.152	0.05221	14.7930	532.563	11921.4	15315.4	126.213	46.36	68.77	1621
210.000	18.874	0.05298	13.8499	499.305	12561.6	16005.4	129.579	46.61	69.25	1571
220.000	18.597	0.05377	12.9809	468.701	13205.5	16700.7	132.813	46.94	69.81	1523
230.000	18.320	0.05458	12.1781	440.525	13853.8	17401.8	135.930	47.35	70.42	1475
240.000	18.044	0.05542	11.4352	414.569	14507.0	18109.3	138.941	47.84	71.09	1431
250.000	17.769	0.05628	10.7464	390.642	15165.5	18823.6	141.857	48.38	71.79	1388
260.000	17.494	0.05716	10.1070	368.570	15829.6	19545.1	144.686	48.97	72.51	1347
270.000	17.220	0.05807	9.5129	348.198	16499.3	20274.0	147.437	49.59	73.25	1308
280.000	16.948	0.05901	8.9604	329.383	17174.8	21010.2	150.114	50.23	73.99	1270
290.000	16.676	0.05997	8.4461	311.999	17855.9	21753.7	152.723	50.88	74.72	1234
300.000	16.406	0.06095	7.9671	295.932	18542.6	22504.6	155.269	51.55	75.46	1200
310.000	16.138	0.06197	7.5209	281.077	19235.2	23263.0	157.756	52.30	76.25	1167
320.000	15.871	0.06301	7.1049	267.344	19934.8	24030.2	160.192	53.26	77.25	1136
330.000	15.606	0.06408	6.7169	254.650	20644.4	24809.4	162.589	54.66	78.66	1104
340.000	15.344	0.06517	6.3551	242.919	21368.3	25604.6	164.963	57.35	81.36	1071
350.000	15.083	0.06630	6.0174	232.085	22110.6	26420.1	167.326	57.77	81.77	1045
360.000	14.825	0.06745	5.7021	222.086	22856.2	27240.6	169.638	58.38	82.36	1021
370.000	14.570	0.06864	5.4078	212.866	23606.5	28067.8	171.904	59.13	83.08	997
380.000	14.317	0.06985	5.1329	204.373	24362.5	28902.5	174.130	59.97	83.87	975
390.000	14.067	0.07109	4.8761	196.558	25124.8	29745.4	176.320	60.89	84.73	954
400.000	13.821	0.07235	4.6360	189.378	25894.1	30597.1	178.476	61.86	85.62	934
410.000	13.578	0.07365	4.4116	182.791	26670.8	31458.0	180.602	62.87	86.55	915
420.000	13.338	0.07497	4.2016	176.760	27455.0	32328.2	182.699	63.92	87.49	897
430.000	13.103	0.07632	4.0052	171.248	28247.0	33207.9	184.768	64.98	88.45	880
440.000	12.871	0.07770	3.8213	166.221	29046.9	34097.1	186.813	66.07	89.40	865
450.000	12.643	0.07910	3.6491	161.648	29854.6	34995.9	188.832	67.16	90.36	850
460.000	12.419	0.08052	3.4878	157.499	30670.3	35904.1	190.829	68.27	91.30	837
470.000	12.200	0.08197	3.3365	153.747	31494.0	36821.8	192.802	69.37	92.24	825
480.000	11.985	0.08344	3.1946	150.364	32325.5	37748.9	194.754	70.48	93.16	813
490.000	11.775	0.08492	3.0615	147.327	33164.9	38685.0	196.684	71.58	94.06	802
500.000	11.570	0.08643	2.9365	144.612	34011.9	39630.0	198.593	72.68	94.95	793
520.000	11.173	0.08950	2.7087	140.058	35729.0	41546.4	202.351	74.86	96.68	776
540.000	10.796	0.09263	2.5071	136.540	37476.0	43496.6	206.031	77.00	98.33	761
560.000	10.439	0.09580	2.3284	133.908	39252.2	45479.1	209.636	79.11	99.91	750
