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THERMODYNAMIC PROPERTIES OF LIQUEFIED PETROLEUM GASES

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16. Abstract

The thermodynamic properties of several liquefied petroleum gases (with particular emphasis on propane) are discussed in detail. It is concluded that the widely used propane data by Stearns and George are too inconsistent and too inaccurate to be used for mass flow calculations of propane and propane mixtures through safety valves of rail tank cars. Accordingly, the thermodynamic properties of propane, propylene, n-butane, and a mixture of 65% (by mole) propane, 25% propylene, and 10% n-butane are recalculated using equations of states proposed by Benedict-Webb-Rubin (BWR) and by Starling. It is shown that Starling's equation results in thermodynamic properties which are more consistent and compare better with measured values than the BWR equation. Thermodynamic data for the four liquefied petroleum gases discussed above are calculated and presented in tabular form. In addition, predictions of pure propane mass flow rates (based upon isentropic), homogeneous equilibrium flow) are given. The influence of the thermodynamic data upon the predicted mass flow rates is demonstrated.

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Preface

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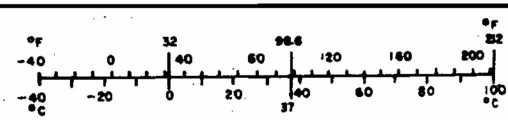
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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Nomenclature

A = Gibbs free energy

$\bar{A}$ = Residual work content, Btu/lb

C_p = Constant pressure specific heat, Btu/lb-°F

C_v = Constant volume specific heat, Btu/lb-°F

E = Internal energy, Btu/lb

G = Mass flux, lb/ft^2-sec

G_c = Critical mass flux, lb/ft^2-sec

g_c = Newton constant, 32.2 lb-ft/lb$_f$-sec^2

H = Enthalpy, Btu/lb

J = Mechanical to thermal energy conversion factor, 778 ft-lb$_f$/Btu

K = Slip ratio, U_g/U_ℓ, dimensionless

P = Pressure, lb$_f$/ft^2

Q = Heat added, Btu/ft^2-sec

R = Gas constant, 1.987 Btu/lb-mole-°R

S = Entropy, Btu/lb-°F

S_0 = Stagnation entropy, Btu/lb-°F

S_ℓ = Liquid phase entropy, Btu/lb-°F

S_g = Vapor phase entropy, Btu/lb-°F

$S_{\ell g}$ = Entropy of evaporation, Btu/lb-°F

T = Temperature, °R

U = Internal energy, Btu/lb

V = Specific volume, ft^3/lb

W_g = Mass of gas phase, lb

W_ℓ = Mass of liquid phase, lb

X = Quality, $X = W_g/(W_g + W_\ell)$, dimensionless

α = Constant of state equation

Nomenclature (Cont.)

ρ = Density, lb/ft^3

ρ_g = Vapor phase density, lb/ft^3

ρ_ℓ = Liquid phase density, lb/ft^3

Chapter 1. Executive Summary

The thermodynamic properties of propane, propylene, and n-butane and of a mixture consisting of 65% (by mole) propane, 25% propylene, and 10% n-butane were calculated using virial equations of state. The particular virial equations chosen for the calculations were those by Benedict-Webb-Rubin and by Starling. All experimental input into these semi-empirical equations was reevaluated using numerical techniques to achieve the best possible accuracy. Starling's equation results in thermodynamic properties which are most consistent and compare best with measured values. It was found that the widely used propane data by Stearns and George are too inconsistent and too inaccurate to be used for mass flow calculations of propane and propane mixtures. This report includes extensive saturation temperature tables for propane, propylene, n-butane, and a pseudo-fluid consisting of a mixture of propane, propylene, and n-butane which approximates commercial propane. While the Benedict-Webb-Rubin and the Starling equation were used for the calculation of the properties of pure propane and the respective results listed in separate tables, the results given for propylene, n-butane, and the hydrocarbon mixture are based on Starling's equation. Thermodynamic data of pure propane in the compressed liquid region were calculated and are given in extensive tables. Temperature-entropy diagrams for propane, propylene, and n-butane based on Starling's equation of state were constructed. In addition, predictions of pure propane mass flow rates based upon isentropic, homogeneous equilibrium flow are given. To demonstrate the importance of accuracy and consistency of the thermodynamic data, the mass flow rate prediction calculations were performed twice, once using the propane data as reported by Stearns and George, and one using calculated propane properties based on Starling's equation.

Chapter 2. Introduction

The flow of commerical propane through safety valves is being studied at the University of Maryland under the sponsorship of the Department of Transportation. The aim of this study is to provide industry and the Department of Transportation with accurate valve sizing equations or charts. The program includes interpretation and evaluation of already completed full scale propane flow tests and future active participation of full scale propane flow tests. The main thrust of the Safety Valve Study at the University of Maryland, however, is the formulation of valve sizing equations and their verification.

The flow rate prediction of propane through safety valves is very complex because of three fundamentally different reasons:

1. Two-phase flow occurs during the discharge of the propane (most of the existing fluid flow prediction equations are only valid for one-phase flow).
2. The thermodynamic data of commercial propane are at present not known with sufficient accuracy to give reasonably accurate flow-rate predictions based on homogeneous flow.
3. The flow path (stream line picture) through a safety valve is very complex and its influence on the mass flow rates for a given pressure gradient across the valve will vary with the different two-phase flow regimes.

The different two-phase flow regimes which may occur are vapor flow, mist and spray flow, bubble and slug flow, annular flow, liquid flow, and flashing flow. The establishing of the particular flow regime which will govern the maximum possible mass discharge through the safety valve is dependent upon the individual accident condition; e.g., the position of the safety valve, the rate of heat input into the tank car, the amount of propane in the tank car, etc.

Any mathematical description of flow of real fluid includes the continuity equation, the momentum equation, the energy equation, and the equation of state of the fluid. Without an accurate equation of state, correct modeling of the flow, such as predicting the mass flow rates is not possible. During the early part of the investigation of propane flow through safety valves a lack of accurate and consistent thermodynamic data of propane was found to exist. This lack of data prompted the study which is described in this report.

Chapter 3. Thermodynamic Properties of Propane

3.0 Background and Development of Virial Equations of State

The first systematic investigation of the thermodynamic properties of propane is that by Dana et al (6) in 1926. Dana et al (6) made vapor pressure measurements and published pressure-temperature tables for the saturated liquid and saturated vapor of propane. Since then, a number of researchers have made additional contributions in this field. Among them, Sage, Schaafsma, and Lacey (8) and Burgoyne (5) published the pressure-volume-temperature relations and thermal properties such as enthalpy and internal energy of propane. Beattie, Kay and Kaminsky (2) made additional P-V-T measurements. Beattie, Poffenberger, and Hadlock (3) measured the critical constants (T_c and P_c) of propane. Stearns and George (10) summarized all of the above and other available experimental data in 1943. To this date, the thermodynamic tables and diagrams by Stearns and George (10) are the most often referenced propane data. This data, however, will lead to large inconsistent fluctuation in calculated mass flow rates as is discussed in Chapter 4. For this reason, it was necessary to find or develop a more accurate equation of state for propane. Two semi-empirical equations of state for propane were found in the literature and were further investigated in detail in this study, namely, the Benedict - Webb-Rubin (B-W-R) equation (4) and Starling's (9) equation. Starling's work is essentially an extension of the approach taken by Benedict et al. The above two semi-empirical equations are virial equations in which the virial coefficients are obtained by determining the deviation between the Helmholtz free energy of the real gas and that of an ideal gas. The introduction of empirical data requires curve fitting of this data which significantly influences the consistency of the calculated thermodynamic values. For this reason, both the calculations of B-W-R and that of Starling's were repeated, improved and expanded. A discussion of the development of the B-W-R equation of state is given in the following paragraph.

The work content, also known as the Helmholtz free energy or the Gibb's ψ-function, is related to the internal energy E, the absolute temperature T, and the entropy S by the equation

$$A = E - TS \tag{3-1}$$

The residual work content $\bar{A}$ is defined as the difference between the work content of a mole of hydrocarbons at molar density ρ, absolute temperature T and its work content in the hypothetical ideal gas state at the same density and temperature. The residual work content is defined by

$$\bar{A} = A - RT \ln \rho - \lim_{\rho \to 0} (A - RT \ln \rho) \qquad (3\text{-}2)$$

The above equation is considered as a fundamental equation because a number of thermodynamic properties of the medium may be computed from it. For instance, an equation of state in which the pressure P is expressed as a function of the density and temperature may be obtained by the relation:

$$P = \rho RT + \rho^2 \left(\frac{\partial \bar{A}}{\partial \rho}\right)_T \qquad (3\text{-}3)$$

Ursell (11) and Mayor (7) showed that the residual work content $\bar{A}$ of a stable gas can be expressed by the series:

$$\bar{A} = Q_1(T)\rho + Q_2(T)\rho^2 + \ldots \qquad (3\text{-}4)$$

where Q_1 and Q_2 are functions of the temperature.

In developing the equation of state, attention was first directed to the constant density line (isometrics) when the quantity $(P - \rho RT)/\rho^2$ is plotted against temperature; these isometrics are very nearly straight lines. It was found that for most hydrocarbons including propane the isometrics could be represented by an equation of the form:

$$(P - \rho RT)/\rho^2 = RTB(\rho) - A(\rho) - C(\rho)/T^2 \qquad (3\text{-}5)$$

where A, B, and C are functions of density. $B(\rho)$ in turn could be represented by the simple linear equation:

$$B(\rho) = B_0 + b\rho \qquad (3\text{-}6)$$

The plots of $A(\rho)$ and $C(\rho)$ against density, however, showed marked curvature; $A(\rho)$ was represented by an equation of the form

$$A(\rho) = A_0 + a\rho(1 - \alpha\rho^3) \qquad (3\text{-}7)$$

and $C(\rho)$ by an equation of the form:

$$C(\rho) = C_0 - c\rho(1 + \gamma\rho^2) \exp(-\gamma\rho^2) \quad (3\text{-}8)$$

When the expressions (3-5), (3-6), (3-7), and (3-8) are combined, the equation of state is obtained. The equation of state is

$$P = \rho RT + \rho^2 RT(B_0 + \rho b) - (A_0 + a\rho + a\alpha\rho^4) + (1/T^2)(C_0 - c\rho(1 + \gamma\rho^2) \exp(-\gamma\rho^2)) \quad (3\text{-}9)$$

or

$$P = \rho RT + (B_0RT - A_0 - C_0/T^2)\rho^2 + (bRT - a)\rho^3 + a\alpha\rho^6 + \frac{c\rho^3(1 + \gamma\rho^2) \exp(-\gamma\rho^2)}{T^2} \quad (3\text{-}10)$$

The numerical values of the parameters A_0, B_0, C_0, a, b, c, α, and γ can be determined from experimental P-V-T data. Benedict-Webb-Rubin (4) describe at length the manner in which this is done; Table 3-1a gives a listing of these values for the B-W-R equation.

An equation of state similar to the B-W-R equation was recently developed by Starling (9). Starling's equation of state has more virial coefficients and, according to its author, is more accurate than B-W-R equation in the liquid region. Corresponding to the coefficients of the B-W-R equation, Starling gives the following equation of state for hydrocarbons:

$$P = \rho RT + \left(B_0RT - A_0 - \frac{C_0}{T^2} + \frac{D_0}{T^3} - \frac{E_0}{T^4}\right)\rho^2 + \left(bRT - a - \frac{d}{T}\right)\rho^3 + \alpha\left(a + \frac{d}{T}\right)\rho^6 + \frac{c^3}{T^2}(1 + \gamma\rho^2) \exp(-\gamma\rho^2) \quad (3\text{-}11)$$

The coefficients of the above equation as derived by Starling are given in Table 3-1b.

3.1 Thermodynamic Properties of Pure Propane

Thermodynamic properties such as enthalpy, entropy, etc. of a pure substance can be derived from an equation of state of the substance which relates pressure, volume, and temperature by means of Maxwell's relations. Thermodynamic properties of primary importance in flow predictions are specific volume (or density), enthalpy, entropy, and specific heat in addition to temperature and pressure. The derivation of these properties are discussed in detail below for both the B-W-R equation and the equation of state proposed by K. E. Starling.

3.1.1 Density

The B-W-R equation is written as

$$P = \rho RT + \left(B_0RT - A_0 - \frac{C_0}{T^2}\right)\rho^2 + (bRT - a)\rho^3 + a\alpha\rho^6 + \frac{C\rho^3}{T^2}(1 + \gamma\rho^2)\exp(-\gamma\rho^2) \qquad (3\text{-}12)$$

Similarly, Starling's equation is of the form

$$P = \rho RT + \left(B_0RT - A_0 - \frac{C_0}{T^2} + \frac{D_0}{T^3} - \frac{E_0}{T^4}\right)\rho^2 + (bRT - a - \frac{d}{T})\rho^3 + \alpha(a + \frac{d}{T})\rho^6 + \frac{c\ ^3}{T^2}(1 + \gamma\rho^2)\exp(-\gamma\rho^2) \qquad (3\text{-}13)$$

The density ρ can only be obtained by an iterative procedure. It should be pointed out that the derivative of pressure with respect to density in the liquid phase is extremely large so that a very slight change in liquid density can cause a dramatic change in pressure of the liquid phase. It was found that in order to match the calculated values of the liquid pressure with those given by Starling ([9]), more than the significant figures given by Starling's tabulated values of liquid density are required. In other words, when the values of temperature and liquid density tabulated by Starling in reference (9) are substituted into his equation of state, the calculated pressure values do not agree with the tabulated pressures (see Figure 3-1). Instead, if the values of the liquid density which were computed using 18 significant figures are used to compute the corresponding pressures for any given temperature and density, the values of computed and tabulated pressures are in close agreement. Two additional curves were plotted in Figure 3-1 to show the sensitivity of $dP/d\rho$ liquid. Curves (1) and (2) were constructed using the values of liquid pressure calculated from saturation temperatures and specific volume values which were either slightly smaller or slightly larger than those tabulated by Starling, i.e., (V - 0.00005) and (V + 0.00004). Figure 3-1 shows the effect of the significant figures of liquid density on the pressure values. The great difference in calculated saturation pressure due to the small variation in liquid density (+0.00004 or -0.00005) is very significant, since all the thermodynamic properties required for critical mass flow rate predictions are functions of temperature and pressure. The fluctuations in maximum flow rate predictions which are obtained by using Stearns and George's thermodynamic data (see Chapter 4) is in part due to the lack of accuracy in density which also influences other thermodynamic properties. Since thermodynamic properties are tied to density predictions, poor accuracy in the density prediction will cause inaccuracies in calculating enthalpy, entropy, and specific heat values. It was found that inaccuracies of thermodynamic properties were magnified when mass flow rates were computed.

3.1.2 Enthalpy

The enthalpy of a real substance (e.g., Propane) at any temperature and pressure can be obtained from the relation

$$H = (H - H^0) + (H^0 - H_0^0) + H_0^0 \qquad (3\text{-}14)$$

where H_0^0 is the standard enthalpy of formation of that substance from the elements (i.e., carbon and hydrogen) at 0°R and 0 psia. $(H^0 - H_0^0)$ is the difference in the enthalpy of the substance in the ideal gas state at the temperature of interest and the enthalpy of the reference state of 0°R. $H - H^0$ is the enthalpy departure, that is, the difference in the enthalpy of the substance at the temperature and pressure of interest and the enthalpy of the substance in the ideal gas state at the same temperature. From classic thermodynamics, one can write

$$dH = TdS + VdP$$
$$= T\left[\left(\frac{\partial S}{\partial P}\right)_T dP + \left(\frac{\partial S}{\partial T}\right)_p dT\right] + VdP \quad (3\text{-}15)$$

Applying the Maxwell's relation

$$\left(\frac{\partial S}{\partial T}\right)_p = \frac{Cp}{T} \quad (3\text{-}16)$$

results in

$$dH = d(PV) + \left[T\left(\frac{\partial P}{\partial T}\right)_V - P\right]_T dV \quad (3\text{-}17)$$

Integrating yields

$$H - H^0 = \frac{P}{\rho} - RT + \int_0^\rho \left[p - T\left(\frac{\partial P}{\partial T}\right)_\rho\right]_T \frac{d\rho}{\rho^2} \quad (3\text{-}18)$$

Substituting the B-W-R equation of state into equation (3-1) results in

$$H - H^0 = \left(B_0RT - 2A_0 - 4\frac{C_0}{T^2}\right)\rho + \frac{1}{2}\left(2bRT - 3a\right)\rho^2$$
$$+ \frac{6}{5}\alpha a\rho^5 + \frac{C}{\gamma T^2}\left[3 - \left(3 + \frac{1}{2}\gamma\rho^2 - \gamma^2\rho^4\right) \exp(-\gamma\rho)\right] \quad (3\text{-}19)$$

Likewise, by substituting Starling's equation of state to equation (3-1), the following expression is obtained:

$$(H - H^0) = \left[B_0RT - 2A_0 - \frac{4C_0}{T^2} + \frac{5D_0}{T^3} - \frac{6E_0}{T^4}\right]\rho$$
$$+ \frac{1}{2}\left(2bRT - 3a - \frac{4d}{T}\right)\rho^2 + \frac{1}{5}\alpha\left(6a + \frac{7d}{T}\right)\rho^5$$
$$+ \frac{C}{T^2}\left[3 - (3 + \frac{1}{2}\gamma\rho^2 - \gamma^2\rho^4) \exp(-\gamma\rho^2)\right] \quad (3\text{-}20)$$

The differences between the enthalpy of propane in the ideal gas state at the temperature of interest and the enthalpy at the reference state of 0°R ($H^0 - H^0_0$) are given in reference (1) as a function of temperature. Since

$dH = dQ + VdP$, the change in enthalpy during an isobaric process is equal to the heat that is transferred. That is,

$$H^0 - H_0^0 = Q \qquad (3\text{-}21)$$

or

$$H^0 - H_0^0 = \int_i^f C_p dT \qquad (3\text{-}22)$$

The data given by reference (1) are tabulated values over a range of temperatures. In order to obtain values between these tabulated values, curve-fitting becomes necessary. The degree of the polynomial chosen for curve-fitting strongly influences the accuracy of the finally computed enthalpies. Figure 3-2a shows the data points of $(H^0 - H_0^0)$ (see reference (1)) and a third order polynomial curve-fitting. As a general rule of curve-fitting, as long as the predicted values do not start to oscillate, the higher the degree of polynomial, the better the curve-fitting. It was found that a ninth order curve-fitting is necessary in order to obtain a consistent prediction of the maximum mass flux of propane. The ninth order curve-fitting of $(H^0 - H_0^0)$ is shown on Figure 3-2b. It is difficult to visually detect an improvement in going from a third degree polynomial to a 9th degree polynomial. Yet the effect of the degree of polynomial used in curve-fitting upon maximum mass flow rate is very severe.

The equation representing the ninth order polynomial is

$$H^0 - H_0^0 = \sum_{n=1}^{N=9} C_{e(n)} P_{(n)} (T)$$

with $P_0 = 0$

$P_1 = 1.0$

$P_{(j)}(T) = T\, P_{(j-1)}(T) - \alpha_{e(j-1)} P_{(j-1)} - \beta_{e(j-1)} P_{(j-2)}$

where $j = 2, 3, \ldots, N$.

The numerical values of $\alpha_{e(j-1)}$, $\beta_{e(j-1)}$, $C_{e(n)}$, and H_0^0 are given in Table 3-2.

3.1.3 Entropy

Gibbs' function is defined by

$$A = U - TS \quad (3\text{-}23)$$

The work content of a gaseous state may be obtained from the equation of state by the relation

$$A = RT \ln \rho RT + E_0 - TS_0 + \int_0^\rho \left[\frac{P - \rho RT}{\rho^2}\right] d\rho \quad (3\text{-}24)$$

The first three terms represent the work content of an ideal gas at the density and temperature of the actual condition. E_0 and S_0 are, respectively, the internal energy and the entropy of one mole of the substance in the ideal gas state at unit pressure. The integral represents the difference between the work content of the actual compound and that of an ideal gas.

Entropy is related to the work content by the following expression:

$$S = -(\partial A/\partial T)_{\rho,x} \quad (3\text{-}25)$$

Substituting equation (3-24) into (3-25) yields

$$S = S_0 - R \ln(\rho RT) - \int_0^\rho \left[-\rho R + \left(\frac{\partial P}{\partial T}\right)_\rho\right]\frac{d\rho}{\rho^2} \quad (3\text{-}26)$$

and finally

$$S - S_0 = -R \ln(\rho RT) + \int_0^\rho \left[\rho R - \left(\frac{\partial P}{\partial T}\right)_\rho\right] \frac{d\rho}{\rho^2} \quad (3\text{-}27)$$

when the B-W-R equation of state is employed, the following equation is obtained

$$S - S_0 = -R \ln \rho RT - \left(B_0 R + 2\frac{C_0}{T^3}\right)\rho - \frac{bR\rho^2}{2} + \frac{2C\rho^2}{T^3}\left[\frac{1 - e^{-(\gamma\rho^2)}}{\gamma\rho^2} - \frac{e^{-\gamma\rho^2}}{2}\right] \quad (3\text{-}28)$$

where $S - S_0$ is often called "entropy departure."

A parallel development for Starling's equation gives

$$S - S_0 = -R \ln \rho RT - \left(B_0 R + \frac{2C_0}{T^3} - \frac{3D_0}{T^4} + \frac{4E_0}{T^5}\right)\rho - \frac{1}{2}\left(bR + \frac{d}{T^2}\right)\rho^2$$

$$+ \frac{\alpha\rho^5 d}{5T^2} + \frac{2C}{\gamma T^3}\left[1 - \left(1 + \frac{1}{2}\gamma\rho^2\right)\exp(-\gamma\rho^2)\right] \quad . \qquad (3\text{-}29)$$

The entropies of propane in the ideal gas state at unit pressure and various temperatures are given in reference (1); this report contains most of the available experimental thermodynamic data on hydrocarbons in the literature up to the year of 1952. Similar to the polynomial curve-fitting for enthalpy departure, the entropy departure of propane is fitted to polynomials ranging from the second order to the ninth order. Figure 3-3a shows the data points obtained from reference (1) and a third order polynomial curve-fitting, while Figure 3-3b gives the finally chosen ninth order polynomial representing $(S_0 - S_0^0)$ values.

The equation representing $(S_0 - S_0^0)$ is

$$S_0 - S_0^0 = \sum_{n=1}^{N=9} C_{e(n)} P_{(n)}(T) \qquad \text{(Btu/lb-moles °F)}$$

with $P_1(T) = 1.0$

$$P_j(T) = T\,P_{(j-1)}(T) - \alpha_{e(j-1)} P_{(j-1)} - \beta_{e(j-1)} P_{(j-2)}$$

where $j = 2, 3, \ldots, N$

The numerical values of $\alpha_{e(j-1)}$, $\beta_{e(j-1)}$, $C_{e(n)}$ are given in Table 3-b.

3.1.4 Heat Capacity

From classical thermodynamics, the following relations are obtained:

$$\left(\frac{\partial S}{\partial T}\right)_v = \frac{C_v}{T} \qquad (3\text{-}30)$$

$$dS = -\left(\frac{\partial V}{\partial T}\right)_p dP + \frac{C_p}{T} dT \qquad (3\text{-}31)$$

Going through a proper limiting process yields

$$\left(\frac{\partial S}{\partial T}\right)_V = -\left(\frac{\partial V}{\partial T}\right)_p \left(\frac{\partial P}{\partial T}\right)_V + \frac{C_p}{T} \qquad (3\text{-}32)$$

Combining with equation (3-30), and then substituting for $(\partial P/\partial T)_V$ according to

$$\left(\frac{\partial Z}{\partial X}\right)_y = -\left(\frac{\partial Y}{\partial X}\right)_Z \left(\frac{\partial Z}{\partial Y}\right)_X = -\frac{(\partial Y/\partial X)_Z}{(\partial Y/\partial Z)_X}$$

gives

$$(C_p - C_v) = T\left(\frac{\partial V}{\partial T}\right)_p \left(\frac{\partial P}{\partial T}\right)_V = -T\left(\frac{\partial V}{\partial T}\right)_p^2 \left(\frac{\partial P}{\partial V}\right)_T \qquad (3\text{-}33)$$

The specific heat departure $(C_p - C_p^*)$ can be estimated as follows:

$$C_p - C_p^* = C_p - C_v^\infty - R \qquad (3\text{-}34)$$

or

$$C_p - C_p^* = (C_p - C_v) + (C_v - C_v^\infty) - R \qquad (3\text{-}35)$$

where C_p^* is the specific heat of the gas exhibiting ideal gas behavior

C_p is constant pressure heat capacity of the real gas

C_v is the constant volume heat capacity of the real gas

C_v^∞ is the constant-volume specific heat at zero pressure or infinite volume of the real gas.

Relations for $C_p - C_v$ and $C_v - C_v^\infty$ in terms of the equation of state may be developed from the following relationships:

$$C_p - C_v = -T\left(\frac{\partial P}{\partial T}\right)_V^2 \Big/ \left(\frac{\partial P}{\partial V}\right)_T \qquad (3\text{-}36)$$

$$\left(\frac{\partial C_v}{\partial V}\right)_T = T\left(\frac{\partial^2 P}{\partial T^2}\right)_V \qquad (3\text{-}37)$$

$$C_v - C_v^\infty = \Delta(C_v)_T = \int_\infty^V \left(\frac{dC_v}{dV}\right)_T dV \qquad (3\text{-}38)$$

Combining equations (3-34), (3-35), and (3-36) gives

$$C_p - C_p^* = \frac{-T\left(\frac{\partial P}{\partial T}\right)_V^2}{\left(\frac{\partial P}{\partial V}\right)_T} + \int_\infty^V \left(\frac{\partial C_v}{\partial V}\right)_T dV - R \tag{3-39}$$

$$= \frac{-T\left(\frac{\partial P}{\partial T}\right)_V^2}{\left(\frac{\partial P}{\partial V}\right)_T} + \int_\infty^V \left(\frac{\partial^2 P}{\partial T^2}\right)_V dV - R \tag{3-40}$$

Applying the B-W-R equation of state results in

$$C_p - C_p^* = -R + \frac{6C_0}{T^3}\rho + \frac{6C}{T^3\gamma}\left(e^{-\gamma\rho^2} - 1\right) + \frac{3C}{T^3}\rho^2 e^{-\gamma\rho^2}$$

$$+ \frac{T\left[R + \left(B_0R + \frac{2C_0}{T^3}\right)\rho + (bR\rho^2) - \frac{2C\rho^2}{T^3}(1 + \gamma\rho^2)\exp(-\gamma\rho^2)\right]^2}{\text{denominator}} \tag{3-41}$$

where the denominator is

$$\{RT + 2\rho\left(B_0RT - A_0 - \frac{C_0}{T^2}\right) + 3\rho^2(bRT - a)$$

$$+ 6a\alpha\rho^5 + \frac{C\rho^2}{T^2}(3 + 3\gamma^2\rho - 2\gamma^2\rho^4)\exp(-\gamma\rho^2)\}$$

When employing Starling's equation, the specific heat departure becomes

$$C_p - C_p^* = -R + \left(\frac{6C_0}{T^3} - \frac{12D_0}{T^4} - \frac{20E_0}{T^5}\right)\rho + \frac{d}{T^2}\rho^2$$

$$+ \frac{2}{5}\frac{\alpha d}{T^2}\rho^5 + \frac{6C}{\gamma T^3}\left(e^{-\gamma\rho^2} - 1\right) + \frac{3C}{T^3}\rho^2 e^{-\gamma\rho^2} + (\overline{P}) \tag{3-42}$$

where $(\overline{P})$ is

$$\frac{T\left[R + \rho\left(B_0R + \frac{2C_0}{T^3} - \frac{3D_0}{T^4} + \frac{4E_0}{T^5}\right) + \rho^2\left(bR + \frac{d}{T^2}\right) - \frac{\alpha d\rho^5}{T^2} - \frac{2c\rho^2}{T^3}(1 + \gamma\rho^2)\exp(-\gamma\rho^2)\right]^2}{\text{denominator}}$$

where the denominator is

$$\{RT + 2\left(B_0RT - A_0 - \frac{C_0}{T^2} + \frac{D_0}{T^3} - \frac{E_0}{T^4}\right)\rho + 3\rho^2\left(bRT - a - \frac{d}{T}\right)$$

$$+ 6\alpha\rho^2(a + \frac{d}{T}) + \frac{C\rho^2}{T^2}(3 + 3\gamma\rho^2 - 2\gamma^2\rho^4)\exp(-\gamma\rho^2)\}$$

Experimentally found values for the heat capacity C_p^* are given in reference (1); again, curve fitting was employed to make interpolation between the given data points possible. The results of the third and ninth order polynomial curve-fitting of the reference value C_p^* are shown in Figures 3-4a and b. The final equation adapted to represent the specific heat of propane exhibiting ideal gas behavior is the ninth order polynomial of the form

$$C_p^*(T) = \sum_{n=1}^{N} C_{e(n)}P_n(T) \qquad \text{(Btu/lb-mole-°F)}$$

with $P_0(T) = 0$

$P_1(T) = 1.0$

and $P_j(T) = T\,P_{(j-1)}(T) - \alpha_{e(j-1)}P_{(j-1)} - \beta_{e(j-1)}P_{(j-2)}$

where $j = 2, 3, 4, \ldots, N$

The numerical values of the coefficients $\alpha_{e(j-1)}$, $\beta_{e(j-1)}$, and $C_{e(n)}$ are given in Table 3-4.

Tables 5 and 6 give the thermodynamic properties of pure propane as obtained from the B-W-R equation and Starling's equation, respectively. The calculations for these two equations were extended into the subcooled region. To make a comparison easier, a listing of the already existing data by Stearns and George is also given (see Table 3-7). Figure 3-5, 3-6, and 3-7 are temperature-entropy diagrams for pure propane as obtained from the B-W-R equation, Starling's equation, and Stearns and George's data, respectively.

3.1.5 Fugacity

It is seen that the saturation temperatures and pressures of these three tables are different from one another. The saturation temperatures and their corresponding saturation pressures given by Stearns and George are the measured values while those by Benedict-Webb-Rubin and by Starling are the predicted values. It is known from thermodynamics, that at saturation conditions the following two conditions must be satisfied

$$P(\rho_\ell, T) = P(\rho_g, T) = P \tag{3-42}$$

and

$$f(\rho_\ell, T) = f(\rho_g, T) = f \tag{3-43}$$

The procedure adopted in calculating the saturation pressure for a given saturation temperature is as follows: For a chosen saturation temperature, guess a saturation pressure P. Apply the equation of state (B-W-R or Starling's equation of state) to calculate the density ratio ρ_ℓ/ρ_g. Substituting the values of T and ρ into the appropriate equation relating fugacity f to T and ρ, one obtains the value of f_ℓ/f_g. The new value of pressure for this iterative calculation is the product of the first guessed P and the fugacity ratio (f_ℓ/f_g). The calculation continues until the value of P converges. The expression for the fugacity for Starling's equation is

$$RT\,\ell n\,f = RT\,\ell n(R\rho T) + 2\left(B_0RT - A_0 - \frac{C_0}{T^2} + \frac{D_0}{T^3} - \frac{E_0}{T^4}\right)\rho$$

$$+ \frac{3}{2}(bRT - a - \frac{d}{T})\rho^2 + \frac{6\alpha}{5}(a + \frac{d}{T})\rho^5$$

$$+ \frac{C}{\gamma T^2}[1 - (1 - \frac{1}{2}\gamma\rho^2 - \gamma^2\rho^4)\exp(-\gamma\rho^2)] \tag{3-44}$$

The corresponding expression for the B-W-R equation is

$$RT\,\ell n\,f = RT\,\ell n(\rho RT) + 2\left(B_0RT - A_0 - \frac{C_0}{T^2}\right)\rho + \frac{3}{2}(bRT - a)\rho^2$$

$$+ \frac{6}{5}\alpha a\rho^5 + \frac{C}{\gamma T^2}[1 - (1 - \frac{1}{2}\gamma\rho^2 - \gamma^2\rho^4)\exp(-\gamma\rho^2)] \tag{3-45}$$

The saturation pressure predictions of Starling's equation are much closer to measured values than the predictions by the B-W-R equation of state.

3.2 Thermodynamic Properties of Commerical Propane (A Mixture of Propane, Propylene, and N-Butane

Commercial grade propane has a minimum purity of 65 percent by mole of propane. The major component of the impurities are propylene and butane.

Although the purity may vary from lot to lot, the typical composition of the commercial or industrial grade propane is of 65% propane, 25% propylene, and 10% butane.

The Benedict-Webb-Rubin and the Starling's equation of state for multicomponent mixtures are of the same form as that for the single component case.

The coefficients of Benedict-Webb-Rubin's equation of state for propane mixtures are

$$B_0 = [\sum_i X_i B_{0i}] \qquad (3\text{-}46)$$

$$A_0 = [\sum_i (X_i A_{0i}^{1/2})]^2 \qquad (3\text{-}47)$$

$$C_0 = [\sum_i (X_i C_{0i}^{1/2})]^2 \qquad (3\text{-}48)$$

$$b = [\sum_i (X_i b_i^{1/3})]^3 \qquad (3\text{-}49)$$

$$a = [\sum_i (X_i a_i^{1/3})]^3 \qquad (3\text{-}50)$$

$$c = [\sum_i (X_i c_i^{1/3})]^3 \qquad (3\text{-}51)$$

$$\alpha = [\sum_i (X_i \alpha_i^{1/3})]^3 \qquad (3\text{-}52)$$

$$\gamma = [_i (X_i \gamma_i^{1/2})]^2 \qquad (3\text{-}53)$$

The additional coefficients for Starling's equation are

$$D_0 = \sum_i \sum_j X_i X_j D_{0i}^{1/2} D_{0j}^{1/2} \qquad (3\text{-}54)$$

$$E_0 = \sum_i \sum_j X_i X_j E_{0i}^{1/2} E_{0j}^{1/2} \qquad (3\text{-}55)$$

$$d = [\sum_i X_i d_i^{1/3}]^3 \qquad (3\text{-}56)$$

where i and j are indices for the components and the summations range from

$i = 1$ to $i = n$ and $j = 1$ to $j = n$, with n being the total number of components. X_i is the molar fraction of the ith component of the mixture. The propane mixture thermodynamic property calculation using both the B-W-R and Starling's equation of state are discussed below.

The enthalpy of a propane mixture can be written as

$$H = \left(H - \sum_{i=1}^{n} X_i H^0\right) + \sum_{i=1}^{n} (H^0 - H_0^0)X_i + \sum_{i=1}^{n} H_0^0 X_i \qquad (3\text{-}57)$$

where $\left(H - \sum_{i=1}^{n} X_i H^0\right)$ is the enthalpy departure of the mixture.

Applying the B-W-R equation, $H - \sum_{i=1}^{n} X_i H^0$ becomes

$$\left(H - \sum_{i=1}^{n} X_i H^0\right) = \left(B_0RT - 2A_0 - \frac{4C_0}{T^2}\right)\rho + (2bRT - 3a)\frac{\rho^2}{2}$$
$$+ \frac{6a\alpha\rho^5}{5} + \frac{C\rho^2}{T^2}\left[3\,\frac{(1 - \exp(-\gamma\rho^2))}{\gamma\rho^2} - \frac{\exp(-\gamma\rho^2)}{2} + \gamma\rho^2 \exp(-\gamma\rho^2)\right] \qquad (3\text{-}58)$$

The corresponding expression using Starling's equation of state is

$$\left(H - \sum_{i=1}^{n} X_i H^0\right) = \left(B_0RT - 2A_0 - \frac{4C_0}{T^2} + \frac{5D_0}{T^3} - \frac{6E_0}{T^4}\right)\rho$$
$$+ \frac{1}{2}\left(2bRT - 3a - \frac{4d}{T}\right)\rho^2 + \frac{1}{5}\alpha\left(6a + \frac{7d}{T}\right)\rho^5$$
$$+ \frac{C}{\gamma T^2}[3 - (3 + \frac{1}{2}\gamma\rho^2 - \gamma^2\rho^4)\exp(-\gamma\rho^2)] \qquad (3\text{-}59)$$

The entropy of a propane mixture can be calculated by

$$S = \Sigma X_i[S_i^0 - R\,\ln\,\rho RTX_i] - \left(B_0R + \frac{2C_0}{T^3}\right)\rho - bR\,\frac{\rho^2}{2}$$
$$+ \frac{2C\rho^2}{T^3}\left[\frac{1 - e^{-\gamma\rho}}{\gamma\rho^2} - \frac{e^{-\gamma\rho^2}}{2}\right] \qquad (3\text{-}60)$$

or

$$S = \Sigma X_i [S_i^0 - R \ln RTX_i] - \left(B_0 R + \frac{2C_0}{T^3} - \frac{3D_0}{T^4} + \frac{4E_0}{T^5}\right)\rho$$

$$- \frac{1}{2}\left(bR + \frac{d}{T^2}\right)\rho^2 + \frac{\alpha\rho^5 d}{5T^2} + \frac{2C}{\gamma T^3}\,[1 - (1 + \tfrac{1}{2}\gamma\rho^2)\exp(-\gamma\rho^2)] \qquad (3\text{-}61)$$

corresponding to equations (3-26) and (3-27), respectively, for pure propane.

The specific heat of a propane mixture can be obtained by applying the equation

$$C_p = \Sigma X_i C_p^* - \Sigma X_i R + \frac{6C_0\rho}{T^3} + \frac{6C}{T^3\gamma}\left(e^{-\gamma\rho^2} - 1\right) + \frac{3C}{T^3}\rho^2 e^{-\gamma\rho^2}$$

$$+ \frac{T\left[R + \left(B_0 R + \frac{2C_0}{T^3}\right)\rho + (bR\rho^2) - \frac{2C\rho^2}{T^3}(1 + \gamma\rho^2)\exp(-\gamma\rho^2)\right]^2}{\text{denominator}} \qquad (3\text{-}62)$$

where the denominator is

$$\{RT + 2\rho\left(B_0 RT - A_0 - \frac{C_0}{T^2}\right) + 3\rho^2(bRT - a) + 6a\alpha\rho^5$$

$$+ \frac{C\rho^2}{T^2}(3 + 3\gamma\rho^2 - 2\gamma^2\rho^4 \exp(-\gamma\rho^2))\}$$

for B-W-R equation of state and

$$C_p = \Sigma X_i C_p^* - \Sigma X_i R + \left(\frac{6C_0}{T^3} - \frac{12D_0}{T^4} - \frac{20E_0}{T^5}\right)\rho + \frac{d}{T^2}\rho^2 + \frac{2}{5}\frac{\alpha d}{T^2}\rho^5$$

$$+ \frac{6\,C}{\gamma T^3}(e^{-\gamma\rho^2} - 1) + \frac{3C}{T^3}\rho^2 e^{-\gamma\rho^2} + \bar{A} \qquad (3\text{-}63)$$

using Starling's equation of state where

$$\bar{A} = \frac{T\left[R + \rho\left(B_0 R + \frac{2C_0}{T^3} - \frac{3D_0}{T^4} + \frac{4E_0}{T^5}\right) + \rho^2\left(bR + \frac{d}{T^2}\right) - \frac{c\rho^2}{T^3}(1 + \gamma\rho^2)\exp(-\gamma\rho^2) - \frac{\alpha d\rho^5}{T^2}\right]^2}{\text{denominator}}$$

where the denominator is

$$\{RT + 2\left(B_0RT - A_0 - \frac{C_0}{T^2} + \frac{D_0}{T^3} - \frac{E_0}{T^4}\right)\rho + 3\rho^2\left(bRT - a - \frac{d}{T}\right)$$

$$+ 6\alpha\rho^2\left(a + \frac{d}{T}\right) + \frac{C\rho^2}{T^2}(3 + 3\gamma\rho^2 - 2\gamma^2\rho^4)\exp(-\gamma\rho^2)\}$$

It can be shown that the work content of a gaseous mixture is given by the relation:

$$A = \Sigma X_i[RT \ln \rho RTX_i + E_i^0 - TS_i^0] + \int_0^\rho \frac{P - RT\rho}{\rho^2}\delta\rho \qquad (3\text{-}64)$$

By substituting the B-W-R equation into the above equation, it follows that

$$A = \Sigma X_i[RT \ln \rho RTX_i + E_i^0 - TS_i^0] + \left(B_0RT - A_0 - \frac{C_0}{T^2}\right)\rho + (bRT - a)\frac{\rho^2}{2}$$

$$+ a\alpha\rho^5/5 + \frac{C\rho^2}{T^2}\left[\frac{1 - \exp(-\gamma\rho^2)}{\gamma\rho^2} - \frac{\exp(-\gamma\rho^2)}{2}\right] \qquad (3\text{-}65)$$

where E_i^0 and S_i^0 are, respectively, the energy and entropy of one mole of the ith pure component in the ideal gas state.

The fugacity, f_i, is obtained from the work content by the thermodynamic relation

$$RT \ln f_j = \left(\frac{\partial NA}{\partial n_i}\right)_{v,T,n} - [E_i^0 - TS_i^0 + RT] \qquad (3\text{-}66)$$

where n_i = number of moles of ith component and

N = total number of moles = Σn_i

Substituting the expression for A into the above equation yields

$$RT \ln f_i = RT \ln \rho RTX_i + [(B_0 + B_{0i})RT - 2(A_0A_{0i})^{1/2} - 2(C_0C_{0i})^{1/2}/T^2]\rho$$

$$+ \frac{3}{2}[RT(b^2b_i)^{1/3} - (a^2a_i)^{1/3}]\rho^2 + \frac{3}{5}[a(\alpha^2\alpha_i)^{1/3} + \alpha(a^2a_i)^{1/3}]\rho^5$$

$$+ \frac{3\rho^2(c^2c_i)^{1/3}}{T^2}\left[\frac{1 - \exp(-\gamma\rho^2)}{\gamma\rho^2} - \frac{\exp(-\gamma\rho^2)}{2}\right]$$

$$- \frac{2\rho^2 c}{T^2}\left(\frac{\gamma_i}{\gamma}\right)^{1/2}\left[\frac{1 - \exp(-\gamma\rho^2)}{\gamma\rho^2} - \exp(-\gamma\rho^2)\right.$$

$$\left. - [\gamma\rho^2\exp(-\gamma\rho^2)]/2\right] \qquad (3\text{-}67)$$

Similarly, by applying the equation of state of propane proposed by K. E. Starling, the fugacity of the ith component in a mixture is

$$RT \ln \bar{f}_i = RT \ln (\rho RT_i) + \rho(B_0 + B_{0i})RT + 2\rho \sum_{j=1}^{n} X_i \left[-(A_{0j}A_{0i})^{1/2} - \frac{(C_{0j}C_{0i})^{1/2}}{T^2} + \frac{(D_{0j}D_{0i})^{1/2}}{T^3} - \frac{(E_{0j}E_{0i})^{1/2}}{T^4} \right]$$

$$+ \frac{\rho^2}{2} \left[3(b^2 b_i)^{1/3} RT - 3(a^2 a_i)^{1/3} - \frac{3(d^2 d_i)^{1/3}}{T} \right]$$

$$+ \frac{\alpha\rho^5}{5} \left[3(a^2 a_i)^{1/3} + \frac{3(d^2 d_i)^{1/3}}{T} \right] + \frac{3\rho^5}{5}\left(a + \frac{d}{T}\right)(\alpha^2 \alpha_i)^{1/3}$$

$$+ \frac{3(c^2 c_i)^{1/3}\rho^2}{T^2} \left[\frac{1 - \exp(-\gamma\rho^2)}{\gamma\rho^2} - \frac{\exp(-\gamma\rho^2)}{2} \right]$$

$$- \frac{2c}{\gamma T^2} \left(\frac{\gamma_i}{\gamma}\right)^{1/2} \{1 - \exp(-\gamma\rho^2)[1 + \gamma\rho^2 + \tfrac{1}{2}\gamma^2\rho^4]\} \qquad (3\text{-}68)$$

In order to evaluate the thermodynamic properties of a mixture, the properties of the constituents have to be known. The method employed in obtaining the thermodynamic data for propylene and n-butane was the same as that described above for pure propane. Tables 3-2, 3-3, and 3-4 give the coefficients for the ninth order equations for the enthalpy departure, the entropy reference and the specific heat reference of propylene and n-butane in addition to propane. This will enable the reader of this report to evaluate properties of any mixture of the three constituents without undue difficulties.

Above it was mentioned that Starling's equation appears to be more accurate in predicting saturation properties. In addition, the subcooled liquid data predicted by Starling's equation approximates experimental results better than those predicted by the B-W-R equation. For these reasons, the thermodynamic properties of mixtures were only calculated using Starling's equation.

Table 3-8 is a saturation temperature table for a"Pseudo-Fluid" consisting of 65% (by mole) propane, 25% propylene and 10% n-butane. Figure 3-8 shows the temperature-entropy diagram for this mixture. Also enclosed are the saturation temperature tables for propylene and n-butane (see Tables 3-9 and 3-10). Figure 3-9 and 3-10 give the temperature-entropy diagrams of propylene and n-butane, respectively.

3.3 Discussion on the Thermodynamic Properties

In section 3.0 it was seen that Starling's equation incorporated more virial coefficients then that by Benedict-Webb-Rubin. Therefore, it is plausible to expect a higher accuracy from Starling's equation. This expectation is in part born out when one compares the predicted saturation pressures with those given by Stearns and George. (Compare Tables 3-6a with 3-7, and 3-5a with 3-7.) In addition, the predicted subcooled liquid properties of Starling's equation more closely approximate existing measured values than those resulting from the B-W-R equation. Also, it was found that, using Starling's equation, the calculated saturated liquid density at the critical point was the same as the calculated saturated vapor density, as it should be. This was found not to be the case when those properties were calculated with the B-W-R equation.

It is seen from the appropriate thermodynamic tables that there are negative values of enthalpy at the saturated liquid region for both the B-W-R and Starling's predictions but not for the Stearns and George's data. This is due to the difference in selection of the reference points. As mentioned before, the enthalpy was calculated by adding the standard enthalpy of formation H_0^0 from the elements at 0°R and 0 psia to the difference in the enthalpy of propane in the ideal gas state at the temperature of interest and the reference state $(H_0 - H_0^0)$ and to the enthalpy departure $(H - H_0)$. When the enthalpy departure gives a negative value of magnitude greater than the sum of the other two terms, a negative value of enthalpy results.