580.000	10.101	0.09900	2.1695	132.031	41057.4	47492.7	213.169	81.17	101.44	741
600.000	9.781	0.10224	2.0279	130.792	42891.0	49536.4	216.633	83.20	102.92	734

Table 27. Thermophysical properties along isobars (Continued)

ETHANE ISOBAR AT P = 600.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DP/DT BAR/K	DF/DD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	M M/SEC
98.828	21.975	0.04551	32.5332	1072.177	5532.1	8262.4	78.774	47.79	67.99	2252
100.000	21.940	0.04558	32.1497	1062.379	5607.3	8342.1	79.575	47.75	67.96	2242
110.000	21.640	0.04621	29.1790	983.148	6248.1	9020.7	86.043	47.43	67.77	2161
120.000	21.346	0.04685	26.6520	910.974	6886.8	9697.7	91.934	47.10	67.63	2086
130.000	21.055	0.04750	24.4673	845.002	7523.9	10373.6	97.344	46.78	67.55	2015
140.000	20.766	0.04816	22.5534	784.569	8159.7	11049.9	102.349	46.49	67.53	1947
150.000	20.479	0.04882	20.8580	729.144	8794.7	11724.5	107.009	46.25	67.58	1882
160.000	20.194	0.04952	19.3422	678.275	9429.7	12400.9	111.375	46.07	67.71	1821
170.000	19.909	0.05023	17.9767	631.569	10065.2	13079.0	115.485	45.97	67.91	1762
180.000	19.624	0.05096	16.7386	588.676	10702.0	13759.4	119.374	45.95	68.19	1705
190.000	19.340	0.05171	15.6102	549.274	11340.7	14443.0	123.070	46.02	68.55	1650
200.000	19.056	0.05248	14.5771	513.070	11982.0	15130.6	126.597	46.18	68.99	1597
210.000	18.772	0.05327	13.6279	479.786	12626.7	15823.0	129.975	46.43	69.49	1545
220.000	18.486	0.05409	12.7533	449.180	13275.4	16520.8	133.221	46.76	70.07	1496
230.000	18.204	0.05493	11.9456	421.018	13928.6	17224.6	136.350	47.18	70.71	1449
240.000	17.921	0.05580	11.1981	395.090	14586.9	17935.0	139.373	47.67	71.39	1403
250.000	17.637	0.05670	10.5054	371.203	15250.6	18652.5	142.302	48.22	72.11	1359
260.000	17.355	0.05762	9.8625	349.184	15920.0	19377.3	145.145	48.81	72.86	1317
270.000	17.072	0.05857	9.2655	328.874	16595.3	20109.7	147.909	49.44	73.62	1276
280.000	16.791	0.05956	8.7105	310.135	17276.4	20849.7	150.600	50.08	74.38	1238
290.000	16.511	0.06057	8.1942	292.835	17963.3	21597.3	153.223	50.74	75.13	1201
300.000	16.232	0.06161	7.7138	276.866	18655.9	22352.4	155.783	51.42	75.89	1166
310.000	15.954	0.06268	7.2666	262.123	19354.4	23115.3	158.285	52.18	76.71	1132
320.000	15.677	0.06379	6.8501	248.517	20060.1	23887.3	160.735	53.14	77.73	1099
330.000	15.402	0.06492	6.4621	235.966	20775.8	24671.3	163.148	54.55	79.16	1067
340.000	15.130	0.06610	6.1006	224.395	21505.9	25471.7	165.537	57.24	81.88	1033
350.000	14.859	0.06730	5.7638	213.737	22254.5	26292.5	167.916	57.68	82.32	1007
360.000	14.590	0.06854	5.4498	203.930	23006.3	27118.6	170.243	58.30	82.93	982
370.000	14.324	0.06981	5.1571	194.919	23762.8	27951.5	172.525	59.05	83.65	958