TABLE 3-1a

CONSTANTS FOR THE BENEDICT-WEBB-RUBIN EQUATION

Substances	Units	Propylene	Propane	n-Butane
molecular weight		42.047	44.062	58.078
B_0	$\frac{ft^3}{lb\text{-}mole}$	1.36263	1.55884	1.99211
A_0	$\frac{ft^6\text{-}lb_f}{in^2\text{-}lb\text{-}mole^2}$	23049.2	25915.4	38029.6
$C_0 \times 10^{-6}$	$\frac{ft^6R^2lb_f}{lb\text{-}mole^2\text{-}in^2}$	5365.97	6209.93	12130.5
b	$\frac{ft^6}{lb\text{-}mole^2}$	4.79997	5.77355	10.2636
a	$\frac{lb_f\text{-}ft^9}{lb\text{-}mole^3\text{-}in^2}$	46758.6	57248.0	113705.0
$C \times 10^{-6}$	$\frac{lb_f\text{-}ft^9\text{-}R^2}{in^2\text{-}lb\text{-}mole^3}$	20083.0	25247.8	61925.6
α	$\frac{ft^9}{lb\text{-}mole^3}$	1873.12	2495.77	4526.93
γ	$\frac{ft^6}{lb\text{-}mole^2}$	469.325	564.524	872.447

TABLE 3 - 1b

CONSTANTS FOR STARLING'S EQUATION

Substances	Units	Propylene	Propane	n-Butane
Molecular Weight		42.047	44.062	58.078
B_0	$\frac{ft^3}{lb\text{-}mole}$	0.114457	0.964762	1.56588
A_0	$\frac{ft^6\text{-}lb_f}{in^2\text{-}lb\text{-}mole^2}$	6051.36	18634.7	32544.7
C_0	$\frac{ft^6 R^2 lb_f}{lb\text{-}mole^2\text{-}in^2}$	974762×10^4	796178×10^4	137436×10^5
D_0	$\frac{ft^6 R^3 lb_f}{lb\text{-}mole^2\text{-}in^2}$	705921×10^6	453708×10^6	333159×10^6
E_0	$\frac{ft^6 R^4 lb_f}{lb\text{-}mole^2\text{-}in^2}$	341250×10^8	256053×10^8	230902×10^7
b	$\frac{ft^6}{lb\text{-}mole^2}$	7.64114	5.46248	9.14066
a	$\frac{lb_f\text{-}ft^9}{lb\text{-}mole^3\text{-}in^2}$	81880.4	40066.4	71181.8
d	$\frac{ft^9 R\ lb_f}{in^2\text{-}lb\text{-}mole^3}$	54193.5×10^2	150520×10^2	364238×10^2
α	$\frac{ft^9}{lb\text{-}mole^3}$	1.36532	2.01402	4.00985
c	$\frac{lb_f\text{-}ft^9\text{-}R^2}{in^2\text{-}\ lb\text{-}mole^3}$	294141×10^5	274461×10^5	700044×10^5
γ	$\frac{ft^6}{lb\text{-}mole^2}$	4.07919	4.56182	7.54122

Table 3-2

	Propane	Propylene	N-Butane
α_{e1}	$.742481481481 \times 10^{3}$	$.111045237968 \times 10^{4}$	$.802791666667 \times 10^{3}$
α_{e2}	$.995278195229 \times 10^{3}$	$.107023834244 \times 10^{4}$	$.100514466012 \times 10^{4}$
α_{e3}	$.727096407095 \times 10^{3}$	$.836734429396 \times 10^{3}$	$.649244242375 \times 10^{3}$
α_{e4}	$.818422637234 \times 10^{3}$	$.963958858537 \times 10^{3}$	$.839380451085 \times 10^{3}$
α_{e5}	$.830353420162 \times 10^{3}$	$.119605120652 \times 10^{4}$	$.971719198416 \times 10^{3}$
α_{e6}	$.865844174954 \times 10^{3}$	$.123523622846 \times 10^{4}$	$.981070432727 \times 10^{3}$
α_{e7}	$.932582802450 \times 10^{3}$	$.122910114799 \times 10^{4}$	$.955651779468 \times 10^{3}$
α_{e8}	$.917816919015 \times 10^{3}$	$.123840922182 \times 10^{4}$	$.101726967301 \times 10^{4}$
α_{e9}	$.858860971639 \times 10^{3}$	$.126348199349 \times 10^{4}$	$.980490358349 \times 10^{3}$
β_{e1}	$.182214471879 \times 10^{6}$	$.289148135505 \times 10^{6}$	$.172047081597 \times 10^{6}$
β_{e2}	$.202821566954 \times 10^{6}$	$.303593655594 \times 10^{6}$	$.210130748405 \times 10^{6}$
β_{e3}	$.223279163286 \times 10^{6}$	$.359719906439 \times 10^{6}$	$.254086490775 \times 10^{6}$
β_{e4}	$.189349834247 \times 10^{6}$	$.198487765514 \times 10^{6}$	$.147054880648 \times 10^{6}$
β_{e5}	$.172040258843 \times 10^{6}$	$.138702585635 \times 10^{6}$	$.117199772498 \times 10^{6}$
β_{e6}	$.148017284610 \times 10^{6}$	$.127279693740 \times 10^{6}$	$.123341054830 \times 10^{6}$
β_{e7}	$.118381676422 \times 10^{6}$	$.129278290233 \times 10^{6}$	$.103664754054 \times 10^{6}$
β_{e8}	$.139840562107 \times 10^{6}$	$.147957814196 \times 10^{6}$	$.883803087541 \times 10^{5}$
β_{e9}	$.118493330732 \times 10^{6}$	$.174325424377 \times 10^{6}$	$.946889837873 \times 10^{5}$
C_{e1}	$.126140038915 \times 10^{5}$	$.201157556705 \times 10^{5}$	$.182684354167 \times 10^{5}$
C_{e2}	$.254420893407 \times 10^{2}$	$.249178060153 \times 10^{2}$	$.343889910054 \times 10^{2}$
C_{e3}	$.111693664398 \times 10^{-1}$	$.793873123412 \times 10^{-2}$	$.142798901081 \times 10^{-1}$
C_{e4}	$.981725124759 \times 10^{-6}$	$.112252896961 \times 10^{-5}$	$.151117378284 \times 10^{-5}$
C_{e5}	$.194411920914 \times 10^{-8}$	$.572184000520 \times 10^{-9}$	$.192631943869 \times 10^{-8}$
C_{e6}	$.153143261260 \times 10^{-11}$	$.705903272455 \times 10^{-12}$	$.194002529244 \times 10^{-11}$
C_{e7}	$.138220156370 \times 10^{-15}$	$.472345691675 \times 10^{-15}$	$.621958539961 \times 10^{-15}$
C_{e8}	$.305475135778 \times 10^{-17}$	$.390746140224 \times 10^{-18}$	$.111591462586 \times 10^{-17}$
C_{e9}	$.628558859816 \times 10^{-20}$	$.150828380816 \times 10^{-20}$	$.202228932320 \times 10^{-20}$
C_{e10}	$.604295630108 \times 10^{-23}$	$.848699864953 \times 10^{-23}$	$.127422880370 \times 10^{-22}$
H_0^0	-35042.06798	14534.46128	11768.34008

Table 3-3

	Propane	Propylene	N-Butane
α_{e1}	$.121486500000 \times 10^{4}$	$.553847718462 \times 10^{9}$	$.145800000000 \times 10^{4}$
α_{e2}	$.157575186470 \times 10^{4}$	$.664615397654 \times 10^{10}$	$.152575335121 \times 10^{4}$
α_{e3}	$.146640593519 \times 10^{4}$	$.161423147522 \times 10^{4}$	$.156891382752 \times 10^{4}$
α_{e4}	$.139993086664 \times 10^{4}$	$.162766912336 \times 10^{4}$	$.156539439070 \times 10^{4}$
α_{e5}	$.146520971796 \times 10^{4}$	$.719999522832 \times 10^{10}$	$.153356457801 \times 10^{4}$
α_{e6}	$.143264451942 \times 10^{4}$	$.631478364392 \times 10^{4}$	$.149922265352 \times 10^{4}$
α_{e7}	$.142047526795 \times 10^{4}$	$.170709680249 \times 10^{4}$	$.148560135399 \times 10^{4}$
α_{e8}	$.139214986725 \times 10^{4}$	$.124270164341 \times 10^{9}$	$.148865270315 \times 10^{4}$
α_{e9}	$.134990212476 \times 10^{4}$	$.707573157625 \times 10^{10}$	$.148324423940 \times 10^{4}$
β_{e1}	$.613757596275 \times 10^{6}$	$.368094501245 \times 10^{19}$	$.563976000000 \times 10^{6}$
β_{e2}	$.405377805164 \times 10^{6}$	$.543757512200 \times 10^{7}$	$.400713794392 \times 10^{6}$
β_{e3}	$.477683840709 \times 10^{6}$	$.386499419225 \times 10^{6}$	$.364028426115 \times 10^{6}$
β_{e4}	$.431356410957 \times 10^{6}$	$.553679411841 \times 10^{12}$	$.357374314602 \times 10^{6}$
β_{e5}	$.399730302774 \times 10^{6}$	$.338024126545 \times 10^{14}$	$.358830780250 \times 10^{6}$
β_{e6}	$.399682917428 \times 10^{6}$	$.286971601807 \times 10^{6}$	$.350381228412 \times 10^{6}$
β_{e7}	$.374740444251 \times 10^{6}$	$.241240598015 \times 10^{6}$	$.324510014436 \times 10^{6}$
β_{e8}	$.377041634817 \times 10^{6}$	$.879289793523 \times 10^{18}$	$.292118892082 \times 10^{6}$
β_{e9}	$.338738853360 \times 10^{6}$	$.120207105186 \times 10^{8}$	$.266308028731 \times 10^{6}$
C_{e1}	$.825700000000 \times 10^{2}$	$.883538461538 \times 10^{2}$	$.106566666667 \times 10^{3}$
C_{e2}	$.266135841725 \times 10^{-1}$	$.292708189478 \times 10^{-8}$	$.334716370909 \times 10^{-1}$
C_{e3}	$.395796189449 \times 10^{-5}$	$.281725147400 \times 10^{-11}$	$.480866637359 \times 10^{-5}$
C_{e4}	$.788110527067 \times 10^{-9}$	$.420386090977 \times 10^{-15}$	$.572031476567 \times 10^{-9}$
C_{e5}	$.688562267346 \times 10^{-12}$	$.923330124310 \times 10^{-20}$	$.160064264642 \times 10^{-12}$
C_{e6}	$.907615953571 \times 10^{-15}$	$.918526012476 \times 10^{-29}$	$.221775210984 \times 10^{-15}$
C_{e7}	$.956080011946 \times 10^{-18}$	$.483637271218 \times 10^{-33}$	$.439488097002 \times 10^{-18}$
C_{e8}	$.968897518982 \times 10^{-21}$	$.797306956991 \times 10^{-33}$	$.503179453448 \times 10^{-21}$
C_{e9}	$.137432907223 \times 10^{-23}$	$.638050169456 \times 10^{-41}$	$.402404744657 \times 10^{-24}$
C_{e10}	$.686591484810 \times 10^{-27}$	$.395373525494 \times 10^{-48}$	$.233709969648 \times 10^{-27}$

Table 3-4

	Propane	Propylene	N-Butane
α_{e1}	$.121171500000 \times 10^{4}$	$.111890476190 \times 10^{4}$	$.732764705882 \times 10^{3}$
α_{e2}	$.156393932388 \times 10^{4}$	$.127428305279 \times 10^{4}$	$.928122739667 \times 10^{3}$
α_{e3}	$.144300986829 \times 10^{4}$	$.132273649816 \times 10^{4}$	$.883526559810 \times 10^{3}$
α_{e4}	$.139317577302 \times 10^{4}$	$.130752856489 \times 10^{4}$	$.877112912243 \times 10^{3}$
α_{e5}	$.148108914194 \times 10^{4}$	$.126887266352 \times 10^{4}$	$.821626216559 \times 10^{3}$
α_{e6}	$.146525609386 \times 10^{4}$	$.123145100632 \times 10^{4}$	$.838146564495 \times 10^{3}$
α_{e7}	$.146426799121 \times 10^{4}$	$.122428880142 \times 10^{4}$	$.825270570532 \times 10^{3}$
α_{e8}	$.143686445275 \times 10^{4}$	$.124021816239 \times 10^{4}$	$.807006176432 \times 10^{3}$
α_{e9}	$.136105738084 \times 10^{4}$	$.124873578342 \times 10^{4}$	$.763580499084 \times 10^{3}$
β_{e1}	$.619898773275 \times 10^{6}$	$.278948181406 \times 10^{6}$	$.588451211073 \times 10^{5}$
β_{e2}	$.417344093380 \times 10^{6}$	$.169462158799 \times 10^{6}$	$.457379553837 \times 10^{5}$
β_{e3}	$.491622431021 \times 10^{6}$	$.155950524167 \times 10^{6}$	$.393482833606 \times 10^{5}$
β_{e4}	$.427343890147 \times 10^{6}$	$.161217407838 \times 10^{6}$	$.467988179474 \times 10^{5}$
β_{e5}	$.384885019474 \times 10^{6}$	$.171708625504 \times 10^{6}$	$.407590942774 \times 10^{5}$
β_{e6}	$.374955579138 \times 10^{6}$	$.174439209490 \times 10^{6}$	$.361214749425 \times 10^{5}$
β_{e7}	$.346493535855 \times 10^{6}$	$.162501007150 \times 10^{6}$	$.267115109296 \times 10^{5}$
β_{e8}	$.355265885086 \times 10^{6}$	$.146873882126 \times 10^{6}$	$.265722245049 \times 10^{5}$
β_{e9}	$.345189959100 \times 10^{6}$	$.136435643095 \times 10^{6}$	$.176479405673 \times 10^{5}$
C_{e1}	$.294185000000 \times 10^{2}$	$.247374285714 \times 10^{2}$	$.295083529412 \times 10^{2}$
C_{e2}	$.168993352207 \times 10^{-1}$	$.149128702681 \times 10^{-1}$	$.306182347186 \times 10^{-1}$
C_{e3}	$-.583778927465 \times 10^{-5}$	$-.515569210551 \times 10^{-5}$	$-.895371840923 \times 10^{-5}$
C_{e4}	$.958637032132 \times 10^{-9}$	$.621288442486 \times 10^{-9}$	$-.799920168655 \times 10^{-8}$
C_{e5}	$.792131317606 \times 10^{-12}$	$.111130562037 \times 10^{-11}$	$.213486869887 \times 10^{-10}$
C_{e6}	$.745544270460 \times 10^{-16}$	$-.171640456258 \times 10^{-14}$	$-.298797054874 \times 10^{-13}$
C_{e7}	$.367952233356 \times 10^{-18}$	$.857104317985 \times 10^{-18}$	$.878606120216 \times 10^{-16}$
C_{e8}	$.200994242615 \times 10^{-23}$	$.137562067206 \times 10^{-20}$	$-.214733834833 \times 10^{-18}$
C_{e9}	$-.555179524348 \times 10^{-23}$	$-.258502116823 \times 10^{-23}$	$-.656409752151 \times 10^{-21}$
C_{e10}	$.234126033182 \times 10^{-26}$	$.181970505311 \times 10^{-26}$	$.129920025308 \times 10^{-22}$

Table 3-5a

Saturation Temperature Table for Propane Calculated from the Benedict-Webb-Rubin Equation of State.

THERMODYNAMIC PROPERTIES OF PROPANE AS PREDICTED BY BENIDICT-WEBB-RUBIN EQUATION OF STATE

P	T	VF	VG	HF	HG	SF	SG
PSIA	DEG F	FT3/LBM	FT3/LBM	BTU/LBM	BTU/LBM	BTU/LBM/DEG F	BTU/LBM/DEG F
13.01	-50.	.0281355234	7.3747385042	-897.855983866	-700.200723856	.76470066726	1.24676773012
13.73	-48.	.0282095932	7.0105602159	-896.080507607	-699.659097114	.76902516575	1.24576458410
14.49	-46.	.0282839016	6.6659409404	-894.323176268	-699.119155834	.77328417498	1.24477440533
15.27	-44.	.0283584569	6.3421779469	-892.583417590	-698.581166697	.77747957283	1.24379333960
16.08	-42.	.0284332762	6.0451165613	-890.860736420	-698.040417362	.78101375315	1.24290223241
16.92	-40.	.0285083597	5.7624086563	-889.154529994	-697.502151300	.78568808610	1.24200892728
17.80	-38.	.0285837115	5.4891313670	-887.464242035	-696.968956473	.78970437075	1.24107694957
18.71	-36.	.0286593604	5.2421247966	-885.789489363	-696.430686505	.79366472739	1.24026213776
19.65	-34.	.0287352967	5.0030684220	-884.129650218	-695.897400690	.79757046059	1.23941148554
20.63	-32.	.0288115376	4.7776518051	-882.484289265	-695.365273780	.80142334328	1.23858318536
21.64	-30.	.0288881015	4.5697468295	-880.852984601	-694.830463955	.80522510453	1.23782778483
22.69	-28.	.0289649868	4.3708691774	-879.235206153	-694.298671708	.80897704858	1.23706697014
23.77	-26.	.0290422001	4.1792356810	-877.630488142	-693.771409484	.81268058975	1.23628436503
24.89	-24.	.0291197696	4.0024224545	-876.038402044	-693.241058845	.81633746823	1.23557489310
26.05	-22.	.0291976885	3.8319170285	-874.458697275	-692.715231991	.81994876099	1.23484519210
27.25	-20.	.0292759918	3.6759348966	-872.890813659	-692.184222435	.82351621660	1.23420741321
28.49	-18.	.0293546567	3.5220678422	-871.334263279	-691.661784575	.82704056028	1.23350535169
29.76	-16.	.0294337245	3.3794488034	-869.788800295	-691.136312983	.83052354537	1.23295831453
31.08	-14.	.0295131894	3.2423715193	-868.253954667	-690.614605768	.83396610520	1.23222257226
32.44	-12.	.0295930931	3.1173129842	-866.729485834	-690.086094628	.83736989249	1.23167468914
33.84	-10.	.0296733925	2.9914139216	-865.214777932	-689.570545827	.84073518321	1.23102770286
35.29	-8.	.0297541495	2.8749869851	-863.709691763	-689.050757274	.84406385877	1.23045164487
36.78	-6.	.0298353540	2.7630504755	-862.213778279	-688.534680087	.84735664600	1.22986974683
38.31	-4.	.0299170505	2.6500341941	-860.726819817	-688.012504565	.85061505201	1.22936334311
39.89	-2.	.0299992067	2.5597149426	-859.248299935	-687.498881455	.85383941778	1.22882104149
41.51	0.	.0300818574	2.4620011110	-857.777976369	-686.987193901	.85703104010	1.22828335989
43.19	2.	.0301650254	2.3705979266	-856.315559916	-686.475092566	.86019099594	1.22777590981
44.90	4.	.0302487373	2.2851859785	-854.860776015	-685.959534575	.86332037504	1.22732118978
46.67	6.	.0303329581	2.2005470946	-853.413148251	-685.454574180	.86641939535	1.22680835987
48.49	8.	.0304177626	2.1220762194	-851.972575425	-684.944044000	.86948974127	1.22636339469
50.36	10.	.0305031432	2.0471803324	-850.538682966	-684.434684973	.87253194153	1.22593299986
52.27	12.	.0305691310	1.9766042826	-849.111225267	-683.923046433	.87554701270	1.22554134710
54.25	14.	.0306756505	1.9042539750	-847.689658684	-683.431564165	.87853459652	1.22503133935
56.27	16.	.0307628667	1.8393885588	-846.274125564	-682.924087511	.88149734126	1.22465194142
58.35	18.	.0308505916	1.7753769780	-844.864061420	-682.427704018	.88443468826	1.22422829449
60.48	20.	.0309391968	1.7149841635	-843.459341045	-681.928521764	.88734803255	1.22384177841
62.66	22.	.0310284045	1.6579626899	-842.059705159	-681.426926360	.89023812603	1.22349193597
64.91	24.	.0311182615	1.6011621141	-840.664729517	-680.938297754	.89310482667	1.22308254451
67.20	26.	.0312088729	1.5479594700	-839.274358081	-680.444967420	.89594981047	1.22272414705
69.56	28.	.0313002339	1.4970935830	-837.888281679	-679.952575158	.89877344448	1.22238090242
71.97	30.	.0313923863	1.4489966163	-836.506293911	-679.457535864	.90157660191	1.22207283247
74.44	32.	.0314852883	1.4016479383	-835.128031036	-678.972066059	.90435921472	1.22173005353
76.96	34.	.0315790965	1.3585130308	-833.753497773	-678.472097718	.90712334164	1.22148667034
79.56	36.	.0316735897	1.3133902840	-832.382038116	-678.001106294	.90986698970	1.22110473940
82.22	38.	.0317690304	1.2719898620	-831.013828091	-677.517468553	.91259326498	1.22081102386
84.92	40.	.0318654300	1.2334865100	-829.648597547	-677.024839769	.91530256433	1.22058177817
87.72	42.	.0319625402	1.1926952094	-828.285735208	-676.567322896	.91799269183	1.22019276252
90.56	44.	.0320607407	1.1560623681	-826.925516635	-676.088747827	.92066774104	1.21992952533
93.48	46.	.0321598411	1.1196905944	-825.567429551	-675.623504730	.92332608107	1.21961988137
96.45	48.	.0322600024	1.0855408624	-824.211418698	-675.151995431	.92596952010	1.21935913943
99.46	50.	.0323613883	1.0549834160	-822.857387417	-674.656712836	.92859978877	1.21922546556
102.60	52.	.0324634430	1.0207207814	-821.504541594	-674.219100109	.93121193568	1.21884405052
105.74	54.	.0325670324	.9925169089	-820.153459251	-673.725948518	.93381413433	1.21873082719
109.02	56.	.0326712901	.9605378046	-818.803152327	-673.296404650	.93639870818	1.21835358143
112.29	58.	.0327772295	.9344778197	-817.454179703	-672.805421877	.93897486019	1.21826005396
115.58	60.	.0328841397	.9070898549	-816.105772676	-672.347812599	.94153643411	1.21803863611
119.16	62.	.0329921424	.8794530289	-814.757824275	-671.911530193	.94408469577	1.21774612178
122.70	64.	.0331014846	.8532278173	-813.410256579	-671.472036497	.94662188283	1.21748556352
126.32	66.	.0332121477	.8278863862	-812.062831925	-671.036613603	.94914793242	1.21722679445

Table 3-5a (continued)

130.00	68.	.0333242975	.3041027987	-810.715395416	-670.592574463	.95156427271	1.21701914309
133.75	70.	.0334378955	.7812240767	-809.367670898	-670.149781753	.95417063425	1.21682268617
137.52	72.	.0335533208	.7608249574	-808.019533299	-669.676036214	.95667001840	1.21675744870
141.51	74.	.0336693951	.7368573729	-806.670581351	-669.292072459	.95915332292	1.21637357336
145.48	76.	.0337876771	.7165935245	-805.320827742	-668.850844870	.96163264029	1.21621823352
149.55	78.	.0339074911	.6965079177	-803.969968979	-668.423676515	.96410274760	1.21602722670
153.71	80.	.0340288993	.6766903808	-802.617817329	-668.003492606	.96656413611	1.21580636655
157.94	82.	.0341521301	.6577485735	-801.264155719	-667.593604224	.96901846111	1.21550766768
162.24	84.	.0342772847	.6397121533	-799.908752809	-667.173754380	.97146637947	1.21543784217
166.64	86.	.0344042543	.6219903608	-798.551426216	-666.764841025	.97390705228	1.21524641913
171.03	88.	.0345337947	.6063790286	-797.191743446	-666.314372840	.97634559243	1.21520550433
175.68	90.	.0346641616	.5881608925	-795.830095565	-665.961078931	.97877001285	1.21486380027
182.08	92.	.0347942661	.5731004528	-794.466977308	-665.531177581	.98117344734	1.21478336234
187.74	94.	.0349272179	.5562445571	-793.101031944	-665.180710316	.98357668677	1.21446845098
192.47	96.	.0350645465	.5403518555	-791.731128277	-664.821760841	.98598917648	1.21419849982
194.79	98.	.0352104384	.5269340568	-790.354246102	-664.394566318	.98843632770	1.21415052930
199.80	100.	.0353529135	.5125822662	-788.977073739	-664.022128407	.99084212271	1.21395148755
207.36	102.	.0354913917	.4976924935	-787.600387279	-663.695094342	.99320756980	1.21363571954
211.69	104.	.0356418629	.4849311524	-786.214023343	-663.303280263	.99562123637	1.21352376836
215.83	106.	.0357957633	.4728078736	-784.822294927	-662.903505322	.99803839637	1.21344664813
220.73	108.	.0359504123	.4597455136	-783.427533758	-662.568125407	1.00044033759	1.21320201124
226.09	110.	.0361081485	.4484242175	-782.027823363	-662.172430968	1.00284067279	1.21313850313
231.82	112.	.0362667893	.4350148350	-780.625017394	-661.904990041	1.00522696950	1.21274013756
237.31	114.	.0364318500	.4248344567	-779.213952731	-661.494080626	1.00762967827	1.21274300515
243.06	116.	.0365990962	.4135902524	-777.798359409	-661.161757620	1.01002479424	1.21254895893
248.91	118.	.0367700446	.4026021582	-776.376651616	-660.839574418	1.01242046800	1.21234299693
254.84	120.	.0369452136	.3920720592	-774.948168263	-660.515016799	1.01481880092	1.21215754955
261.09	122.	.0371223722	.3804008358	-773.515202767	-660.290364038	1.01720797978	1.21173557575
268.83	124.	.0373006817	.3708297048	-772.078791600	-659.957256328	1.01958392008	1.21160169085
273.59	126.	.0374931944	.3600739125	-770.623844354	-659.733027346	1.02201003092	1.21121495562
279.77	128.	.0376394049	.3515929728	-769.163156897	-659.372855238	1.02443024556	1.21117329359
286.43	130.	.0379346109	.3412701811	-767.698930109	-659.177826845	1.02683413563	1.21075011998
293.53	132.	.0380855383	.3317949990	-766.226733294	-658.949968967	1.02924016307	1.21042344094
299.78	134.	.0382972996	.3230321012	-764.738688418	-658.693569569	1.03167548658	1.21017858599
307.36	136.	.0385107822	.3152052490	-763.246256262	-658.383217991	1.03409751259	1.21007092921
315.27	138.	.0387248022	.3050373378	-761.751263940	-658.317431118	1.03650141249	1.20942616833
320.33	140.	.0389683318	.2985542516	-760.214887160	-657.936013910	1.03901144115	1.20950278889
327.86	142.	.0392003002	.2890214027	-758.692063345	-657.895605654	1.04144913359	1.20886349251
335.09	144.	.0394461177	.2612790457	-757.148567774	-657.690130949	1.04392232964	1.20855989603
343.29	146.	.0396962992	.2740915209	-755.597460554	-657.465662229	1.04639039040	1.20833254720
350.53	148.	.0399610743	.2663706330	-754.024432793	-657.334770331	1.04889322501	1.20792183054
357.75	150.	.0402356712	.2582363780	-752.436183412	-657.286907301	1.05140980641	1.20735687168
365.01	152.	.0405297197	.2525690242	-750.818912080	-656.980890643	1.05397472913	1.20733855495
373.41	154.	.0408171667	.2439472908	-749.210539490	-657.088959250	1.05648887388	1.20649295668
381.23	156.	.0411315313	.2375573460	-747.562608137	-656.939882696	1.05907486497	1.20618538642
389.10	158.	.0414626019	.2314420772	-745.890134278	-656.785193351	1.06169149350	1.20590202828
397.63	160.	.0417978331	.2240279795	-744.212032172	-656.867140773	1.06429324696	1.20517194456
405.67	162.	.0421661396	.2183267452	-742.486044689	-656.725160423	1.06697635240	1.20489327979
414.32	164.	.0425425297	.2115353388	-740.749733503	-656.803835689	1.06965331812	1.20420838958
423.06	166.	.0429423584	.2049856292	-738.931084965	-656.893998142	1.07237206119	1.20352267136
431.69	168.	.0433750354	.1990717582	-737.167101914	-656.919067195	1.07515719011	1.20297702585
440.52	170.	.0438353835	.1930857925	-735.316661198	-657.006249340	1.07798697919	1.20233420790
449.84	172.	.0443162971	.1864653375	-733.441583560	-657.279092015	1.08083622706	1.20137481382
458.94	174.	.0448492145	.1806377829	-731.497695975	-657.449127333	1.08378977589	1.20062277271
468.78	176.	.0453993555	.1737028962	-729.537732867	-657.936261780	1.08674324644	1.19933286040
478.30	178.	.0460234886	.1677461249	-727.482769483	-658.276074332	1.08984333778	1.19832888830
488.22	180.	.0467000179	.1616437175	-725.367894493	-658.728859643	1.09301984283	1.19715409236
497.85	182.	.0474745305	.1557515535	-723.134791837	-659.209871673	1.09637312139	1.19535676522
507.12	184.	.0484064789	.1510978022	-720.712211466	-659.418499338	1.10001805538	1.19523924093
517.68	186.	.0493680219	.1443047279	-718.282660456	-660.338298803	1.10363408500	1.19335769496
527.94	188.	.0505499770	.1382674108	-715.607534080	-661.149005022	1.10762238629	1.19169092646
538.17	190.	.0520227686	.1324611981	-712.628344165	-661.999782053	1.11206461209	1.18998821940