380.000	14.061	0.07112	4.8842	186.651	24524.9	28792.0	174.767	59.90	84.46	936
390.000	13.801	0.07246	4.6297	179.076	25293.4	29640.8	176.972	60.82	85.33	914
400.000	13.544	0.07383	4.3923	172.151	26068.7	30498.6	179.143	61.80	86.23	894
410.000	13.291	0.07524	4.1709	165.832	26851.2	31365.6	181.284	62.81	87.16	875
420.000	13.041	0.07668	3.9642	160.080	27641.1	32241.9	183.396	63.86	88.10	857
430.000	12.796	0.07815	3.7712	154.858	28438.6	33127.7	185.480	64.93	89.05	840
440.000	12.554	0.07965	3.5910	150.129	29243.7	34023.0	187.538	66.02	90.00	825
450.000	12.317	0.08119	3.4227	145.862	30056.5	34927.7	189.571	67.12	90.94	811
460.000	12.085	0.08275	3.2653	142.024	30877.0	35841.7	191.580	68.23	91.87	797
470.000	11.858	0.08433	3.1182	138.588	31705.0	36765.0	193.566	69.33	92.79	785
480.000	11.635	0.08595	2.9806	135.523	32540.6	37697.4	195.529	70.44	93.68	774
490.000	11.418	0.08758	2.8517	132.806	33383.6	38638.6	197.469	71.54	94.56	764
500.000	11.206	0.08924	2.7311	130.409	34234.1	39588.5	199.388	72.64	95.42	755
520.000	10.798	0.09261	2.5121	126.485	35956.8	41513.6	203.163	74.82	97.07	739
540.000	10.411	0.09605	2.3194	123.576	37707.9	43470.8	206.856	76.96	98.65	726
560.000	10.047	0.09953	2.1494	121.524	39487.0	45459.1	210.472	79.07	100.16	716
580.000	9.704	0.10305	1.9991	120.190	41293.6	47476.8	214.012	81.13	101.61	709
600.000	9.381	0.10660	1.8657	119.450	43127.5	49523.3	217.480	83.15	103.02	702

Table 27. Thermophysical properties along isobars (Continued)
ETHANE ISOBAR AT P = 550.0 BAR

T DEG K	DEN MOL/L	VOL L/MOL	DP/CT BAR/K	DF/DD BAR-L/MOL	E J/MOL	H J/MOL	S J/MOL/K	CV J/MOL/K	CP J/MOL/K	M M/SEC
98.115	21.950	0.04556	32.6681	1061.842	5511.8	8017.5	78.598	47.55	68.02	2247
100.000	21.892	0.04568	32.0432	1045.873	5633.3	8145.6	79.892	47.50	67.98	2231
110.000	21.589	0.04632	29.0532	965.907	6277.0	8824.6	86.363	47.19	67.81	2149
120.000	21.290	0.04697	26.5101	893.140	6918.7	9502.1	92.258	46.86	67.70	2071
130.000	20.995	0.04763	24.3117	826.687	7559.0	10178.7	97.674	46.55	67.64	1999
140.000	20.702	0.04831	22.3856	765.872	8198.2	10855.0	102.686	46.27	67.64	1930
150.000	20.410	0.04900	20.6753	710.144	8837.0	11531.7	107.355	46.03	67.71	1864
160.000	20.119	0.04970	19.1537	659.041	9475.8	12209.5	111.729	45.86	67.86	1801
170.000	19.829	0.05043	17.7790	612.157	10115.4	12889.2	115.849	45.76	68.09	1740
180.000	19.538	0.05118	16.5324	569.132	10756.5	13571.5	119.749	45.74	68.39	1682
190.000	19.248	0.05195	15.3960	529.632	11399.7	14257.2	123.457	45.82	68.77	1626
200.000	18.957	0.05275	14.3556	493.361	12045.8	14947.2	126.995	45.98	69.23	1572
210.000	18.666	0.05357	13.3996	460.040	12695.5	15642.1	130.386	46.24	69.76	1519