Table 3-5a (continued)

THERMODYNAMIC PROPERTIES OF PROPANE AS PREDICTED BY BENEDICT-WEBB-RUBIN EQUATION OF STATE

P	T	CPF	CPG	CVF	CVG	AF	AG
PSIA	DEG F	BTU/LBM/DEG F	BTU/LBM/DEG F	BTU/LBM/DEG F	BTU/LBM/DEG F	FT/SEC	FT/SEC
13.01	-50.	.6497263427	.3347616616	.5557935968	.2863074698	3781.285707	704.541960
13.73	-48.	.6416579934	.3365673351	.5501371978	.2870153464	3747.203409	705.388625
14.49	-46.	.6339339959	.3383936711	.5446698213	.2889345359	3713.477613	706.194505
15.27	-44.	.6264258238	.3402424993	.5393853156	.2902655669	3680.102025	706.957451
16.08	-42.	.6191649156	.3420817542	.5342794277	.2915554093	3647.064690	707.715935
16.92	-40.	.6121437929	.3439470433	.5293456320	.2929382793	3614.365200	708.427266
17.80	-38.	.6053550642	.3458557061	.5245796273	.2943008709	3582.000526	709.070239
18.71	-36.	.5987905541	.3477392021	.5199757236	.2956657842	3549.552245	709.727900
19.65	-34.	.5924440396	.3496653139	.5155298050	.2970297964	3518.226571	710.317903
20.63	-32.	.5863083955	.3516091665	.5112370358	.2984124877	3486.812942	710.871555
21.64	-30.	.5803767361	.3535420006	.5070927316	.2997936820	3455.700516	711.420489
22.69	-28.	.5746432187	.3555049320	.5030929305	.3011881813	3424.890908	711.917812
23.77	-26.	.5691018771	.3575062575	.4992335627	.3025996081	3394.380701	712.350921
24.89	-24.	.5637461815	.3594969304	.4955101442	.3040081784	3364.154099	712.782704
26.05	-22.	.5585711119	.3615256823	.4919192435	.3054332501	3334.216094	713.150163
27.25	-20.	.5535703632	.3635286495	.4884565094	.3068500615	3304.547702	713.533745
28.49	-18.	.5487398428	.3655967576	.4851191338	.3082931587	3275.163288	713.819160
29.76	-16.	.5440734567	.3676531147	.4819028920	.3097331942	3246.041042	714.102788
31.09	-14.	.5395668784	.3697424262	.4788047880	.3111869859	3217.185862	714.327909
32.44	-12.	.5352144437	.3717950984	.4758208838	.3126283860	3188.576726	714.582834
33.84	-10.	.5310132966	.3739406473	.4729491860	.3141056693	3160.239050	714.701888
35.29	-8.	.5269575148	.3760660357	.4701855634	.3155765798	3132.141588	714.829065
36.78	-6.	.5230435235	.3782230851	.4675275077	.3170602870	3104.292051	714.897439
38.31	-4.	.5192663371	.3803476693	.4649715313	.3185331755	3076.669844	714.989684
39.89	-2.	.5156232605	.3825348798	.4625157175	.3200300641	3049.294322	714.981826
41.51	0.	.5121098646	.3847412826	.4601569523	.3215349134	3022.150334	714.929457
43.19	2.	.5087222239	.3869513678	.4578924664	.3230420644	2995.229451	714.852350
44.90	4.	.5054564757	.3891452918	.4557195325	.3245444084	2968.521833	714.773425
46.67	6.	.5023103924	.3914131525	.4536355294	.3260742993	2942.047913	714.581208
48.49	8.	.4992791857	.3936505643	.4516400995	.3275942628	2915.774921	714.404855
50.36	10.	.4963502084	.3959004995	.4497293344	.3291197417	2889.710558	714.199433
52.27	12.	.4935500172	.3981405597	.4478987884	.3306428300	2863.844265	713.964553
54.25	14.	.4908475747	.4005127128	.4461506211	.3322136387	2838.214440	713.535167
56.27	16.	.4882467969	.4027905855	.4444796193	.3337523092	2812.750060	713.209395
58.35	18.	.4857470663	.4051338971	.4428952415	.3353151448	2787.495409	712.766981
60.48	20.	.4833445937	.4074655903	.4413647981	.3368751634	2762.423330	712.313017
62.66	22.	.4810366963	.4097839194	.4399163648	.3384319144	2737.529313	711.849359
64.91	24.	.4788221746	.4121840636	.4385389809	.3400185634	2712.840926	711.239666
67.20	26.	.4766969727	.4145549546	.4372298183	.3415966227	2688.318748	710.639494
69.56	28.	.4746591888	.4169310073	.4359874629	.3431782024	2663.970585	709.999646
71.97	30.	.4727061790	.4192894380	.4348100209	.3447556115	2639.785177	709.348903
74.44	32.	.4706367762	.4217040684	.4336965514	.3463544655	2615.785323	708.580032
76.96	34.	.4690466689	.4240274721	.4326441024	.3479242065	2591.915152	707.908720
79.56	36.	.4673375973	.4265215988	.4316535858	.3495551392	2568.267384	706.940414
82.22	38.	.4657033360	.4289336676	.4307211655	.3511605846	2544.746623	706.052008
84.92	40.	.4641437381	.4312859147	.4298456148	.3527494585	2521.356721	705.211262
87.72	42.	.4626592710	.4338374805	.4290279567	.3544081478	2498.196772	704.010906
90.56	44.	.4612436409	.4362550976	.4282637438	.3560253979	2475.133590	702.968119
93.48	46.	.4599980747	.4387390855	.4275535376	.3576694999	2452.244685	701.753810
96.45	48.	.4586191217	.4411740574	.4268950038	.3593010662	2429.480418	700.580057
99.46	50.	.4574035885	.4434608828	.4262359983	.3608859532	2406.793755	699.583356
102.60	52.	.4562569169	.4460575323	.4257296032	.3625836537	2384.383475	698.001310
105.74	54.	.4551677248	.4483266727	.4252187410	.3641728376	2361.964736	696.909118
109.02	56.	.4541447706	.4509271323	.4247584435	.3658843262	2339.835783	695.166690
112.29	58.	.4531758297	.4531718935	.4243412370	.3674772733	2317.673927	693.976507
115.68	60.	.4522676095	.4555751838	.4239708826	.3691333518	2295.720700	692.423068
119.16	62.	.4514176717	.4580647011	.4236457103	.3708284610	2273.544451	690.618450
122.70	64.	.4506225882	.4605075264	.4233635130	.3725159494	2252.278207	688.801268
126.32	66.	.4498816814	.4629392136	.4231236915	.3742093190	2230.738854	686.899434

Table 3-5a (continued)

130.00	68.	.4491026432	.4652941447	.4223247296	.3758950735	2209.288995	695.039502
133.75	70.	.4485550947	.4676206081	.4227662111	.3775614271	2187.952929	683.123553
137.52	72.	.4479552304	.4697642058	.4226456396	.3791801654	2166.636516	681.479057
141.51	74.	.4474317972	.4722906759	.4225681567	.3809585861	2145.632287	678.875867
145.48	76.	.4469416795	.4745059959	.4225258227	.3826317297	2124.669062	676.812355
149.55	78.	.4464996417	.4767406191	.4225212171	.3843275619	2103.796117	674.560198
153.71	80.	.4461045563	.4789831503	.4225535172	.3860435278	2083.062422	672.128345
157.94	82.	.4457542681	.4811662201	.4226213894	.3877535407	2062.421733	669.669477
162.24	84.	.4454476640	.4832796855	.4227240708	.3894537121	2041.864815	667.208793
166.64	86.	.4451649920	.4853810662	.4228614803	.3911695240	2021.435166	664.589426
171.03	88.	.4449613730	.4872686176	.4230310510	.3928116855	2000.967819	662.373043
175.68	90.	.4447864790	.4894562334	.4232372006	.3946144628	1980.894867	659.073815
182.08	92.	.4446647257	.4913027099	.4234815005	.3962847582	1961.461964	656.559070
187.74	94.	.4445764485	.4933540785	.4237554399	.3980829241	1941.960207	653.144282
192.47	96.	.4445204960	.4952974433	.4240559581	.3993618393	1922.084611	649.781081
194.79	98.	.4444730303	.4969580940	.4243753416	.4015250078	1901.000014	647.131524
199.80	100.	.4444919408	.4987142568	.4247379936	.4032727027	1881.300369	643.849318
207.36	102.	.4445732196	.5005149918	.4251402813	.4050876105	1862.937511	640.034264
211.69	104.	.4446562853	.5020628283	.4255534597	.4067939911	1842.973664	636.910430
215.83	106.	.4447726283	.5035217846	.4260052585	.4084832950	1822.928992	633.854375
220.73	108.	.4449336398	.5050550521	.4264844877	.4102677819	1803.431354	630.063125
226.09	110.	.4451302656	.5063799581	.4269926354	.4119533419	1784.047774	626.931080
231.82	112.	.4453690909	.5078776741	.4275313972	.4138289164	1765.188954	622.357757
237.31	114.	.4456330395	.5090245215	.4280956154	.4154800883	1745.902169	619.383914
243.06	116.	.4459351687	.5102362626	.4286889009	.4172438038	1726.967178	615.534662
248.91	118.	.4462709345	.5113820436	.4293093404	.4190155691	1708.143405	611.591738
254.84	120.	.4466393140	.5124439915	.4299581338	.4207765648	1689.385368	607.671767
261.09	122.	.4470452971	.5135415740	.4306343373	.4226745601	1671.066174	602.682287
268.83	124.	.4474896024	.5144304974	.4313377695	.4244070795	1653.311793	598.927168
273.59	126.	.4479476103	.5153440151	.4320669157	.4262862707	1634.260414	594.023224
279.77	128.	.4484429604	.5160681179	.4328239732	.4279646375	1615.665625	590.655542
286.43	130.	.4489773308	.5168371813	.4336078882	.4298647584	1597.759474	585.567910
293.53	132.	.4495442586	.5175018573	.4344184180	.4317079484	1580.049725	580.924647
299.78	134.	.4501367586	.5180820272	.4352576123	.4335018891	1561.821299	576.678038
307.36	136.	.4507666839	.5185859575	.4361226920	.4352133967	1544.264862	573.093383
315.27	138.	.4514336318	.5190801764	.4370118426	.4372387422	1527.500370	567.129745
320.33	140.	.4521144905	.5194696956	.4379418372	.4388365260	1508.356863	564.499736
327.86	142.	.4528434091	.5198263555	.4388890124	.4409531881	1491.459045	558.741157
335.09	144.	.4536016054	.5201254433	.4398688960	.4426682283	1474.084891	554.604032
343.29	146.	.4543951381	.5203868442	.4408746527	.4444340714	1457.269924	550.929536
350.53	148.	.4552210872	.5205929784	.4419149550	.4463031526	1440.102628	546.612716
357.75	150.	.4560824474	.5207364030	.4429361373	.4482573112	1423.130353	541.845071
365.01	152.	.4569801772	.5209287067	.4440984154	.4498842064	1405.647356	539.549932
373.41	154.	.4579145515	.5209527327	.4452239066	.4519689303	1389.826431	534.149942
381.23	156.	.4588884312	.5210479984	.4463990118	.4537706932	1373.103553	531.183212
389.10	158.	.4599037420	.5211337896	.4476133147	.4555302959	1356.438791	528.578299
397.63	160.	.4609566777	.5211017384	.4488508145	.4575387545	1340.747396	524.728856
405.67	162.	.4620604293	.5211671618	.4501481466	.4592760339	1324.287281	522.826081
414.32	164.	.4632043450	.5211240492	.4514726304	.4612341219	1308.727493	520.047562
423.06	166.	.4643989935	.5210760662	.4523440527	.4631779300	1293.272506	517.833453
431.69	168.	.4656519928	.5210671759	.4542754906	.4650273718	1277.635865	516.570323
440.52	170.	.4669625054	.5210374403	.4557590810	.4669145207	1262.274975	515.675083
449.84	172.	.4683249025	.5209292042	.4572827843	.4689555668	1247.610587	514.905467
458.94	174.	.4697696023	.5208912173	.4588916162	.4708603037	1232.581906	515.365019
468.78	176.	.4712633189	.5207227446	.4605308167	.4730245241	1218.622929	516.209549
478.30	178.	.4729659126	.5206535358	.4622930896	.4750043396	1204.069490	518.540699
488.22	180.	.4745559744	.5205622913	.4641110371	.4770360527	1189.901515	522.077577
497.85	182.	.4763865669	.5204910389	.4660770978	.4790372329	1175.270239	527.027407
507.12	184.	.4784312683	.5205651714	.4682583090	.4807655256	1159.500175	532.785781
517.68	186.	.4805282255	.5203766398	.4704495388	.4829906552	1145.416008	541.736161
527.94	188.	.4829043608	.5202704505	.4729056264	.4850412357	1129.918583	552.505812
538.17	190.	.4856291942	.5201802551	.4756758623	.4870265069	1112.768816	565.487719

120.	.02923587	-872.685237	.8228420	.55494905	.48942493	3327.4474
100.	.02924446	-872.729803	.8229867	.55465302	.48921685	3322.5339
90.	.02924877	-872.752037	.8230592	.55450475	.48911266	3320.0721
80.	.02925309	-872.774240	.8231318	.55435630	.48900836	3317.6070
70.	.02925741	-872.796409	.8232045	.55420768	.48890396	3315.1385
60.	.02926175	-872.818547	.8232772	.55405888	.48879946	3312.6666
50.	.02926609	-872.840651	.8233501	.55390991	.48869486	3310.1913
40.	.02927043	-872.862723	.8234231	.55376076	.48859015	3307.7126
30.	.02927479	-872.884762	.8234961	.55361144	.48848534	3305.2305

TEMPERATURE= -10 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.02942896	-864.054704	.8369185	.53845448	.47813096	3292.6650
540.	.02943780	-864.100511	.8370589	.53818001	.47793883	3287.8064
520.	.02944667	-864.146193	.8371995	.53790491	.47774634	3282.9348
500.	.02945553	-864.191747	.8373406	.53762918	.47755348	3278.0501
480.	.02946451	-864.237173	.8374820	.53735282	.47736026	3273.1521
460.	.02947349	-864.282469	.8376237	.53707581	.47716666	3268.2408
440.	.02948250	-864.327636	.8377659	.53679816	.47697289	3263.3161
420.	.02949154	-864.372671	.8379083	.53651987	.47677835	3258.3779
400.	.02950062	-864.417573	.8380512	.53624092	.47658363	3253.4261
380.	.02950973	-864.462342	.8381944	.53596131	.47638853	3248.4605
360.	.02951888	-864.506976	.8383380	.53568104	.47619305	3243.4812
340.	.02952807	-864.551474	.8384820	.53540011	.47599718	3238.4879
320.	.02953729	-864.595835	.8386264	.53511850	.47580093	3233.4806
300.	.02954655	-864.640058	.8387711	.53483622	.47560428	3228.4591
280.	.02955584	-864.684142	.8389163	.53455326	.47540725	3223.4234
260.	.02956518	-864.728085	.8390618	.53426962	.47520982	3218.3734
240.	.02957455	-864.771886	.8392077	.53398529	.47501199	3213.3098
220.	.02958395	-864.815544	.8393540	.53370026	.47481376	3208.2298
200.	.02959340	-864.859058	.8395007	.53341453	.47461513	3203.1360
180.	.02960288	-864.902427	.8396478	.53312810	.47441609	3198.0274
160.	.02961241	-864.945649	.8397953	.53284095	.47421665	3192.9039
140.	.02962197	-864.988722	.8399432	.53255310	.47401679	3187.7653
120.	.02963157	-865.031647	.8400916	.53226452	.47381652	3182.6116
100.	.02964122	-865.074421	.8402403	.53197522	.47361584	3177.4426
90.	.02964605	-865.095750	.8403148	.53183029	.47351534	3174.8524
80.	.02965090	-865.117042	.8403895	.53168518	.47341473	3172.2583
70.	.02965576	-865.138296	.8404642	.53153989	.47331402	3169.6602
60.	.02966062	-865.159510	.8405391	.53139442	.47321320	3167.0583
50.	.02966550	-865.180687	.8406140	.53124875	.47311228	3164.4525
40.	.02967039	-865.201824	.8406891	.53110291	.47301125	3161.8428

TEMPERATURE= 0 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.02981222	-856.683697	.8531631	.51925958	.46506573	3159.0519
540.	.02982207	-856.727886	.8533070	.51899240	.46488122	3153.9677
520.	.02983196	-856.771927	.8534513	.51872457	.46469633	3148.8687
500.	.02984189	-856.815820	.8535960	.51845609	.46451108	3143.7548
480.	.02985187	-856.859563	.8537411	.51818634	.46432545	3138.6259
460.	.02986189	-856.903155	.8538866	.51791712	.46413945	3133.4818
440.	.02987194	-856.946594	.8540325	.51764664	.46395307	3128.3224
420.	.02988205	-856.989879	.8541789	.51737548	.46376631	3123.1477
400.	.02989219	-857.033009	.8543256	.51710363	.46357917	3117.9574
380.	.02990238	-857.075983	.8544728	.51683110	.46339164	3112.7515
360.	.02991261	-857.118799	.8546204	.51655788	.46320372	3107.5298
340.	.02992289	-857.161453	.8547684	.51628396	.46301542	3102.2923
320.	.02993321	-857.203947	.8549169	.51600935	.46282672	3097.0386
300.	.02994358	-857.246279	.8550658	.51573402	.46263762	3091.7689
280.	.02995399	-857.288446	.8552151	.51545798	.46244812	3086.4828
260.	.02996445	-857.330448	.8553649	.51518122	.46225822	3081.1803
240.	.02997496	-857.372282	.8555151	.51490374	.46206792	3075.8612

Table 3-5b (continued)

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
220.	.02998552	-857.413949	.8556658	.51462553	.46187720	3070.5253
200.	.02999612	-857.455443	.8558170	.51434658	.46169608	3065.1726
180.	.03000677	-857.496766	.8559686	.51406690	.46149454	3059.8029
160.	.03001747	-857.537914	.8561206	.51378647	.46130259	3054.4161
140.	.03002821	-857.578839	.8562732	.51350528	.46111022	3049.0119
120.	.03003901	-857.619684	.8564262	.51322334	.46091742	3043.5903
100.	.03004986	-857.660301	.8565797	.51294063	.46072420	3038.1511
90.	.03005530	-857.680542	.8566566	.51279899	.46062742	3035.4248
80.	.03006076	-857.700737	.8567336	.51265715	.46053054	3032.6941
70.	.03006623	-857.720887	.8568108	.51251512	.46043356	3029.9588
60.	.03007171	-857.740991	.8568881	.51237289	.46033646	3027.2191
50.	.03007720	-857.761048	.8569655	.51223047	.46023925	3024.4749

TEMPERATURE= 10 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.03020581	-849.520259	.8686074	.50321019	.45435667	3030.9049
540.	.03021681	-849.562517	.8687554	.50295021	.45417383	3025.5947
520.	.03022785	-849.604602	.8689039	.50268955	.45400261	3020.2478
500.	.03023895	-849.646513	.8690529	.50242821	.45382503	3014.8938
480.	.03025010	-849.688247	.8692023	.50216618	.45364707	3009.5228
460.	.03026130	-849.729804	.8693521	.50190346	.45346873	3004.1345
440.	.03027256	-849.771181	.8695025	.50164004	.45329001	2998.7298
420.	.03028386	-849.812377	.8696533	.50137592	.45311091	2993.3056
400.	.03029522	-849.853390	.8698046	.50111108	.45293143	2987.8646
380.	.03030664	-849.894217	.8699564	.50084553	.45275156	2982.4058
360.	.03031811	-849.934858	.8701087	.50057925	.45257129	2976.9330
340.	.03032964	-849.975310	.8702615	.50031225	.45239063	2971.4339
320.	.03034122	-850.015571	.8704147	.50004452	.45220958	2965.9205
300.	.03035285	-850.055639	.8705685	.49977604	.45202812	2960.3986
280.	.03036455	-850.095513	.8707228	.49950682	.45184626	2954.8330
260.	.03037630	-850.135190	.8708776	.49923685	.45166400	2949.2685
240.	.03038812	-850.174668	.8710329	.49896612	.45148133	2943.6800
220.	.03039999	-850.213945	.8711887	.49869462	.45129824	2938.0722
200.	.03041192	-850.253018	.8713450	.49842235	.45111474	2932.4451
180.	.03042391	-850.291887	.8715019	.49814931	.45093082	2926.7933
160.	.03043596	-850.330548	.8716593	.49787547	.45074647	2921.1318
140.	.03044808	-850.369000	.8718173	.49760085	.45056170	2915.4453
120.	.03046025	-850.407239	.8719758	.49732543	.45037650	2909.7386
100.	.03047249	-850.445264	.8721348	.49704920	.45019087	2904.0116
90.	.03047864	-850.464196	.8722146	.49691078	.45009790	2901.1404
80.	.03048480	-850.483072	.8722944	.49677216	.45000481	2898.2640
70.	.03049097	-850.501895	.8723744	.49663333	.44991161	2895.3824
60.	.03049716	-850.520662	.8724546	.49649430	.44981830	2892.4956

TEMPERATURE= 20 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.03061143	-842.527887	.8833619	.48988451	.44570351	2907.6652
540.	.03062374	-842.567849	.8835147	.48963165	.44553445	2902.0970
520.	.03063610	-842.607607	.8836681	.48937810	.44536502	2896.5096
500.	.03064853	-842.647159	.8838220	.48912383	.44519523	2890.9029
480.	.03066102	-842.686503	.8839765	.48886885	.44502506	2885.2703
460.	.03067358	-842.725636	.8841315	.48861315	.44485451	2879.6303
440.	.03068620	-842.764556	.8842870	.48835673	.44468359	2873.9652
420.	.03069889	-842.803262	.8844431	.48809957	.44451229	2868.2795
400.	.03071165	-842.841750	.8845997	.48784167	.44434061	2862.5735
380.	.03072447	-842.880017	.8847569	.48758303	.44416854	2856.8473
360.	.03073737	-842.918063	.8849146	.48732363	.44399608	2851.0999
340.	.03075033	-842.955883	.8850729	.48706348	.44382322	2845.3319
320.	.03076336	-842.993476	.8852318	.48680255	.44364997	2839.5429
300.	.03077646	-843.030839	.8853912	.48654086	.44347632	2833.7325
280.	.03078964	-843.067969	.8855513	.48627839	.44330227	2827.9007
260.	.03080288	-843.104864	.8857119	.48601512	.44312781	2822.0472

Table 3-5b (continued)

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
240.	.03081621	-843.141520	.8858732	.48575107	.44295295	2816.1717
220.	.03082960	-843.177935	.8860350	.48548621	.44277757	2810.2740
200.	.03084307	-843.214107	.8861975	.48522054	.44260198	2804.3539
180.	.03085662	-843.250031	.8863605	.48495406	.44242536	2798.4112
160.	.03087024	-843.285706	.8865242	.48468675	.44224933	2792.4456
140.	.03088395	-843.321128	.8866886	.48441861	.44207236	2786.4569
120.	.03089773	-843.356294	.8868535	.48414963	.44189497	2780.4448
100.	.03091159	-843.391202	.8870192	.48387980	.44171714	2774.4091
90.	.03091855	-843.408557	.8871022	.48374456	.44162807	2771.3823
80.	.03092554	-843.425847	.8871854	.48360911	.44153888	2769.3495
70.	.03093254	-843.443070	.8872688	.48347345	.44144958	2765.3106

TEMPERATURE= 30 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.03103105	-835.673721	.8975230	.47892587	.43884971	2789.9112
540.	.03104485	-835.710956	.8976815	.47868010	.43868862	2782.9808
520.	.03105873	-835.747949	.8978406	.47843361	.43852716	2777.1285
500.	.03107269	-835.784696	.8980003	.47818639	.43836535	2771.2543
480.	.03108673	-835.821196	.8981606	.47793843	.43820317	2765.3577
460.	.03110085	-835.857445	.8983215	.47768972	.43804062	2759.4387
440.	.03111505	-835.893439	.8984830	.47744026	.43787771	2753.4969
420.	.03112934	-835.929176	.8986452	.47719004	.43771442	2747.5322
400.	.03114371	-835.964653	.8988081	.47693905	.43755075	2741.5442
380.	.03115816	-835.999866	.8989715	.47668728	.43738671	2735.5327
360.	.03117270	-836.034813	.8991357	.47643474	.43722229	2729.4975
340.	.03118733	-836.069489	.8993004	.47618140	.43705747	2723.4383
320.	.03120205	-836.103891	.8994659	.47592726	.43689228	2717.3549
300.	.03121685	-836.138017	.8996320	.47567232	.43672668	2711.2469
280.	.03123175	-836.171861	.8997989	.47541657	.43656070	2705.1141
260.	.03124674	-836.205421	.8999664	.47515999	.43639431	2699.9562
240.	.03126182	-836.238694	.9001346	.47490258	.43622753	2692.7729
220.	.03127700	-836.271674	.9003035	.47464433	.43606033	2686.5640
200.	.03129227	-836.304359	.9004731	.47438524	.43589273	2680.3291
190.	.03130764	-836.336744	.9006435	.47412529	.43572472	2674.0679
160.	.03132311	-836.368825	.9008146	.47386448	.43555629	2667.7801
140.	.03133868	-836.400599	.9009865	.47360279	.43538744	2661.4654
120.	.03135435	-836.432061	.9011591	.47334021	.43521816	2655.1236
100.	.03137012	-836.463207	.9013324	.47307675	.43504846	2648.7541
90.	.03137804	-836.478660	.9014194	.47294468	.43496345	2645.5590
80.	.03138599	-836.494032	.9015066	.47281238	.43487832	2642.3568

TEMPERATURE= 40 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.03146695	-828.927872	.9111753	.47003177	.43357571	2673.8545
540.	.03148249	-828.961866	.9113403	.46979312	.43342285	2667.7454
520.	.03149812	-828.995571	.9115060	.46955371	.43326964	2661.6113
500.	.03151385	-829.028981	.9116725	.46931356	.43311609	2655.4521
480.	.03152969	-829.062093	.9118396	.46907263	.43296219	2649.2673
460.	.03154562	-829.094903	.9120075	.46883094	.43280794	2643.0566
440.	.03156166	-829.127407	.9121761	.46858847	.43265333	2636.8199
420.	.03157761	-829.159600	.9123454	.46834521	.43249837	2630.5568
400.	.03159405	-829.191479	.9125155	.46810116	.43234305	2624.2669
380.	.03161042	-829.223040	.9126864	.46785631	.43218736	2617.9500
360.	.03162689	-829.254277	.9128580	.46761064	.43203131	2611.6057
340.	.03164346	-829.285186	.9130304	.46736415	.43187489	2605.2337
320.	.03166015	-829.315763	.9132036	.46711684	.43171810	2598.8336
300.	.03167696	-829.346003	.9133775	.46686869	.43156034	2592.4051
280.	.03169398	-829.375900	.9135523	.46661969	.43140339	2585.9479
260.	.03171092	-829.405451	.9137280	.46636983	.43124546	2579.4615
240.	.03172807	-829.434650	.9139044	.46611911	.43108715	2572.9457
220.	.03174535	-829.463492	.9140817	.46586751	.43092845	2566.4000
200.	.03176276	-829.491971	.9142598	.46561503	.43076935	2559.8240

Table 3-5b (continued)

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
180.	.03178023	-829.520082	.9144388	.46536166	.43060386	2553.2174
160.	.03179794	-829.547820	.9146187	.46510737	.43044997	2546.5797
140.	.03181572	-829.575179	.9147995	.46485217	.43028968	2539.9106
120.	.03183363	-829.602153	.9149811	.46459605	.43012898	2533.2096
100.	.03185169	-829.628736	.9151637	.46433899	.42996787	2526.4762
90.	.03186075	-829.641879	.9152553	.46421010	.42988716	2523.0973

TEMPERATURE= 50 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.03192182	-822.262801	.9243936	.46294505	.42969338	2562.3368
540.	.03193938	-822.292935	.9245663	.46271360	.42954912	2555.9297
520.	.03195707	-822.322718	.9247398	.46248137	.42940455	2549.4939
500.	.03197488	-822.352145	.9249141	.46224838	.42925966	2543.0292
480.	.03199281	-822.381210	.9250893	.46201459	.42911445	2536.5352
460.	.03201088	-822.409908	.9252653	.46178002	.42896691	2530.0114
440.	.03202908	-822.438234	.9254422	.46154465	.42882305	2523.4575
420.	.03204741	-822.466182	.9256199	.46130846	.42867686	2516.8731
400.	.03206587	-822.493746	.9257985	.46107146	.42853034	2510.2578
380.	.03208448	-822.520920	.9259781	.46083363	.42838348	2503.6112
360.	.03210322	-822.547698	.9261585	.46059496	.42823629	2496.9329
340.	.03212211	-822.574075	.9263399	.46035545	.42808875	2490.2224
320.	.03214114	-822.600042	.9265222	.46011508	.42794087	2483.4793
300.	.03216031	-822.625595	.9267055	.45987384	.42779265	2476.7031
280.	.03217964	-822.650727	.9268897	.45963172	.42764408	2469.8934
260.	.03219912	-822.675430	.9270749	.45938872	.42749515	2463.0498
240.	.03221875	-822.699697	.9272611	.45914482	.42734587	2456.1716
220.	.03223854	-822.723521	.9274483	.45890001	.42719624	2449.2586
200.	.03225849	-822.746896	.9276365	.45865428	.42704624	2442.3100
180.	.03227860	-822.769812	.9278258	.45840762	.42689588	2435.3255
160.	.03229888	-822.792263	.9280162	.45816001	.42674515	2428.3044
140.	.03231933	-822.814241	.9282076	.45791145	.42659405	2421.2463
120.	.03233995	-822.835736	.9284001	.45766192	.42644258	2414.1505
100.	.03236074	-822.856741	.9285937	.45741141	.42629073	2407.0166

TEMPERATURE= 60 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.03239888	-815.652726	.9372452	.45744670	.42704151	2453.8267
540.	.03241383	-815.678242	.9374259	.45722263	.42690639	2447.0980
520.	.03243894	-815.703329	.9376095	.45699778	.42677099	2440.3363
500.	.03245920	-815.727980	.9377931	.45677214	.42663531	2433.5442
480.	.03247963	-815.752188	.9379777	.45654570	.42649936	2426.7162
460.	.03250022	-815.775944	.9381633	.45631846	.42636313	2419.8538
440.	.03252098	-815.799242	.9383495	.45609040	.42622661	2412.9564
420.	.03254191	-815.822074	.9385376	.45586151	.42608981	2406.0237
400.	.03256302	-815.844432	.9387263	.45563178	.42595272	2399.0551
380.	.03258430	-815.866307	.9389161	.45540121	.42581534	2392.0500
360.	.03260577	-815.887692	.9391070	.45516978	.42567767	2385.0080
340.	.03262742	-815.908577	.9392991	.45493748	.42553971	2377.9284
320.	.03264926	-815.928953	.9394922	.45470431	.42540145	2370.8106
300.	.03267128	-815.948811	.9396865	.45447024	.42526290	2363.6542
280.	.03269351	-815.968143	.9398820	.45423527	.42512405	2356.4584
260.	.03271593	-815.986937	.9400787	.45399939	.42498490	2349.2227
240.	.03273856	-816.005185	.9402766	.45376258	.42484545	2341.9464
220.	.03276139	-816.022876	.9404757	.45352483	.42470569	2334.6289
200.	.03278443	-816.039998	.9406761	.45328614	.42456563	2327.2695
180.	.03280769	-816.056542	.9408777	.45304648	.42442526	2319.8674
160.	.03283117	-816.072496	.9410807	.45280584	.42428458	2312.4221
140.	.03285487	-816.087848	.9412850	.45256422	.42414359	2304.9328
120.	.03287880	-816.102587	.9414906	.45232158	.42400228	2297.3986

TEMPERATURE= 70 DEG F

Table 3-5b (continued)

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.03290205	-809.073016	.9497912	.45335007	.42548220	2347.9174
540.	.03292464	-809.092975	.9499834	.45313371	.42535693	2340.8426
520.	.03294783	-809.112403	.9501768	.45291656	.42523144	2333.7296
500.	.03297103	-809.131291	.9503714	.45269862	.42510575	2326.5778
480.	.03299444	-809.149627	.9505672	.45247988	.42497983	2319.3866
460.	.03301806	-809.167402	.9507642	.45226032	.42485371	2312.1554
440.	.03304191	-809.184605	.9509624	.45203995	.42472736	2304.8835
420.	.03306598	-809.201226	.9511619	.45181873	.42460081	2297.5702
400.	.03309027	-809.217251	.9513627	.45159668	.42447403	2290.2150
380.	.03311480	-809.232671	.9515648	.45137376	.42434704	2282.8170
360.	.03313957	-809.247473	.9517633	.45114998	.42421983	2275.3756
340.	.03316458	-809.261645	.9519731	.45092532	.42409241	2267.9901
320.	.03318983	-809.275173	.9521793	.45069977	.42396477	2260.3536
300.	.03321535	-809.288045	.9523869	.45047332	.42383691	2252.7835
280.	.03324112	-809.300246	.9525960	.45024595	.42370884	2245.1608
260.	.03326715	-809.311764	.9528065	.45001766	.42358055	2237.4907
240.	.03329345	-809.322582	.9530185	.44978842	.42345205	2229.7725
220.	.03332004	-809.332686	.9532321	.44955823	.42332332	2222.0052
200.	.03334690	-809.342061	.9534472	.44932707	.42319439	2214.1880
180.	.03337406	-809.350690	.9536639	.44909493	.42306523	2206.3198
160.	.03340151	-809.358556	.9538823	.44886179	.42293586	2198.3997
140.	.03342926	-809.365642	.9541023	.44862763	.42280628	2190.4267

TEMPERATURE= 80 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.03343612	-802.499545	.9620884	.45049625	.42489796	2244.2241
540.	.03346234	-802.512763	.9622932	.45028811	.42478353	2236.7709
520.	.03348883	-802.525314	.9624995	.45007920	.42466897	2229.2733
500.	.03351559	-802.537184	.9627071	.44986350	.42455430	2221.7303
480.	.03354263	-802.548360	.9629163	.44965902	.42443951	2214.1412
460.	.03356995	-802.558825	.9631270	.44944773	.42432460	2206.5052
440.	.03359756	-802.568566	.9633391	.44923563	.42420959	2198.8215
420.	.03362547	-802.577566	.9635529	.44902270	.42409446	2191.0891
400.	.03365368	-802.585808	.9637682	.44880895	.42397923	2183.3072
380.	.03368220	-802.593276	.9639852	.44859434	.42386390	2175.4748
360.	.03371104	-802.599951	.9642038	.44837887	.42374646	2167.5910
340.	.03374020	-802.605817	.9644242	.44816254	.42363293	2159.6543
320.	.03376970	-802.610853	.9646462	.44794532	.42351731	2151.6652
300.	.03379954	-802.615040	.9648701	.44772721	.42340159	2143.6211
280.	.03382973	-802.618357	.9650957	.44750819	.42328579	2135.5214
260.	.03386028	-802.620785	.9653233	.44728825	.42316991	2127.3650
240.	.03389120	-802.622299	.9655527	.44706738	.42305395	2119.1507
220.	.03392250	-802.622878	.9657840	.44684555	.42293792	2110.8774
200.	.03395419	-802.622498	.9660174	.44662276	.42282182	2102.5437
180.	.03398627	-802.621134	.9662528	.44639900	.42270567	2094.1483
160.	.03401877	-802.618760	.9664903	.44617424	.42258945	2085.6900

TEMPERATURE= 90 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.03400715	-795.907930	.9741910	.44875047	.42518957	2142.3819
540.	.03403759	-795.912833	.9744109	.44855135	.42508733	2134.5134
520.	.03406838	-795.916984	.9746327	.44835148	.42498510	2126.5925
500.	.03409953	-795.920213	.9748562	.44815087	.42488290	2118.6184
480.	.03413105	-795.922551	.9750816	.44794951	.42478074	2110.5899
460.	.03416296	-795.923973	.9753088	.44774739	.42467862	2102.5059

440.	.03419525	-795.924459	.9755380	.44754449	.42457654	2094.3654
420.	.03422795	-795.923984	.9757691	.44734080	.42447452	2086.1671
400.	.03426106	-795.922523	.9760022	.44713633	.42437256	2077.9098
380.	.03429459	-795.920052	.9762374	.44693105	.42427068	2069.5923
360.	.03432855	-795.916543	.9764746	.44672495	.42416888	2061.2133
340.	.03436296	-795.911969	.9767142	.44651803	.42406717	2052.7715
320.	.03439783	-795.906300	.9769559	.44631026	.42396557	2044.2653
300.	.03443318	-795.899507	.9771999	.44610165	.42386408	2035.6934
280.	.03446901	-795.891559	.9774463	.44589218	.42376271	2027.0542
260.	.03450534	-795.882420	.9776950	.44568184	.42366149	2018.3463
240.	.03454219	-795.872058	.9779462	.44547061	.42356042	2009.5678
220.	.03457958	-795.860436	.9781999	.44525848	.42345951	2000.7171
200.	.03461751	-795.847516	.9784563	.44504543	.42335878	1991.7925
180.	.03465601	-795.833259	.9787153	.44483147	.42325825	1982.7920

TEMPERATURE= 100 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.03462292	-789.272573	.9861523	.44799948	.42627459	2042.0438
540.	.03465862	-789.267254	.9863908	.44781055	.42618642	2033.7156
520.	.03469481	-769.260826	.9866315	.44762097	.42609849	2025.3254
500.	.03473149	-789.253257	.9868745	.44743072	.42601081	2016.8719
480.	.03476867	-789.244517	.9871198	.44723981	.42592339	2008.3537
460.	.03480639	-789.234572	.9873675	.44704822	.42583625	1999.7692
440.	.03484463	-789.223387	.9876177	.44685595	.42574941	1991.1170
420.	.03488344	-789.210925	.9878704	.44666298	.42566289	1982.3954
400.	.03492281	-789.197150	.9881257	.44646933	.42557670	1973.6028
390.	.03496278	-789.182020	.9883837	.44627496	.42549086	1964.7374
360.	.03500336	-789.165494	.9886445	.44607589	.42540540	1955.7974
340.	.03504458	-789.147527	.9889081	.44588410	.42532034	1946.7309
320.	.03508644	-789.128074	.9891746	.44568758	.42523571	1937.6860
300.	.03512898	-789.107085	.9894442	.44549034	.42515152	1928.5105
290.	.03517222	-789.084510	.9897168	.44529235	.42506781	1919.2522
260.	.03521619	-789.060294	.9899927	.44509362	.42498461	1909.9090
240.	.03526090	-789.034380	.9902719	.44489413	.42490195	1900.4783
220.	.03530639	-789.006708	.9905546	.44469388	.42481985	1890.9578
200.	.03535270	-788.977213	.9908408	.44449287	.42473837	1881.3447

TEMPERATURE= 110 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.03529368	-782.565349	.9980275	.44814979	.42808672	1942.8788
540.	.03533612	-782.547041	.9982889	.44797287	.42801532	1934.0374
520.	.03537923	-782.527251	.9985533	.44779545	.42794449	1925.1218
500.	.03542303	-782.505930	.9988206	.44761753	.42787426	1916.1302
480.	.03546755	-782.483029	.9990910	.44743911	.42780465	1907.0605
460.	.03551281	-782.458495	.9993645	.44726018	.42773570	1897.9108
440.	.03555883	-782.432272	.9996413	.44708076	.42766745	1888.6788
420.	.03560565	-782.404301	.9999214	.44690084	.42759994	1879.3623
400.	.03565329	-782.374520	1.0002051	.44672043	.42753320	1869.9589
380.	.03570180	-782.342864	1.0004923	.44653952	.42746728	1860.4661
360.	.03575119	-782.309263	1.0007833	.44635813	.42740223	1850.8813
340.	.03580151	-782.273643	1.0010781	.44617625	.42733809	1841.2018
320.	.03585280	-782.235925	1.0013770	.44599389	.42727491	1831.4246
300.	.03590509	-782.196028	1.0016800	.44581106	.42721276	1821.5466
280.	.03595842	-782.153861	1.0019873	.44562777	.42715169	1811.5647
260.	.03601286	-782.109331	1.0022991	.44544401	.42709177	1801.4754
240.	.03606843	-782.062336	1.0026156	.44525981	.42703307	1791.2751

TEMPERATURE= 120 DEG F

PRESSURE	VOLUME	ENTHALAPY	ENTROPY	CP	CV	SONIC VELOCITY

PSIA	FT3/LBM	BTU/LBM	BTU/LBM/DEG F	BTU/LBM/DEG F	BTU/LBM/DEG F	FT/SEC
560.	.03603338	-775.753655	1.0098764	.44912729	.43057624	1844.5704
540.	.03608468	-775.718549	1.0101671	.44896516	.43052553	1835.1504
520.	.03613695	-775.681400	1.0104616	.44880281	.43047592	1825.6404
500.	.03619021	-775.642127	1.0107602	.44864028	.43042748	1816.0377
480.	.03624452	-775.600549	1.0110628	.44847757	.43038025	1806.3395
460.	.03629992	-775.556877	1.0113698	.44831469	.43033432	1796.5428
440.	.03635645	-775.510716	1.0116812	.44815168	.43028976	1786.6446
420.	.03641418	-775.462065	1.0119974	.44798856	.43024663	1776.6414
400.	.03647314	-775.410317	1.0123183	.44782534	.43020503	1766.5298
380.	.03653340	-775.356857	1.0126443	.44766207	.43016505	1756.3061
360.	.03659503	-775.300061	1.0129756	.44749976	.43012679	1745.9663
340.	.03665809	-775.240297	1.0133124	.44733546	.43009034	1735.5063
320.	.03672264	-775.177421	1.0136550	.44717220	.43005583	1724.9215
300.	.03678879	-775.111279	1.0140036	.44700903	.43002339	1714.2072
280.	.03685660	-775.041706	1.0143586	.44684598	.42999313	1703.3583
260.	.03692617	-774.968519	1.0147202	.44668313	.42996523	1692.3692

TEMPERATURE= 130 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.03686178	-768.797294	1.0217691	.45087833	.43371201	1746.8155
540.	.03692514	-768.739316	1.0220980	.45073541	.43369795	1736.7354
520.	.03698996	-768.679403	1.0224323	.45059284	.43366588	1726.5441
500.	.03705630	-768.615917	1.0227722	.45045065	.43364594	1716.2376
480.	.03712423	-768.549210	1.0231179	.45030892	.43362824	1705.8119
460.	.03719386	-768.479124	1.0234699	.45016769	.43361293	1695.2624
440.	.03726525	-768.405486	1.0238283	.45002705	.43360017	1684.5845
420.	.03733853	-768.328109	1.0241935	.44988706	.43359011	1673.7730
400.	.03741378	-768.246790	1.0245658	.44974782	.43358294	1662.8225
380.	.03749114	-768.161309	1.0249457	.44960942	.43357886	1651.7271
360.	.03757072	-768.071425	1.0253335	.44947197	.43357809	1640.4805
340.	.03765268	-767.976872	1.0257297	.44933558	.43359088	1629.0758
320.	.03773716	-767.877361	1.0261349	.44920038	.43358748	1617.5056
300.	.03782435	-767.772571	1.0265495	.44906653	.43359820	1605.7618

TEMPERATURE= 140 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.03780818	-761.643043	1.0337936	.45337399	.43748653	1649.3230
540.	.03788976	-761.554560	1.0341746	.45325757	.43749862	1638.4781
520.	.03797166	-761.461626	1.0345635	.45314266	.43751431	1627.4926
500.	.03805702	-761.363979	1.0349608	.45302931	.43753387	1616.3603
480.	.03814500	-761.261332	1.0353670	.45291769	.43755756	1605.0748
460.	.03823578	-761.153368	1.0357825	.45280797	.43758571	1593.6290
440.	.03832955	-761.039738	1.0362081	.45270036	.43761866	1582.0151
420.	.03842652	-760.920054	1.0366443	.45259507	.43765678	1570.2248
400.	.03852695	-760.793886	1.0370920	.45249237	.43770052	1558.2487
380.	.03863109	-760.660751	1.0375519	.45239254	.43775037	1546.0767
360.	.03873927	-760.520107	1.0380250	.45229592	.43780685	1533.6976
340.	.03885183	-760.371341	1.0385123	.45220289	.43787062	1521.0989

TEMPERATURE= 150 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC

Table 3-5b (continued)

560.	.03891905	-754.214245	1.0460726	.45661945	.44192630	1551.8085
540.	.03902583	-754.080330	1.0465287	.45654288	.44199145	1540.0585
520.	.03913663	-753.939125	1.0469973	.45647002	.44206276	1528.1244
500.	.03925178	-753.790066	1.0474795	.45640127	.44214141	1515.9980
480.	.03937165	-753.632512	1.0479764	.45633708	.44222809	1503.6621
460.	.03949667	-753.465739	1.0484891	.45627798	.44232357	1491.1101
440.	.03962734	-753.288916	1.0490190	.45622456	.44242875	1479.3260
420.	.03976422	-753.101090	1.0495678	.45617755	.44254465	1465.2938
400.	.03990798	-752.901153	1.0501373	.45613778	.44267248	1451.9957
380.	.04005941	-752.687809	1.0507297	.45610622	.44281366	1438.4108
360.	.04021942	-752.459525	1.0513475	.45608407	.44296988	1424.5154

TEMPERATURE= 160 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.04027499	-746.388277	1.0587973	.46067881	.44712017	1453.9733
540.	.04042554	-746.192019	1.0593708	.46066811	.44726831	1441.1141
520.	.04058400	-745.962330	1.0599670	.46066665	.44743025	1427.9996
500.	.04075130	-745.727732	1.0605882	.46067566	.44760765	1414.6101
480.	.04092854	-745.476472	1.0612373	.46069665	.44780250	1400.9228
460.	.04111706	-745.206443	1.0619178	.46073144	.44801720	1386.9110
440.	.04131851	-744.915081	1.0626338	.46078228	.44825470	1372.5431
420.	.04153491	-744.599216	1.0633906	.46085197	.44851863	1357.7807
400.	.04176887	-744.254855	1.0641947	.46094410	.44881362	1342.5768

TEMPERATURE= 170 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.04203613	-737.938566	1.0723157	.46573849	.45328011	1355.4027
540.	.04227177	-737.600228	1.0731004	.46585505	.45358199	1341.0821
520.	.04252682	-737.231565	1.0739347	.46599754	.45391756	1326.3622
500.	.04280496	-736.827167	1.0748273	.46617121	.45429318	1311.1917
480.	.04311110	-736.379909	1.0757897	.46638308	.45471729	1295.5050
460.	.04345196	-735.880115	1.0768373	.46664277	.45520134	1279.2150

TEMPERATURE= 180 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.04460419	-728.336946	1.0874339	.47233229	.46097407	1254.9839
540.	.04506207	-727.682953	1.0887151	.47277484	.46164594	1238.2836
520.	.04559665	-726.922144	1.0901660	.47332528	.46244212	1220.6825
500.	.04624116	-726.011113	1.0918550	.47403043	.46341402	1201.8736

TEMPERATURE= 190 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.04972073	-715.506783	1.1073151	.48276165	.47250342	1144.9225
540.	.05170459	-713.015848	1.1114356	.48523237	.47524971	1116.6903

TEMPERATURE= 200 DEG F

Table 3-5b (continued)

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.14046336	-653.710960	1.2017890	.52458429	.48855772	567.3130
540.	.15812786	-648.597800	1.2103744	.52672264	.48478004	557.1793

Table 3-6a
Saturation Temperature Table for Propane Calculated from Starling's Equation of State.