220.000	18.374	0.05442	12.5188	429.414	13349.3	16342.6	133.645	46.58	70.36	1469
230.000	18.083	0.05530	11.7054	401.248	14007.9	17049.5	136.787	47.00	71.02	1420
240.000	17.791	0.05621	10.9527	375.330	14671.7	17763.2	139.824	47.50	71.73	1373
250.000	17.499	0.05715	10.2553	351.467	15341.2	18484.3	142.767	48.05	72.48	1328
260.000	17.207	0.05812	9.6084	329.483	16016.6	19212.9	145.625	48.65	73.26	1284
270.000	16.916	0.05912	9.0078	309.221	16698.0	19949.4	148.405	49.28	74.04	1243
280.000	16.625	0.06015	8.4498	290.543	17385.5	20693.8	151.112	49.94	74.83	1203
290.000	16.334	0.06122	7.9311	273.321	18078.8	21446.0	153.751	50.60	75.61	1165
300.000	16.044	0.06233	7.4487	257.443	18778.1	22206.1	156.328	51.29	76.40	1129
310.000	15.756	0.06347	7.0001	242.811	19483.4	22974.3	158.847	52.05	77.25	1095
320.000	15.468	0.06465	6.5827	229.333	20196.0	23751.7	161.315	53.03	78.30	1061
330.000	15.182	0.06587	6.1943	216.930	20918.8	24541.6	163.746	54.44	79.76	1028
340.000	14.897	0.06713	5.8330	205.528	21656.0	25348.1	166.153	57.14	82.50	993
350.000	14.614	0.06843	5.4968	195.059	22411.8	26175.3	168.551	57.58	82.97	967
360.000	14.333	0.06977	5.1840	185.464	23170.8	27008.0	170.896	58.21	83.60	941
370.000	14.055	0.07115	4.8929	176.685	23934.5	27847.7	173.197	58.97	84.35	917
380.000	13.780	0.07257	4.6220	169.668	24703.9	28695.3	175.457	59.82	85.17	894
390.000	13.507	0.07403	4.3700	161.364	25479.4	29551.4	177.681	60.75	86.05	872
400.000	13.238	0.07554	4.1355	154.727	26261.7	30416.4	179.871	61.74	86.96	851
410.000	12.973	0.07708	3.9173	148.712	27051.1	31290.7	182.030	62.76	87.90	832
420.000	12.711	0.07867	3.7141	143.277	27847.6	32174.4	184.159	63.81	88.84	814
430.000	12.454	0.08029	3.5250	138.384	28651.4	33067.5	186.261	64.89	89.78	798
440.000	12.202	0.08195	3.3489	133.995	29462.5	33970.0	188.335	65.98	90.72	783
450.000	11.955	0.08365	3.1849	130.075	30281.1	34881.8	190.384	67.08	91.64	769
460.000	11.712	0.08538	3.0320	126.592	31106.8	35802.7	192.408	68.19	92.54	756
470.000	11.476	0.08714	2.8896	123.512	31939.9	36732.5	194.408	69.30	93.43	744
480.000	11.245	0.08893	2.7567	120.807	32779.9	37671.1	196.384	70.41	94.29	733
490.000	11.019	0.09075	2.6327	118.448	33626.9	38618.2	198.337	71.51	95.13	724
500.000	10.800	0.09259	2.5170	116.408	34480.9	39573.5	200.267	72.61	95.94	715
520.000	10.380	0.09634	2.3080	113.182	36209.4	41508.1	204.061	74.79	97.50	701
540.000	9.984	0.10016	2.1252	110.938	37964.4	43473.0	207.768	76.93	98.98	689
560.000	9.613	0.10402	1.9650	109.509	39745.6	45466.8	211.394	79.03	100.39	680
580.000	9.266	0.10792	1.8241	108.744	41552.9	47488.3	214.940	81.09	101.76	674
600.000	8.942	0.11183	1.6998	108.518	43386.1	49536.8	218.412	83.11	103.08	669