THERMODYNAMIC PROPERTIES OF PROPANE AS PREDICTED BY STARLINGS EQUATION OF STATE

P	T	VF	VG	HF	HG	SF	SG
PSIA	DEG F	FT3/LBM	FT3/LBM	BTU/LBM	BTU/LBM	BTU/LBM/DEG F	BTU/LBM/DEG F
12.58	-50.	.0279440630	7.6414118504	-884.169821917	-700.143555228	.79957822992	1.24842004159
13.23	-48.	.0280001292	7.2926299739	-883.103500211	-699.589621119	.80217829326	1.24760417204
13.90	-46.	.0280564921	6.9598568981	-882.035362679	-699.037439597	.80476957539	1.24678414865
14.61	-44.	.0281131597	6.6429620526	-880.965386564	-698.486909638	.80735220784	1.24596427883
15.34	-42.	.0281701466	6.3492825940	-879.893600952	-697.934554760	.80992641629	1.24520589164
16.09	-40.	.0282274592	6.0741067444	-878.819963253	-697.381479453	.81249230386	1.24448644505
16.88	-38.	.0282850962	5.8057533563	-877.744364046	-696.832944261	.81504985341	1.24372008476
17.70	-36.	.0283430781	5.5563188220	-876.666874644	-696.282647730	.81759937451	1.24301017924
18.54	-34.	.0284014110	5.3212665066	-875.587441293	-695.732207654	.82014095477	1.24232885776
19.42	-32.	.0284600953	5.0932979906	-874.505968931	-695.185744989	.82267460422	1.24161571485
20.33	-30.	.0285191490	4.8789298098	-873.422496348	-694.638915145	.82520058300	1.24093587103
21.27	-28.	.0285785882	4.6806641052	-872.337036955	-694.088961449	.82771911050	1.24032486006
22.25	-26.	.0286384046	4.4871716813	-871.249430759	-693.543858605	.83023007499	1.23967369305
23.26	-24.	.0286986195	4.3046898066	-870.159726860	-692.998506512	.83273376610	1.23905195041
24.30	-22.	.0287592375	4.1299929485	-869.067654052	-692.455232094	.83523024325	1.23842984586
25.38	-20.	.0288202722	3.9642125061	-867.973800781	-691.912616975	.83771968443	1.23782561177
26.49	-18.	.0288817431	3.8096685361	-866.877587449	-691.367237323	.84020233766	1.23727839762
27.65	-16.	.0289436424	3.6597861692	-865.779059811	-690.826364079	.84267809553	1.23670316401
28.84	-14.	.0290059902	3.5170179483	-864.678239864	-690.286366865	.84514721103	1.23614293235
30.07	-12.	.0290688013	3.3819982176	-863.575108914	-689.746074776	.84760985889	1.23560993073
31.34	-10.	.0291320769	3.2516904153	-862.469568113	-689.209185693	.85006604356	1.23506514335
32.65	-8.	.0291958471	3.1300707629	-861.361681677	-688.669334649	.85251612469	1.23457395135
34.00	-6.	.0292600970	3.0109119104	-860.251258949	-688.135756650	.85495990439	1.23404370740
35.40	-4.	.0293248601	2.8984308093	-859.138374882	-687.601321977	.85739777342	1.23354565869
36.84	-2.	.0293901416	2.7908065996	-858.022945775	-687.068595147	.85982977236	1.23305476890
38.32	0.	.0294559711	2.6902002259	-856.905009115	-686.532609948	.86225622548	1.23261559854
39.84	2.	.0295223305	2.5916955141	-855.784366773	-686.002905412	.86467690295	1.23214240568
41.41	4.	.0295892791	2.5010473348	-854.661187593	-685.466237762	.86709245561	1.23175039539
43.03	6.	.0296567814	2.4117378109	-853.535193647	-684.937033663	.86950245254	1.23131566794
44.70	8.	.0297248434	2.3234012422	-852.406311151	-684.417082805	.87190694405	1.23082800099
46.41	10.	.0297935416	2.2420882849	-851.274757131	-683.889811840	.87430673961	1.23042147393
48.18	12.	.0298628555	2.1636779337	-850.140326933	-683.365003142	.87670157876	1.23001649194
49.99	14.	.0299328024	2.0887701895	-849.002976554	-682.842330123	.87909160969	1.22961612909
51.85	16.	.0300034091	2.0173776763	-847.862695715	-682.319221733	.88147707985	1.22923937917
53.77	18.	.0300746627	1.9475388279	-846.719321897	-681.802844809	.88385781274	1.22883472806
55.74	20.	.0301466205	1.8817351669	-845.572948474	-681.283774184	.88623435949	1.22846973870
57.76	22.	.0302193078	1.8199205007	-844.423538336	-680.760799173	.88860692302	1.22815043608
59.84	24.	.0302926605	1.7577134593	-843.270763042	-680.252044227	.89097481138	1.22775536588
61.97	26.	.0303668148	1.7007953313	-842.114946370	-679.732239701	.89333933064	1.22745233641
64.15	28.	.0304417375	1.6462624956	-840.955852954	-679.213128325	.89570008629	1.22716218493
66.41	30.	.0305173589	1.5906577157	-839.793165874	-678.712601728	.89805634839	1.22677506972
68.72	32.	.0305938185	1.5386442196	-838.627175823	-678.206687848	.90040940926	1.22644153023
71.08	34.	.0306710930	1.4884040710	-837.457691490	-677.704391595	.90275897503	1.22610593785
73.51	36.	.0307492473	1.4410965079	-836.264757392	-677.198007689	.90510558079	1.22581303285
75.99	38.	.0308282773	1.3956890137	-835.108233182	-676.692879863	.90744910872	1.22553070864
78.56	40.	.0309081479	1.3509102974	-833.927917563	-676.197485402	.90978916488	1.22521241574
81.15	42.	.0309890254	1.3093466020	-832.744062859	-675.692982925	.91212717324	1.22496183600
83.83	44.	.0310707867	1.2681924475	-831.556268342	-675.199385269	.91446193665	1.22467030057
86.57	46.	.0311535076	1.2283550098	-830.364576957	-674.710007547	.91679404883	1.22437514676
89.37	48.	.0312373150	1.1914902641	-829.169099143	-674.209729524	.91912451410	1.22415305539
92.25	50.	.0313220373	1.1540573138	-827.969390021	-673.729338782	.92145175131	1.22384844964
95.19	52.	.0314079159	1.1194645462	-826.765747836	-673.237159640	.92377772328	1.22361952701
98.21	54.	.0314946093	1.0850338465	-825.557803773	-672.758532225	.92610112120	1.22334243437
101.28	56.	.0315829331	1.0531746479	-824.345756882	-672.267884263	.92842362427	1.22313888714
104.44	58.	.0316721284	1.0213715729	-823.129239962	-671.791857470	.93074379896	1.22288398537
107.66	60.	.0317625641	.9911986543	-821.908354159	-671.312529479	.93306289991	1.22266090437
110.97	62.	.0318540873	.9606702710	-820.682785554	-670.853982970	.93537957893	1.22236304039
114.33	64.	.0319470801	.9330840486	-819.452835443	-670.373461477	.93769672833	1.22217813116
117.74	66.	.0320415335	.9076037387	-818.218312950	-669.878367830	.94001412008	1.22206909109

Table 3-6a (continued)

121.31	68.	.0321308501	.6790686474	-810.978527159	-669.444404521	.94232689805	1.22171959175
124.90	70.	.0322333794	.8539330736	-815.734131227	-668.976539880	.94464155652	1.22152817359
128.54	72.	.0323325662	.8309429369	-814.434865680	-668.489545074	.94695739911	1.22142841080
132.34	74.	.0324321802	.8052477690	-813.230114638	-668.065719934	.94926883798	1.22109343920
136.19	76.	.0325336039	.7820484544	-811.970325623	-667.616620487	.95158225081	1.22087558725
140.11	78.	.0326366085	.7595602292	-810.705109759	-667.172223522	.95399574375	1.22065610431
144.11	80.	.0327413335	.7381454223	-809.434646387	-666.724618212	.95621011556	1.22046458437
148.22	82.	.0328476371	.7166620980	-808.158476527	-666.292824353	.95852415694	1.22023084372
152.39	84.	.0329557594	.6965335317	-806.376624948	-665.859249602	.96033940943	1.22002006404
156.65	86.	.0330658108	.6771403110	-805.598946493	-665.422908515	.96315620540	1.21983477693
160.99	88.	.0331777755	.6594055673	-804.295283321	-664.989277486	.96547437037	1.21965508905
165.40	90.	.0332917850	.6404462005	-802.995484308	-664.554554319	.96779447146	1.21949383320
169.94	92.	.0334076328	.6224091720	-801.689416527	-664.141355691	.97011488812	1.21927503288
174.57	94.	.0335253320	.6047593392	-803.376942696	-663.733201160	.97243678639	1.21903937274
179.25	96.	.0336460425	.5886357474	-799.057792713	-663.310085971	.97476347370	1.21890054584
184.22	98.	.0337685254	.5731134595	-797.731948325	-662.882132928	.97709054658	1.21877456072
190.52	100.	.0338903694	.5562571813	-796.400339706	-662.519924070	.97940161564	1.21845974615
193.85	102.	.0340216468	.5424928572	-795.058870435	-662.071325047	.98175865461	1.21842251521
199.01	104.	.0341511400	.5266054428	-793.711836006	-661.720162166	.98409200053	1.21810435389
204.24	106.	.0342836060	.5117164281	-792.357181627	-661.356536827	.98643066576	1.21784212630
210.50	108.	.0344169897	.4977037938	-790.996016470	-660.981948203	.98876217997	1.21762891913
216.40	110.	.0345547072	.4849421580	-789.626169492	-660.577178883	.99110635345	1.21751784496
220.34	112.	.0346998866	.4715702223	-788.244923974	-660.220681871	.99348024492	1.21723235538
225.94	114.	.0348447607	.4586308753	-786.857646135	-659.866541321	.99583975357	1.21705623762
231.68	116.	.0349926791	.4457931792	-785.461913808	-659.537564552	.99820084457	1.21677667076
237.33	118.	.0351459581	.4350139587	-784.055548257	-659.126257409	1.00057872042	1.21673663072
243.36	120.	.0353005219	.4222065145	-782.642041172	-658.644723232	1.00294958574	1.21636094476
249.37	122.	.0354604665	.4111466123	-781.217512067	-658.494964291	1.00533512877	1.21618384915
255.31	124.	.0356257035	.4009443072	-779.781720176	-658.118702793	1.00773396853	1.21608900620
261.48	126.	.0357945122	.3904362842	-778.336273873	-657.783574934	1.01013642134	1.21590064736
269.65	128.	.0359594796	.3782548833	-776.889589670	-657.583866634	1.01250471728	1.21538630249
274.56	130.	.0361422970	.3678300579	-775.417060223	-657.301952122	1.01494769557	1.21509837985
281.08	132.	.0363253054	.3581626905	-773.937881879	-656.995451786	1.01737735304	1.21488667998
287.55	134.	.0365169473	.3495607426	-772.444155083	-656.636111210	1.01982733612	1.21491601120
294.29	136.	.0367117489	.3403213242	-770.939565560	-656.349375096	1.02228039119	1.21458345839
301.43	138.	.0369098283	.3299826230	-769.425909776	-656.182376020	1.02473058197	1.21408569914
308.71	140.	.0371152661	.3205549658	-767.897487930	-655.976676825	1.02719765821	1.21369875592
315.43	142.	.0373341329	.3130358303	-766.345740343	-655.633304394	1.02970752956	1.21364232955
323.02	144.	.0375520693	.3031575381	-764.790430397	-655.536876346	1.03219458233	1.21304243617
331.50	146.	.0377779150	.2955116276	-763.219495867	-655.263342777	1.03469773248	1.21295631742
337.69	148.	.0380252178	.2876266749	-761.613027970	-655.042939899	1.03727294792	1.21256796182
345.59	150.	.0382702263	.2787871888	-760.005618405	-654.960570658	1.03981737894	1.21199746780
353.08	152.	.0385338527	.2719553303	-758.366499735	-654.693270843	1.04241722127	1.21184044329
361.45	154.	.0387963907	.2628740937	-756.725459872	-654.724546035	1.04499041945	1.21107068977
369.72	156.	.0390772690	.2555776238	-755.053247637	-654.586194026	1.04761375505	1.21067689413
377.14	158.	.0393843892	.2497100126	-753.337447367	-654.297452651	1.05031372298	1.21060519535
385.60	160.	.0396935659	.2424710790	-751.615916521	-654.222800614	1.05299477432	1.21011154338
393.90	162.	.0400220911	.2354651428	-749.862120450	-654.158614857	1.05572045717	1.20961543138
402.80	164.	.0403596494	.2277757675	-748.092862890	-654.243653414	1.05845051451	1.20934558320
411.20	166.	.0407324098	.2218154684	-746.267201882	-654.110247421	1.06127471058	1.20852168165
420.49	168.	.0411128349	.2149175473	-744.429700754	-654.171006082	1.06409251115	1.20784062868
429.11	170.	.0415315637	.2085459592	-742.532528184	-654.193967418	1.06700442162	1.20725101573
438.76	172.	.0419561565	.2010340789	-740.628578892	-654.480533587	1.06989852482	1.20619275900
447.35	174.	.0424543344	.1961961633	-738.611816110	-654.319124366	1.07298595607	1.20598330899
456.86	176.	.0429641548	.1897960418	-736.582676443	-654.509157967	1.07606245426	1.20514590016
467.07	178.	.0434927978	.1324381095	-734.531612852	-654.973786248	1.07914879718	1.20384113746
476.04	180.	.0441367954	.1777904617	-732.311786722	-654.910100173	1.08251576634	1.20350076240
486.04	182.	.0448014740	.1715274516	-730.074850426	-655.271955888	1.08587625416	1.20242804642
496.62	184.	.0455093645	.1645484724	-727.789789238	-655.898863502	1.08928838692	1.20092558763
506.27	186.	.0463834139	.1595315063	-725.231079191	-656.103433381	1.09305499379	1.20017465611
516.58	188.	.0473383445	.1536236126	-722.687259533	-656.622472739	1.09692624341	1.19891170742
527.14	190.	.0484265023	.1475049225	-719.945343154	-657.299867730	1.10100636389	1.19741244628

THERMODYNAMIC PROPERTIES OF PROPANE AS PREDICTED BY STARLINGS EQUATION OF STATE

P	T	CFF	CFG	CVF	CVG	AF	AG
PSIA	DEG F	BTU/LBM/DEG F	BTU/LBM/DEG F	BTU/LBM/DEG F	BTU/LBM/DEG F	FT/SEC	FT/SEC
12.58	-50.	.3056685800	.3332762756	.3502306603	.2861160223	3195.708041	704.181770
13.23	-49.	.3101478121	.3349814243	.3516397477	.2873963667	3190.956991	705.123460
13.90	-46.	.3144683508	.3367079752	.3530282638	.2886889769	3185.173949	706.024331
14.61	-44.	.3186366828	.3384552551	.3543970725	.2899936861	3178.431294	706.885334
15.34	-42.	.3226587256	.3402012123	.3557469060	.2913005654	3170.791221	707.735836
16.09	-40.	.3265405426	.3419529037	.3570786069	.2926126880	3162.316778	708.566612
16.88	-38.	.3302883310	.3437435756	.3583931163	.2939441054	3153.072212	709.333439
17.70	-36.	.3339070141	.3455333753	.3596909985	.2952776859	3143.101705	710.089448
18.54	-34.	.3374020016	.3473325391	.3609730322	.2966177044	3132.456354	710.821078
19.42	-32.	.3407787245	.3491669710	.3622400473	.2979749250	3121.187493	711.493670
20.33	-30.	.3440416318	.3510092826	.3634925928	.2993376787	3109.331108	712.143856
21.27	-28.	.3471951146	.3528421889	.3647312427	.3006987089	3096.922212	712.794911
22.25	-26.	.3502443810	.3547156688	.3659568742	.3020786948	3084.009126	713.379659
23.26	-24.	.3531932391	.3565976872	.3671699461	.3034641940	3070.618238	713.941096
24.30	-22.	.3560460218	.3585027411	.3683711216	.3048610663	3056.784777	714.459603
25.38	-20.	.3588065436	.3604218924	.3695609299	.3062655134	3042.536109	714.947138
26.49	-18.	.3614782641	.3623337567	.3707398203	.3076687621	3027.894271	715.432620
27.65	-16.	.3640655246	.3642835501	.3719085468	.3090890882	3012.896624	715.854610
28.84	-14.	.3665714724	.3662485489	.3730675150	.3105171322	2997.561465	716.243728
30.07	-12.	.3689993501	.3682213910	.3742171878	.3119498538	2981.909318	716.609848
31.34	-10.	.3713527474	.3702248911	.3753581574	.3133962826	2965.967447	716.921588
32.65	-8.	.3736341337	.3722195030	.3764906973	.3148405777	2949.744718	717.232843
34.00	-6.	.3758474040	.3742622123	.3776155331	.3163052600	2933.275502	717.465163
35.40	-4.	.3779947103	.3763087665	.3787328846	.3177727011	2916.564787	717.678958
36.84	-2.	.3800790583	.3783748349	.3798432471	.3192490123	2899.633267	717.852329
38.32	0.	.3821025861	.3804296868	.3809468780	.3207221490	2882.487095	718.027508
39.84	2.	.3840688018	.3825317863	.3820444508	.3222148283	2865.157908	718.123001
41.41	4.	.3859787941	.3845996231	.3831359526	.3236953975	2847.634545	718.251827
43.03	6.	.3878363872	.3867214359	.3842221731	.3251979358	2829.956473	718.290459
44.70	8.	.3896440329	.3889076800	.3853035146	.3267262073	2812.139442	718.223049
46.41	10.	.3914021856	.3910568222	.3863798349	.3282412781	2794.162654	718.191677
48.18	12.	.3931139438	.3932283287	.3874517489	.3297659211	2776.055286	718.112171
49.99	14.	.3947812817	.3954198352	.3885195654	.3312991913	2757.826557	717.987055
51.85	16.	.3964058593	.3976153808	.3895835191	.3328350495	2739.480476	717.838315
53.77	18.	.3979902914	.3998579137	.3906441117	.3343896495	2721.040374	717.603513
55.74	20.	.3995353677	.4020900029	.3917013641	.3359414091	2702.495053	717.364121
57.76	22.	.4010426721	.4043041143	.3927555245	.3374876389	2683.849242	717.130688
59.84	24.	.4025157979	.4066085331	.3938073671	.3390687045	2665.148708	716.744482
61.97	26.	.4039536294	.4088512274	.3948564536	.3406280935	2646.346166	716.426252
64.15	28.	.4053589533	.4111021975	.3959033652	.3421919541	2627.472860	716.073112
66.41	30.	.4067351864	.4134668863	.3969488297	.3437992258	2608.574751	715.526532
68.72	32.	.4080811560	.4158020196	.3979924345	.3453970603	2589.604588	714.997329
71.08	34.	.4093992053	.4181602709	.3990346538	.3470050026	2570.587747	714.405490
73.51	36.	.4106898079	.4204956279	.4000755102	.3486063063	2551.511484	713.819260
75.99	38.	.4119548133	.4228388483	.4011153647	.3502124264	2532.392571	713.190777
78.56	40.	.4131965716	.4252381989	.4021546904	.3518411697	2513.259795	712.443199
81.15	42.	.4144135995	.4275834826	.4031930801	.3534524272	2494.059965	711.745650
83.83	44.	.4156098233	.4299893524	.4042313745	.3550883092	2474.857521	710.916941
86.57	46.	.4167854056	.4324157655	.4052696532	.3567344125	2455.636240	710.016470
89.37	48.	.4179397168	.4347758938	.4063074434	.3583592658	2436.361986	709.182059
92.25	50.	.4190771999	.4372427097	.4073459710	.3600263774	2417.114847	708.131018
95.19	52.	.4201953029	.4396364372	.4083845662	.3616703040	2397.818372	707.153730
98.21	54.	.4212978011	.4420973467	.4094239993	.3633427577	2378.539932	706.015576
101.28	56.	.4223827415	.4444825759	.4104638641	.3649916447	2359.216240	704.953582
104.44	58.	.4234539918	.4469369839	.4115049306	.3666706397	2339.919320	703.718561
107.66	60.	.4245103890	.4493609677	.4125469712	.3683434699	2320.604647	702.477508
110.97	62.	.4255554654	.4518813330	.4135906585	.3700577428	2301.339451	701.001542
114.33	64.	.4265851955	.4542691024	.4146352691	.3717286751	2282.010197	699.696085
117.74	66.	.4276011740	.4565654269	.4156811518	.3733714881	2262.637282	698.492962

Table 3-6a (continued)

Table 3-6a (continued)

121.31	68.	.4286126963	.4591578766	.4167299306	.3751333012	2243.433897	696.661904
124.90	70.	.4296097404	.4615542657	.4177799210	.3768287781	2224.137288	695.117555
128.54	72.	.4305946494	.4638329255	.4188316095	.3784870912	2204.787833	693.722329
132.34	74.	.4315774312	.4663985526	.4198865994	.3802656603	2185.624987	691.666194
136.19	76.	.4325487220	.4688104951	.4209434859	.3819949466	2166.396061	689.815604
140.11	78.	.4335125435	.4712140666	.4220029528	.3837320040	2147.188949	687.876073
144.11	80.	.4344686155	.4735698911	.4230650394	.3854618457	2127.981615	685.926297
148.22	82.	.4354196793	.4759626406	.4241301864	.3872196752	2108.832531	683.774739
152.39	84.	.4363643289	.4783085179	.4251982949	.3889725071	2089.690465	681.597676
156.65	86.	.4373030204	.4806020497	.4262695300	.3907185286	2070.553271	679.405950
160.99	88.	.4382369215	.4828652613	.4273441370	.3924676790	2051.438806	677.144170
165.40	90.	.4391661448	.4850801346	.4284222496	.3942129339	2032.336309	674.851882
169.94	92.	.4400937428	.4873346262	.4295042678	.3959946448	2013.318675	672.294211
174.57	94.	.4410189353	.4895754704	.4305902202	.3977915537	1994.351891	669.588528
179.25	96.	.4419383421	.4916680473	.4316800143	.3995415646	1975.324174	667.103646
184.22	98.	.4428584853	.4937099031	.4327742673	.4012894533	1956.412044	664.578677
190.52	100.	.4437997955	.4959214336	.4338739932	.4031472095	1938.220441	661.326287
193.85	102.	.4446885209	.4977838117	.4349760945	.4048553679	1918.513321	658.936382
199.01	104.	.4456092295	.4999015058	.4360844395	.4067262742	1899.829317	655.476609
204.24	106.	.4465279495	.5019045380	.4371977444	.4085713224	1881.130464	652.112924
210.50	108.	.4474592114	.5038018274	.4383162661	.4103934352	1862.864165	648.833988
216.40	110.	.4483819663	.5055453654	.4394400874	.4121608318	1844.352836	645.853970
220.34	112.	.4492803895	.5073497760	.4405703361	.4140046957	1825.047650	642.320950
225.94	114.	.4502024335	.5090823887	.4417062546	.4158475155	1806.497490	638.737576
231.68	116.	.4511288574	.5107940447	.4428483442	.4177263337	1788.068375	634.857150
237.33	118.	.4520490479	.5122462167	.4439976919	.4194660282	1769.380862	631.866504
243.36	120.	.4529853213	.5138946462	.4451529284	.4214103863	1751.190108	627.436391
249.37	122.	.4539185713	.5153216932	.4463160056	.4232388194	1732.817105	623.751785
255.31	124.	.4548516622	.5160288863	.4474873773	.4250198378	1714.335463	620.358796
261.48	126.	.4557939220	.5179331609	.4486662851	.4268603362	1696.066265	616.518536
269.65	128.	.4567750286	.5193494446	.4498471871	.4289049262	1679.139085	611.206312
274.56	130.	.4577116405	.5205518597	.4510463602	.4308131062	1660.349441	606.821466
281.08	132.	.4586729174	.5216427769	.4522513793	.4326760290	1642.317886	602.736690
287.55	134.	.4596361921	.5226078229	.4534678064	.4344519098	1624.135859	599.261482
294.29	136.	.4606135664	.5235764639	.4546930776	.4363306258	1606.272866	595.046233
301.43	138.	.4616093810	.5245597184	.4559257487	.4383788981	1588.912148	589.616081
308.71	140.	.4626121616	.5254207146	.4571702611	.4403588239	1571.542447	584.687113
315.43	142.	.4636097833	.5261357085	.4584338108	.4421281595	1553.547877	581.288957
323.02	144.	.4646394802	.5268962012	.4597003309	.4442460852	1536.627323	575.432277
331.50	146.	.4656807034	.5275172023	.4609796639	.4460978827	1519.809527	571.522584
337.69	148.	.4667109227	.5280965932	.4622891586	.4480155869	1501.834286	567.202573
345.59	150.	.4677782124	.5286323237	.4635991358	.4501148965	1485.161239	561.689995
353.08	152.	.4688481776	.5290962651	.4649365235	.4519445298	1467.855104	558.152801
361.45	154.	.4699528923	.5295018883	.4662747926	.4541710088	1451.752216	552.012951
369.72	156.	.4710672141	.5298606847	.4676402211	.4561503296	1435.240361	547.715481
377.14	158.	.4721897253	.5302094694	.4690446870	.4579161348	1417.914930	544.973176
385.60	160.	.4733484350	.5304854402	.4704532259	.4599535974	1401.720774	540.620747
393.90	162.	.4745297278	.5307234658	.4718904041	.4619882342	1385.471476	536.514114
402.80	164.	.4757431634	.5308819477	.4733401905	.4641962219	1369.938880	531.634777
411.20	166.	.4769801499	.5310906853	.4748416439	.4661070247	1353.666282	528.824274
420.49	168.	.4782557284	.5312103805	.4763517651	.4682433746	1338.393181	525.053792
429.11	170.	.4795668021	.5313310863	.4779166096	.4703112146	1322.619737	522.061625
438.76	172.	.4809195332	.5313293394	.4794840299	.4726733301	1308.057030	518.117793
447.35	174.	.4823253810	.5315219971	.4811577927	.4744759855	1291.920504	517.294004
456.86	176.	.4837822577	.5315618830	.4828380523	.4766705095	1277.054856	515.263061
467.07	178.	.4852889949	.5314848475	.4845326445	.4791459787	1263.118138	513.021624
476.04	180.	.4868984269	.5316594269	.4863859401	.4809933280	1247.265032	513.603394
486.04	182.	.4885709866	.5316597368	.4882444097	.4832831528	1232.744972	513.709785
496.62	184.	.4903167611	.5315689848	.4901354463	.4858123598	1218.873927	514.614579
506.27	186.	.4922368266	.5316870777	.4922269857	.4878523402	1203.152136	517.362484
516.58	188.	.4942721032	.5317023757	.4943731003	.4901728250	1187.868381	521.161497
527.14	190.	.4964660497	.5316902466	.4966227953	.4925933215	1172.161561	526.681713

Table 3-6b

Compressed Liquid Table for Propane Calculated from Starling's Equation of State.

THERMODYNAMIC PROPERTIES OF PROPANE AS PREDICTED BY STARLINGS EQUATION OF STATE

TEMPERATURE= -30 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.02831413	-871.821326	.8223226	.35292541	.36641287	3249.4854
540.	.02832139	-871.882224	.8224259	.35260362	.36630641	3244.4259
520.	.02832868	-871.942545	.8225295	.35228128	.36619981	3239.3565
500.	.02833599	-872.002787	.8226333	.35195839	.36609307	3234.2773
480.	.02834332	-872.062950	.8227373	.35163496	.36598621	3229.1880
460.	.02835068	-872.123034	.8228416	.35131096	.36587921	3224.0888
440.	.02835807	-872.183039	.8229462	.35098641	.36577208	3218.9794
420.	.02836548	-872.242961	.8230510	.35066129	.36566482	3213.8600
400.	.02837291	-872.302803	.8231551	.35033561	.36555742	3208.7303
380.	.02838038	-872.362563	.8232614	.35000936	.36544989	3203.5903
360.	.02838786	-872.422241	.8233669	.34968254	.36534222	3198.4400
340.	.02839538	-872.481835	.8234728	.34935514	.36523441	3193.2793
320.	.02840292	-872.541346	.8235789	.34902716	.36512647	3188.1081
300.	.02841043	-872.600772	.8236852	.34869861	.36501840	3182.9264
280.	.02841807	-872.660113	.8237918	.34836946	.36491018	3177.7341
260.	.02842569	-872.719369	.8238987	.34803973	.36480183	3172.5312
240.	.02843334	-872.778539	.8240058	.34770941	.36469334	3167.3175
220.	.02844101	-872.837621	.8241132	.34737849	.36458471	3162.0930
200.	.02844871	-872.896616	.8242209	.34704697	.36447594	3156.8576
180.	.02845644	-872.955522	.8243289	.34671485	.36436704	3151.6113
160.	.02846420	-873.014339	.8244371	.34638213	.36425799	3146.3540
140.	.02847193	-873.073067	.8245456	.34604879	.36414880	3141.0855
120.	.02847979	-873.131704	.8246544	.34571484	.36403947	3135.8060
100.	.02848764	-873.190250	.8247634	.34538028	.36393000	3130.5152
90.	.02849157	-873.219489	.8248181	.34521276	.36387521	3127.8655
80.	.02849551	-873.248704	.8248728	.34504509	.36382038	3125.2131
70.	.02849945	-873.277897	.8249275	.34487726	.36376552	3122.5577
60.	.02850340	-873.307066	.8249824	.34470928	.36371062	3119.8996
50.	.02850736	-873.336212	.8250373	.34454113	.36365569	3117.2385
40.	.02851133	-873.365334	.8250923	.34437283	.36360072	3114.5746
30.	.02851531	-873.394433	.8251474	.34420438	.36354572	3111.9078

TEMPERATURE= -20 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.02859705	-866.428985	.8347749	.36750376	.37232608	3185.5326
540.	.02860500	-866.488015	.8348814	.36718615	.37222429	3180.3319
520.	.02861299	-866.546956	.8349881	.36686798	.37212236	3175.1263
500.	.02862100	-866.605806	.8350951	.36654922	.37202032	3169.9976
480.	.02862904	-866.664564	.8352024	.36622989	.37191814	3164.6639
460.	.02863711	-866.723231	.8353100	.36590997	.37181584	3159.4190
440.	.02864521	-866.781805	.8354178	.36558946	.37171342	3154.1628
420.	.02865334	-866.840285	.8355259	.36526836	.37161097	3148.8954
400.	.02866150	-866.898671	.8356343	.36494667	.37150819	3143.6165
380.	.02866969	-866.956962	.8357430	.36462437	.37140538	3138.3262
360.	.02867792	-867.015157	.8358520	.36430148	.37130244	3133.0243
340.	.02868617	-867.073256	.8359613	.36397798	.37119938	3127.7109
320.	.02869445	-867.131257	.8360708	.36365387	.37109619	3122.3857
300.	.02870277	-867.189160	.8361807	.36332915	.37099287	3117.0487
280.	.02871112	-867.246965	.8362908	.36300381	.37088941	3111.6999
260.	.02871950	-867.304669	.8364012	.36267785	.37078583	3106.3392
240.	.02872791	-867.362273	.8365120	.36235126	.37068212	3100.9664
220.	.02873635	-867.419775	.8366230	.36202405	.37057828	3095.5815
200.	.02874483	-867.477175	.8367344	.36169620	.37047430	3090.1844
180.	.02875334	-867.534472	.8368460	.36136771	.37037019	3084.7750
160.	.02876188	-867.591664	.8369580	.36103859	.37026595	3079.3533
140.	.02877046	-867.648752	.8370703	.36070882	.37016158	3073.9191

Table 3-6b (continued)

120.	.02877907	-867.705734	.8371928	.36037839	.37005707	3068.4724
100.	.02878772	-867.762609	.8372957	.36004732	.36995244	3063.0130
90.	.02879205	-867.791006	.8373523	.35989154	.36990006	3060.2736
80.	.02879640	-867.819376	.8374090	.35971559	.36984766	3057.5409
70.	.02880075	-867.847720	.8374657	.35954947	.36979522	3054.8001
60.	.02880511	-867.876035	.8375225	.35938319	.36974275	3052.0560
50.	.02880948	-867.904324	.8375794	.35921675	.36969025	3049.3087
40.	.02881386	-867.932585	.8376363	.35905013	.36963771	3046.5582
30.	.02881825	-867.960318	.8376934	.35888335	.36959513	3043.8044

TEMPERATURE= -10 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.02888899	-860.989014	.8470487	.37985652	.37796663	3111.7950
540.	.02889772	-861.046455	.8471587	.37954289	.37786945	3106.4426
520.	.02890648	-861.103791	.8472691	.37922865	.37777216	3101.0781
500.	.02891527	-861.161023	.8473797	.37891381	.37767475	3095.7012
480.	.02892411	-861.218148	.8474907	.37859836	.37757723	3090.3120
460.	.02893297	-861.275165	.8476019	.37828230	.37747958	3084.9103
440.	.02894187	-861.332075	.8477135	.37796562	.37738182	3079.4961
420.	.02895081	-861.388876	.8478254	.37764931	.37728395	3074.0692
400.	.02895979	-861.445567	.8479376	.37733038	.37718595	3068.6297
380.	.02896880	-861.502147	.8480502	.37701182	.37708784	3063.1773
360.	.02897784	-861.558615	.8481630	.37669262	.37698961	3057.7119
340.	.02898693	-861.614970	.8482762	.37637279	.37689126	3052.2336
320.	.02899605	-861.671212	.8483897	.37605231	.37679279	3046.7422
300.	.02900521	-861.727338	.8485036	.37573118	.37669420	3041.2375
280.	.02901441	-861.783349	.8486177	.37540940	.37659549	3035.7196
260.	.02902364	-861.839243	.8487322	.37508697	.37649666	3030.1802
240.	.02903292	-861.895019	.8488471	.37476387	.37639770	3024.6434
220.	.02904223	-861.950675	.8489623	.37444011	.37629863	3019.0849
200.	.02905158	-862.006212	.8490778	.37411568	.37619944	3013.5128
180.	.02906098	-862.061627	.8491937	.37379057	.37610012	3007.9268
160.	.02907041	-862.116920	.8493099	.37346479	.37600069	3002.3269
140.	.02907989	-862.172090	.8494265	.37313832	.37590113	2996.7129
120.	.02908940	-862.227134	.8495434	.37281116	.37580145	2991.0848
100.	.02909896	-862.282053	.8496607	.37248331	.37570164	2985.4425
90.	.02910375	-862.309465	.8497195	.37231912	.37565169	2982.6160
80.	.02910856	-862.336845	.8497784	.37215476	.37560171	2979.7853
70.	.02911337	-862.364193	.8498373	.37199022	.37555170	2976.9520
60.	.02911820	-862.391509	.8498964	.37182551	.37550166	2974.1146
50.	.02912303	-862.418793	.8499555	.37166062	.37545159	2971.2736
40.	.02912788	-862.446044	.8500148	.37149555	.37540148	2968.4289

TEMPERATURE= 0 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.02919116	-855.497955	.8591604	.39040494	.38339606	3031.0738
540.	.02920076	-855.553552	.8592745	.39009506	.38330350	3025.5593
520.	.02921040	-855.609027	.8593890	.38978455	.38321083	3020.0312
500.	.02922008	-855.664379	.8595037	.38947340	.38311805	3014.4994
480.	.02922980	-855.719607	.8596189	.38916161	.38302517	3008.9337
460.	.02923956	-855.774709	.8597343	.38884917	.38293219	3003.3641
440.	.02924936	-855.829685	.8598502	.38853608	.38283910	2997.7805
420.	.02925921	-855.884532	.8599664	.38822233	.38274590	2992.1827
400.	.02926910	-855.939251	.8600829	.38790792	.38265260	2986.5707
380.	.02927904	-855.993840	.8601998	.38759285	.38255919	2980.9443
360.	.02928902	-856.048298	.8603171	.38727710	.38246568	2975.3034
340.	.02929904	-856.102622	.8604347	.38696068	.38237205	2969.6479
320.	.02930911	-856.156813	.8605527	.38664358	.38227833	2963.9778
300.	.02931922	-856.210869	.8606711	.38632580	.38218449	2958.2927
280.	.02932939	-856.264788	.8607899	.38600732	.38209055	2952.5927
260.	.02933959	-856.318569	.8609090	.38568816	.38199650	2946.8777
240.	.02934985	-856.372211	.8610286	.38536829	.38190235	2941.1474

220.	.02936015	-856.425712	.8611435	.38504771	.38180808	2935.4018
200.	.02937050	-856.479071	.8612668	.38472643	.38171371	2929.6407
180.	.02938083	-856.532287	.8613695	.38440443	.38161923	2923.8641
160.	.02939134	-856.585358	.8615106	.38408171	.38152464	2918.0717
140.	.02940184	-856.638233	.8616322	.38375827	.38142995	2912.2635
120.	.02941238	-856.691060	.8617541	.38343409	.38133514	2906.4393
100.	.02942298	-856.743687	.8618764	.38310917	.38124023	2900.5989
90.	.02942829	-856.769945	.8619377	.38294644	.38119273	2897.6727
80.	.02943362	-856.796164	.8619991	.38278351	.38114521	2894.7423
70.	.02943897	-856.822346	.8620607	.38262040	.38109766	2891.8079
60.	.02944432	-856.848489	.8621223	.38245711	.38105008	2888.8693
50.	.02944969	-856.874593	.8621840	.38229362	.38100247	2885.9266
40.	.02945507	-856.900659	.8622459	.38212994	.38095484	2882.9797

TEMPERATURE= 10 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.02950495	-849.951376	.8711266	.39949358	.38866593	2945.3800
540.	.02951553	-850.004834	.8712453	.39918723	.38857802	2939.6923
520.	.02952616	-850.058149	.8713644	.39888021	.38849001	2933.9893
500.	.02953683	-850.111319	.8714839	.39857251	.38840191	2928.2710
480.	.02954755	-850.164343	.8716037	.39826414	.38831372	2922.5372
460.	.02955834	-850.217219	.8717240	.39795508	.38822544	2916.7879
440.	.02956916	-850.269946	.8718447	.39764534	.38813708	2911.0227
420.	.02958005	-850.322522	.8719657	.39733491	.38804862	2905.2417
400.	.02959098	-850.374946	.8720872	.39702377	.38796007	2899.4447
380.	.02960197	-850.427216	.8722091	.39671194	.38787143	2893.6316
360.	.02961301	-850.479331	.8723314	.39639939	.38779270	2887.8022
340.	.02962410	-850.531289	.8724541	.39608613	.38769388	2881.9503
320.	.02963525	-850.583088	.8725773	.39577215	.38760497	2876.0939
300.	.02964645	-850.634727	.8727009	.39545745	.38751597	2870.2147
280.	.02965771	-850.686204	.8728249	.39514201	.38742688	2864.3187
260.	.02966902	-850.737517	.8729494	.39482584	.38733770	2858.4057
240.	.02968040	-850.788665	.8730743	.39450893	.38724843	2852.4755
220.	.02969183	-850.839646	.8731996	.39419126	.38715907	2846.5279
200.	.02970332	-850.890457	.8733254	.39387284	.38706962	2840.5629
180.	.02971486	-850.941098	.8734517	.39355367	.38698008	2834.5803
160.	.02972647	-850.991565	.8735784	.39323372	.38689045	2828.5798
140.	.02973814	-851.041859	.8737055	.39291300	.38680073	2822.5613
120.	.02974987	-851.091975	.8738332	.39259150	.38671092	2816.5248
100.	.02976166	-851.141913	.8739613	.39226922	.38662103	2810.4699
90.	.02976758	-851.166814	.8740255	.39210778	.38657605	2807.4355
80.	.02977351	-851.191670	.8740899	.39194614	.38653104	2804.3965
70.	.02977946	-851.216481	.8741543	.39178430	.38648601	2801.3529
60.	.02978543	-851.241245	.8742189	.39162227	.38644097	2798.3044
50.	.02979141	-851.265963	.8742837	.39146003	.38639590	2795.2513

TEMPERATURE= 20 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.02983192	-844.344339	.8829639	.40740490	.39381947	2856.1677
540.	.02984362	-844.395313	.8830878	.40710184	.39373629	2850.2946
520.	.02985537	-844.446118	.8832122	.40679808	.39365303	2844.4044
500.	.02986718	-844.496752	.8833370	.40649360	.39356971	2838.4970
480.	.02987906	-844.547213	.8834622	.40618841	.39348632	2832.5722
460.	.02989099	-844.597498	.8835880	.40588250	.39340285	2826.5299
440.	.02990299	-844.647607	.8837141	.40557586	.39331932	2820.6699
420.	.02991505	-844.697536	.8838408	.40526849	.39323571	2814.6921
400.	.02992718	-844.747285	.8839679	.40496039	.39315204	2808.6962
380.	.02993937	-844.796851	.8840955	.40465153	.39306829	2802.6821
360.	.02995162	-844.846231	.8842235	.40434193	.39298448	2796.6496
340.	.02996394	-844.895424	.8843521	.40403157	.39290060	2790.5986
320.	.02997633	-844.944428	.8844811	.40372044	.39281654	2784.5289
300.	.02998878	-844.993241	.8846107	.40340855	.39273262	2778.4403

Table 3-6b (continued)

280.	.03000131	-845.041860	.8847407	.40309588	.39264854	2772.3326
260.	.03001390	-845.090283	.8848712	.40278242	.39256438	2766.2056
240.	.03002656	-845.136508	.8850023	.40246818	.39248016	2760.0591
220.	.03003923	-845.186532	.8851339	.40215314	.39239587	2753.8930
200.	.03005209	-845.234353	.8852659	.40183730	.39231152	2747.7071
180.	.03006497	-845.281969	.8853986	.40152064	.39222710	2741.5011
160.	.03007792	-845.329377	.8855317	.40120317	.39214262	2735.2748
140.	.03009094	-845.376575	.8856654	.40088488	.39205807	2729.0281
120.	.03010404	-845.423559	.8857996	.40056575	.39197346	2722.7607
100.	.03011722	-845.470329	.8859344	.40024578	.39188879	2716.4725
90.	.03012383	-845.493632	.8860020	.40008548	.39184642	2713.3204
80.	.03013047	-845.516880	.8860697	.39992496	.39180405	2710.1631
70.	.03013713	-845.540073	.8861376	.39976423	.39176166	2707.0004
60.	.03014380	-845.563210	.8862056	.39960329	.39171925	2703.8324

TEMPERATURE= 30 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.03017389	-838.671346	.8946890	.41437095	.39889297	2764.4911
540.	.03018686	-838.719431	.8948189	.41407096	.39881468	2758.4190
520.	.03019991	-838.767314	.8949493	.41377022	.39873634	2752.3277
500.	.03021303	-838.814992	.8950802	.41346873	.39865796	2746.2170
480.	.03022622	-838.862464	.8952116	.41316649	.39857953	2740.0867
460.	.03023949	-838.909727	.8953435	.41286349	.39850105	2733.9366
440.	.03025283	-838.956778	.8954760	.41255971	.39842253	2727.7666
420.	.03026625	-839.003615	.8956090	.41225516	.39834397	2721.5764
400.	.03027975	-839.050235	.8957426	.41194983	.39826536	2715.3658
380.	.03029333	-839.096635	.8958767	.41164371	.39818671	2709.1347
360.	.03030699	-839.142813	.8960114	.41133679	.39810802	2702.8827
340.	.03032073	-839.188766	.8961466	.41102906	.39802929	2696.6098
320.	.03033455	-839.234492	.8962824	.41072053	.39795052	2690.3156
300.	.03034845	-839.279987	.8964188	.41041118	.39787171	2684.0000
280.	.03036244	-839.325248	.8965557	.41010100	.39779287	2677.6627
260.	.03037651	-839.370272	.8966933	.40978998	.39771398	2671.3034
240.	.03039067	-839.415057	.8968314	.40947813	.39763506	2664.9220
220.	.03040492	-839.459599	.8969702	.40916542	.39755611	2658.5182
200.	.03041926	-839.503895	.8971095	.40885186	.39747712	2652.0918
180.	.03043368	-839.547942	.8972495	.40853743	.39739810	2645.6425
160.	.03044820	-839.591737	.8973901	.40822213	.39731904	2639.1701
140.	.03046281	-839.635275	.8975313	.40790595	.39723996	2632.6742
120.	.03047751	-839.678555	.8976732	.40758887	.39716085	2626.1547
100.	.03049231	-839.721572	.8978157	.40727089	.39708171	2619.6112
90.	.03049974	-839.742980	.8978872	.40711156	.39704213	2616.3304
80.	.03050720	-839.764322	.8979589	.40695201	.39700254	2613.0435
70.	.03051468	-839.785596	.8980307	.40679222	.39696295	2609.7505

TEMPERATURE= 40 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.03053298	-832.926257	.9063191	.42058276	.40391707	2671.1126
540.	.03054743	-832.970967	.9064558	.42028562	.40384390	2664.8259
520.	.03056197	-833.015435	.9065931	.41998769	.40377072	2658.5175
500.	.03057660	-833.059657	.9067309	.41968897	.40369752	2652.1872
480.	.03059132	-833.103631	.9068694	.41938945	.40362432	2645.8349
460.	.03060613	-833.147352	.9070085	.41908913	.40355109	2639.4601
440.	.03062104	-833.190818	.9071482	.41878798	.40347786	2633.0627
420.	.03063604	-833.234026	.9072886	.41848602	.40340462	2626.6425
400.	.03065114	-833.276971	.9074296	.41818322	.40333137	2620.1991
380.	.03066633	-833.319650	.9075712	.41787958	.40325812	2613.7324
360.	.03068163	-833.362060	.9077135	.41757510	.40318485	2607.2420
340.	.03069702	-833.404197	.9078564	.41726976	.40311159	2600.7277
320.	.03071252	-833.446057	.9080000	.41696356	.40303833	2594.1893
300.	.03072812	-833.487637	.9081443	.41665648	.40296506	2587.6263
280.	.03074382	-833.528932	.9082893	.41634853	.40289180	2581.0386

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
260.	.03075963	-833.569938	.9084345	.41603968	.40281854	2574.4259
240.	.03077555	-833.610652	.9085813	.41572994	.40274529	2567.7878
220.	.03079158	-833.651068	.9087284	.41541928	.40267205	2561.1240
200.	.03080772	-833.691184	.9089762	.41510771	.40259881	2554.4343
180.	.03082397	-833.730994	.9090247	.41479521	.40252559	2547.7183
160.	.03084034	-833.770493	.9091739	.41448178	.40245238	2540.9758
140.	.03085682	-833.809679	.9093240	.41416739	.40237919	2534.2063
120.	.03087342	-833.848544	.9094743	.41385205	.40230601	2527.4035
100.	.03089014	-833.887086	.9096263	.41353574	.40223286	2520.5851
90.	.03089955	-833.906233	.9097024	.41337722	.40219629	2517.1624
80.	.03090698	-833.925298	.9097786	.41321846	.40215973	2513.7327

TEMPERATURE= 50 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.03091170	-827.102156	.9178718	.42619794	.40891786	2576.5779
540.	.03092787	-827.142907	.9180163	.42590346	.40885015	2570.0568
520.	.03094416	-827.183365	.9181615	.42560814	.40878246	2563.5152
500.	.03096055	-827.223524	.9183074	.42531199	.40871481	2556.9468
480.	.03097706	-827.263382	.9184541	.42501499	.40864718	2550.3532
460.	.03099368	-827.302932	.9186014	.42471713	.40857958	2543.7342
440.	.03101041	-827.342172	.9187495	.42441840	.40851202	2537.0895
420.	.03102727	-827.381096	.9188983	.42411880	.40844450	2530.4187
400.	.03104425	-827.419599	.9190479	.42381832	.40837702	2523.7216
380.	.03106135	-827.457979	.9191983	.42351694	.40830957	2516.9977
360.	.03107857	-827.495926	.9193494	.42321467	.40824218	2510.2469
340.	.03109592	-827.533540	.9195013	.42291148	.40817483	2503.4687
320.	.03111339	-827.570813	.9196539	.42260737	.40810753	2496.6628
300.	.03113100	-827.607741	.9198074	.42230232	.40804028	2489.9288
280.	.03114874	-827.644318	.9199617	.42199634	.40797310	2482.9664
260.	.03116661	-827.680540	.9201169	.42168940	.40790597	2476.0752
240.	.03118462	-827.716399	.9202729	.42138151	.40783890	2469.1548
220.	.03120277	-827.751890	.9204297	.42107263	.40777190	2462.2048
200.	.03122105	-827.787009	.9205874	.42076278	.40770497	2455.2249
180.	.03123943	-827.821747	.9207459	.42045192	.40763811	2448.2147
160.	.03125806	-827.856100	.9209054	.42014007	.40757132	2441.1736
140.	.03127679	-827.890060	.9210658	.41982719	.40750462	2434.1014
120.	.03129566	-827.923621	.9212270	.41951328	.40743800	2426.9975
100.	.03131469	-827.956777	.9213893	.41919833	.40737147	2419.8615
90.	.03132427	-827.973201	.9214707	.41904045	.40733824	2416.2813

TEMPERATURE= 60 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.03131305	-821.191176	.9293656	.43134687	.41391787	2481.2711
540.	.03133125	-821.227255	.9295192	.43105488	.41385608	2474.4991
520.	.03134959	-821.262973	.9296736	.43076201	.41379436	2467.6993
500.	.03136807	-821.298326	.9298289	.43046826	.41373273	2460.9711
480.	.03138668	-821.333308	.9299850	.43017360	.41367119	2454.0142
460.	.03140545	-821.367912	.9301419	.42987803	.41360973	2447.1233
440.	.03142436	-821.402133	.9302998	.42958154	.41354838	2440.2130
420.	.03144342	-821.435965	.9304585	.42928413	.41348712	2433.2678
400.	.03146263	-821.469400	.9306181	.42898577	.41342597	2426.2924
380.	.03148199	-821.502433	.9307786	.42868646	.41336492	2419.2863
360.	.03150151	-821.535057	.9309401	.42838619	.41330399	2412.2492
340.	.03152120	-821.567265	.9311024	.42808495	.41324318	2405.1805
320.	.03154104	-821.599049	.9312658	.42778272	.41318248	2398.0799
300.	.03156105	-821.630403	.9314301	.42747950	.41312191	2390.9409
280.	.03158123	-821.661319	.9315954	.42717527	.41306148	2383.7811
260.	.03160158	-821.691789	.9317617	.42687002	.41300118	2376.5818
240.	.03162211	-821.721805	.9319290	.42656374	.41294102	2369.3488
220.	.03164281	-821.751360	.9320974	.42625641	.41288100	2362.0814
200.	.03166370	-821.780444	.9322668	.42594802	.41282114	2354.7792
180.	.03168477	-821.809050	.9324372	.42563857	.41276144	2347.4417

Table 3-6b (continued)

PRESSURE	VOLUME	ENTHALAPY	ENTROPY	CP	CV	SONIC VELOCITY
160.	.03170603	-821.837168	.9326088	.42532802	.41270190	2340.0682
140.	.03172748	-821.864790	.9327815	.42501638	.41264253	2332.6582
120.	.03174913	-821.891905	.9329553	.42470363	.41258335	2325.2112

TEMPERATURE= 70 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.03174069	-815.184246	.9408204	.43613780	.41893705	2385.4536
540.	.03176131	-815.214765	.9409846	.43584819	.41888179	2378.4053
520.	.03178209	-815.244839	.9411497	.43555766	.41882669	2371.3248
500.	.03180306	-815.274458	.9413159	.43526618	.41877175	2364.2119
480.	.03182421	-815.303616	.9414831	.43497375	.41871698	2357.0600
460.	.03184554	-815.332304	.9416513	.43458035	.41866238	2349.8867
440.	.03186705	-815.360513	.9418206	.43438597	.41860796	2342.6735
420.	.03188876	-815.388235	.9419909	.43409061	.41855373	2335.4259
400.	.03191066	-815.415460	.9421624	.43379425	.41849968	2328.1434
380.	.03193277	-815.442180	.9423349	.43349687	.41844584	2320.8254
360.	.03195507	-815.468386	.9425086	.43319847	.41839220	2313.4715
340.	.03197758	-815.494066	.9426834	.43289902	.41833877	2306.0810
320.	.03200030	-815.519212	.9428594	.43259853	.41828557	2298.6534
300.	.03202324	-815.543813	.9430366	.43229697	.41823259	2291.1880
280.	.03204639	-815.567857	.9432149	.43199433	.41817985	2283.6944
260.	.03206977	-815.591335	.9433945	.43169060	.41812735	2276.1418
240.	.03209338	-815.614235	.9435754	.43138576	.41807511	2268.5597
220.	.03211722	-815.636545	.9437576	.43107980	.41802312	2260.9374
200.	.03214130	-815.658252	.9439410	.43077270	.41797141	2253.2741
180.	.03216562	-815.679346	.9441258	.43046444	.41791998	2245.5692
160.	.03219019	-815.699811	.9443119	.43015502	.41786884	2237.8220
140.	.03221502	-815.719636	.9444994	.42984441	.41781800	2230.0318

TEMPERATURE= 80 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.03219913	-809.070722	.9522577	.44066111	.42399366	2289.2952
540.	.03222266	-809.094566	.9524344	.44037386	.42394580	2281.9425
520.	.03224641	-809.117849	.9526122	.44008562	.42389319	2274.5529
500.	.03227039	-809.140561	.9527913	.43979639	.42385086	2267.1258
480.	.03229461	-809.162690	.9529716	.43950615	.42380380	2259.6507
460.	.03231906	-809.184224	.9531532	.43921488	.42375702	2252.1569
440.	.03234376	-809.205151	.9533361	.43892258	.42371054	2244.6137
420.	.03236870	-809.225459	.9535203	.43862922	.42366437	2237.0306
400.	.03239390	-809.245135	.9537058	.43833481	.42361851	2229.4069
380.	.03241936	-809.264165	.9538927	.43803932	.42357298	2221.7418
360.	.03244509	-809.282536	.9540810	.43774273	.42352779	2214.0347
340.	.03247109	-809.300235	.9542708	.43744504	.42348294	2206.2848
320.	.03249736	-809.317245	.9544620	.43714623	.42343846	2198.4914
300.	.03252392	-809.333552	.9546546	.43684628	.42339434	2190.6536
280.	.03255077	-809.349140	.9548488	.43654517	.42335062	2182.7708
260.	.03257791	-809.363993	.9550445	.43624289	.42330729	2174.3421
240.	.03260536	-809.378094	.9552419	.43593943	.42326438	2166.9665
220.	.03263312	-809.391425	.9554408	.43563476	.42322190	2158.8434
200.	.03266121	-809.403969	.9556413	.43532887	.42317986	2150.7716
180.	.03268962	-809.415707	.9558436	.43502173	.42313829	2142.6503
160.	.03271836	-809.426618	.9560476	.43471334	.42309718	2134.4786

TEMPERATURE= 90 DEG F

PRESSURE	VOLUME	ENTHALAPY	ENTROPY	CP	CV	SONIC VELOCITY
PSIA	FT3/LBM	BTU/LBM	BTU/LBM/DEG F	BTU/LBM/DEG F	BTU/LBM/DEG F	FT/SEC

Table 3-6b (continued)

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.03269405	-802.837379	.9637018	.44499300	.42910534	2192.3335
540.	.03272115	-802.853612	.9638934	.44470819	.42906604	2185.2043
520.	.03274855	-802.868628	.9640864	.44442234	.42902714	2177.4723
500.	.03277625	-802.882912	.9642809	.44413545	.42898866	2169.6966
480.	.03280425	-802.896447	.9644770	.44384749	.42895061	2161.9766
460.	.03283257	-802.909216	.9646747	.44355846	.42891300	2154.0113
440.	.03286121	-802.921201	.9648740	.44326833	.42887586	2146.1001
420.	.03289019	-802.932384	.9650749	.44297709	.42883919	2138.1420
400.	.03291950	-802.942747	.9652775	.44268473	.42880301	2130.1361
380.	.03294916	-802.952268	.9654819	.44239123	.42876735	2122.0816
360.	.03297917	-802.960928	.9656880	.44209658	.42873221	2113.9774
340.	.03300955	-802.968706	.9658959	.44180075	.42869763	2105.8226
320.	.03304030	-802.975579	.9661057	.44150373	.42866360	2097.6163
300.	.03307144	-802.981525	.9663174	.44120549	.42863017	2089.3572
280.	.03310298	-802.986519	.9665310	.44090604	.42859735	2081.0445
260.	.03313492	-802.990536	.9667466	.44060533	.42856515	2072.6768
240.	.03316728	-802.993551	.9669642	.44030336	.42853362	2064.2532
220.	.03320006	-802.995536	.9671840	.44000010	.42850276	2055.7723
200.	.03323329	-802.996463	.9674059	.43969554	.42847261	2047.2329
180.	.03326697	-802.996302	.9676299	.43938964	.42844319	2038.6337

TEMPERATURE= 100 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.03323275	-796.470138	.9751809	.44919868	.43429023	2096.2946
540.	.03326432	-796.475872	.9753904	.44891660	.43426110	2088.2308
520.	.03329628	-796.480671	.9756019	.44863345	.43423258	2080.1168
500.	.03332865	-796.484513	.9758152	.44834920	.43420470	2071.9515
480.	.03336143	-796.487372	.9760305	.44806385	.43417747	2063.7341
460.	.03339464	-796.489223	.9762479	.44777737	.43415092	2055.4633
440.	.03342828	-796.490039	.9764673	.44748975	.43412507	2047.1381
420.	.03346237	-796.489792	.9766888	.44720098	.43409996	2038.7572
400.	.03349693	-796.488452	.9769125	.44691103	.43407559	2030.3157
380.	.03353196	-796.485990	.9771384	.44661999	.43405202	2021.8241
360.	.03356748	-796.482374	.9773667	.44632754	.43402926	2013.2692
340.	.03360351	-796.477569	.9775973	.44603396	.43400734	2004.6536
320.	.03364006	-796.471543	.9778303	.44573914	.43398631	1995.9760
300.	.03367715	-796.464257	.9780658	.44544304	.43396618	1987.2349
280.	.03371480	-796.455675	.9783038	.44514566	.43394701	1978.4288
260.	.03375301	-796.445755	.9785445	.44484697	.43392883	1969.5562
240.	.03379182	-796.434457	.9787830	.44454694	.43391168	1960.6153
220.	.03383124	-796.421735	.9790342	.44424557	.43389560	1951.6044
200.	.03387129	-796.407544	.9792833	.44394281	.43388064	1942.5219

TEMPERATURE= 110 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.03382487	-789.947914	.9867286	.45333558	.43956842	1999.5056
540.	.03386215	-789.941098	.9869603	.45305685	.43955175	1991.0213
520.	.03389996	-789.933033	.9871945	.45277701	.43953599	1982.4737
500.	.03393833	-789.923685	.9874312	.45249607	.43952119	1973.8747
480.	.03397727	-789.913013	.9876705	.45221400	.43950738	1965.2085
460.	.03401681	-789.900978	.9879124	.45193079	.43949459	1956.4765
440.	.03405696	-789.887537	.9881570	.45164641	.43948288	1947.6834
420.	.03409774	-789.872646	.9884044	.45136086	.43947229	1938.9214
400.	.03413918	-789.856257	.9886548	.45107411	.43946285	1929.8910
380.	.03418129	-789.838323	.9889081	.45078616	.43945462	1920.8903
360.	.03422411	-789.818790	.9891645	.45049697	.43944766	1911.8177
340.	.03426765	-789.797605	.9894240	.45020653	.43944201	1902.6711
320.	.03431194	-789.774709	.9896869	.44991482	.43943773	1893.4486
300.	.03435702	-789.750042	.9899531	.44962183	.43943489	1884.1431
280.	.03440290	-789.723540	.9902229	.44932753	.43943355	1874.7675
260.	.03444963	-789.695133	.9904963	.44903190	.43943378	1865.3044
240.	.03449723	-789.664751	.9907735	.44873492	.43943565	1855.7564

220.	.03454575	-789.632316	.9910546	.44843656	.43943924	1846.1209

TEMPERATURE= 120 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.03448349	-783.245791	.9983870	.45745556	.44496407	1902.5030
540.	.03452825	-783.222860	.9986467	.45718232	.44496315	1893.5499
520.	.03457378	-783.198212	.9989098	.45690702	.44496362	1884.5205
500.	.03462010	-783.171787	.9991761	.45663064	.44496554	1875.4177
480.	.03466725	-783.143521	.9994460	.45635317	.44496897	1866.2398
460.	.03471526	-783.113348	.9997194	.45607459	.44497399	1856.9845
440.	.03476415	-783.081196	.9999966	.45579490	.44498066	1847.6499
420.	.03481398	-783.046991	1.0002776	.45551407	.44498906	1838.2335
400.	.03486476	-783.010654	1.0005626	.45523211	.44499927	1828.7330
380.	.03491655	-782.972100	1.0008518	.45494898	.44501138	1819.1459
360.	.03496939	-782.931238	1.0011452	.45466469	.44502549	1809.4695
340.	.03502333	-782.887974	1.0014432	.45437922	.44504169	1799.7010
320.	.03507840	-782.842203	1.0017458	.45409256	.44506009	1789.8375
300.	.03513468	-782.793818	1.0020533	.45380469	.44508081	1779.8758
280.	.03519220	-782.742701	1.0023658	.45351561	.44510397	1769.8126
260.	.03525104	-782.688726	1.0026837	.45322530	.44512970	1759.6443

TEMPERATURE= 130 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.03522705	-776.329508	1.0102111	.46161397	.45050857	1805.2696
540.	.03528199	-776.285277	1.0105073	.46134635	.45052836	1795.7705
520.	.03533805	-776.238587	1.0108080	.46107780	.45055029	1786.1243
500.	.03539530	-776.189337	1.0111133	.46080832	.45057449	1776.5033
480.	.03545380	-776.137414	1.0114236	.46053792	.45060106	1766.7397
460.	.03551361	-776.082702	1.0117390	.46026659	.45063012	1756.8754
440.	.03557477	-776.025074	1.0120597	.45999434	.45066182	1746.9123
420.	.03563737	-775.964393	1.0123859	.45972116	.45069630	1736.8468
400.	.03570147	-775.900513	1.0127180	.45944707	.45073371	1726.6756
380.	.03576715	-775.833277	1.0130561	.45917208	.45077422	1716.3945
360.	.03583450	-775.762514	1.0134007	.45889619	.45081802	1705.9996
340.	.03590361	-775.688040	1.0137520	.45861941	.45086530	1695.4865
320.	.03597458	-775.609654	1.0141103	.45834177	.45091629	1684.8503
300.	.03604752	-775.527139	1.0144761	.45806327	.45097122	1674.0861
280.	.03612255	-775.440256	1.0148498	.45778396	.45103036	1663.1883

TEMPERATURE= 140 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.03608276	-769.150676	1.0222770	.46586546	.45624589	1707.7567
540.	.03615214	-769.077182	1.0226223	.46560835	.45629419	1697.6332
520.	.03622330	-768.999984	1.0229743	.46535071	.45634594	1687.4012
500.	.03629635	-768.918890	1.0233331	.46509258	.45640136	1677.0564
480.	.03637139	-768.833688	1.0236993	.46483399	.45646066	1666.5946
460.	.03644854	-768.744151	1.0240732	.46457498	.45652411	1656.0110
440.	.03652793	-768.650028	1.0244552	.46431561	.45659196	1645.3006
420.	.03660971	-768.551046	1.0248457	.46405593	.45666452	1634.4580
400.	.03669403	-768.446905	1.0252454	.46379602	.45674212	1623.4771
380.	.03678105	-768.337276	1.0256548	.46353595	.45682512	1612.3518
360.	.03687098	-768.221791	1.0260745	.46327582	.45691393	1601.0748
340.	.03696402	-768.100047	1.0265052	.46301572	.45700900	1589.6387
320.	.03706042	-767.971592	1.0269476	.46275579	.45711083	1578.0350

TEMPERATURE= 150 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.03709333	-761.636739	1.0346968	.47028389	.46224258	1609.9459
540.	.03718450	-761.520862	1.0351121	.47004486	.46233253	1599.0895
520.	.03727870	-761.398991	1.0355378	.46980631	.46242838	1588.0934
500.	.03737616	-761.270720	1.0359746	.46956838	.46253057	1576.9508
480.	.03747712	-761.135596	1.0364233	.46933124	.46263958	1565.6546
460.	.03758184	-760.993113	1.0368846	.46909507	.46275600	1554.1966
440.	.03769065	-760.842707	1.0373595	.46886010	.46288043	1542.5680
420.	.03780390	-760.683736	1.0378492	.46862658	.46301360	1530.7591
400.	.03792197	-760.515477	1.0383548	.46839481	.46315632	1518.7590
380.	.03804533	-760.337103	1.0388777	.46816513	.46330952	1506.5555
360.	.03817450	-760.147664	1.0394196	.46793796	.46347427	1494.1347
340.	.03831010	-759.946059	1.0399821	.46771380	.46365182	1481.4810

TEMPERATURE= 160 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.03833155	-753.669797	1.0476507	.47497774	.46860857	1511.8252
540.	.03845857	-753.487643	1.0481737	.47477259	.46876450	1500.0833
520.	.03859138	-753.294696	1.0487149	.47457066	.46893146	1488.1520
500.	.03873057	-753.089943	1.0492760	.47437248	.46911060	1476.0188
480.	.03887681	-752.872211	1.0498589	.47417866	.46930320	1463.6698
460.	.03903090	-752.640132	1.0504658	.47398995	.46951081	1451.0888
440.	.03919376	-752.392096	1.0510993	.47380726	.46973521	1438.2573
420.	.03936652	-752.126164	1.0517627	.47363169	.46997857	1425.1536
400.	.03955055	-751.840087	1.0524598	.47346459	.47024349	1411.7521
380.	.03974751	-751.530983	1.0531951	.47330766	.47053317	1398.0222

TEMPERATURE= 170 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.03993759	-745.034689	1.0614659	.48014090	.47554737	1413.3325
540.	.04013210	-744.735561	1.0621759	.48000777	.47582118	1400.4508
520.	.04034004	-744.413262	1.0629239	.47988649	.47611930	1387.2836
500.	.04056348	-744.064432	1.0637153	.47977937	.47644545	1373.8008
480.	.04080503	-743.684873	1.0645558	.47968933	.47680424	1359.9659
460.	.04106806	-743.269227	1.0654571	.47962020	.47720160	1345.7326
440.	.04135699	-742.810496	1.0664274	.47957707	.47764528	1331.0416
420.	.04167786	-742.293254	1.0674828	.47956695	.47814571	1315.8142

TEMPERATURE= 180 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.04224060	-735.257894	1.0768603	.48521024	.48350762	1313.9093
540.	.04259739	-734.701401	1.0779751	.48626771	.48404137	1299.2569
520.	.04299952	-734.074483	1.0792022	.48637604	.48464879	1284.0223
500.	.04346073	-733.357100	1.0805731	.48655205	.48535100	1268.0648
480.	.04400269	-732.518442	1.0821364	.48682201	.48618035	1251.1666
460.	.04466175	-731.506963	1.0839732	.48723069	.48719060	1232.9592

TEMPERATURE= 190 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.04639675	-722.622616	1.0961326	.49464274	.49387322	1208.5299
540.	.04747335	-721.278544	1.0987752	.49556986	.49535266	1187.9847
520.	.04904743	-719.094464	1.1024099	.49707768	.49742678	1162.7700

TEMPERATURE= 200 DEG F

PRESSURE PSIA	VOLUME FT3/LBM	ENTHALAPY BTU/LBM	ENTROPY BTU/LBM/DEG F	CP BTU/LBM/DEG F	CV BTU/LBM/DEG F	SONIC VELOCITY FT/SEC
560.	.14180587	-653.384450	1.2020357	.53462232	.49752069	548.1292
540.	.15987708	-648.130360	1.2108435	.53665348	.49251524	544.1123

Table 3-7
Saturation Temperature Table for Propane as Given by Stearns and George.

THERMODYNAMIC PROPERTIES OF PROPANE AS GIVEN BY STEARNS & GEORGE

P	T	VF	VG	HF	HG	SF	SG
PSIA	DEG F	FT3/LBM		BTU/LBM		BTU/LBM/DEG F	
14.70	-43.71	.02752	6.660	181.36	364.76	.9266	1.3682
15.28	-42.00	.02757	6.420	181.90	365.20	.9289	1.3676
16.[illegible]0	-40.00	.02763	6.160	183.00	365.70	.9315	1.3670
16.79	-38.00	.02769	5.920	184.00	366.30	.9340	1.3664
17.56	-36.00	.02775	5.660	185.10	366.90	.9365	1.3658
18.40	-34.00	.02782	5.440	186.20	367.50	.9391	1.3652
19.30	-32.00	.02788	5.220	187.30	368.00	.9416	1.3646
20.18	-30.00	.02794	5.020	188.40	368.60	.9441	1.3640
21.[illegible]5	-28.00	.02800	4.820	189.40	369.20	.9467	1.3634
22.[illegible]1	-26.00	.02807	4.630	190.50	369.80	.9492	1.3628
22.98	-24.00	.02813	4.440	191.60	370.30	.9517	1.3622
23.98	-22.00	.02820	4.250	192.70	370.90	.9543	1.3616
25.10	-20.00	.02826	4.060	193.80	371.50	.9568	1.3610
26.15	-18.00	.02833	3.900	194.90	372.10	.9592	1.3604
27.30	-16.00	.02839	3.760	196.00	372.70	.9617	1.3599
28.50	-14.00	.02846	3.610	197.10	373.20	.9641	1.3593
29.70	-12.00	.02852	3.470	198.20	373.80	.9666	1.3588
30.95	-10.00	.02859	3.330	199.40	374.40	.9690	1.3582
32.23	-8.00	.02866	3.200	200.50	375.00	.9714	1.3577
33.55	-6.00	.02873	3.080	201.60	375.50	.9739	1.3571
35.[illegible]0	-4.00	.02879	2.980	202.70	376.10	.9763	1.3566
36.40	-2.00	.02886	2.860	203.80	376.70	.9788	1.3560
37.81	.00	.02893	2.740	205.00	377.20	.9812	1.3555
39.30	2.00	.02900	2.660	206.10	377.80	.9836	1.3550
40.85	4.00	.02908	2.560	207.20	378.30	.9860	1.3545
42.50	6.00	.02915	2.470	208.40	378.90	.9884	1.3541
44.13	8.00	.02923	2.380	209.60	379.50	.9908	1.3536
45.85	10.00	.02930	2.300	210.70	380.00	.9932	1.3531
47.55	12.00	.02938	2.220	211.90	380.60	.9956	1.3527
49.35	14.00	.02946	2.140	213.10	381.10	.9979	1.3523
51.20	16.00	.02954	2.080	214.20	381.60	1.0003	1.3518
53.10	18.00	.02962	2.000	215.40	382.10	1.0026	1.3514
55.[illegible]	20.00	.02970	1.930	216.60	382.60	1.0050	1.3510
57.[illegible]5	22.00	.02978	1.860	217.70	383.10	1.0073	1.3506
59.10	24.00	.02986	1.790	218.80	383.60	1.0097	1.3502
61.25	26.00	.02995	1.730	220.00	384.10	1.0120	1.3499
63.45	28.00	.03003	1.670	221.20	384.60	1.0144	1.3495
65.70	30.00	.03011	1.600	222.30	385.10	1.0167	1.3491
67.95	32.00	.03020	1.540	223.40	385.60	1.0190	1.3487
70.33	34.00	.03029	1.480	224.50	386.10	1.0213	1.3484
72.75	36.00	.03037	1.430	225.60	386.60	1.0237	1.3480
75.20	38.00	.03046	1.390	226.80	387.10	1.0260	1.3477
77.80	40.00	.03055	1.330	227.90	387.50	1.0283	1.3473
80.40	42.00	.03064	1.280	229.10	388.00	1.0306	1.3470
83.[illegible]5	44.00	.03073	1.250	230.20	388.50	1.0329	1.3466
85.83	46.00	.03083	1.210	231.40	389.00	1.0352	1.3463
88.65	48.00	.03092	1.170	232.60	389.50	1.0375	1.3459
91.50	50.00	.03101	1.140	233.80	389.90	1.0398	1.3456
94.50	52.00	.03111	1.100	234.90	390.40	1.0421	1.3453
97.50	54.00	.03121	1.070	236.10	390.80	1.0443	1.3450
100.60	56.00	.03130	1.040	237.30	391.30	1.0466	1.3447
103.70	58.00	.03140	1.010	238.50	391.70	1.0488	1.3444
106.90	60.00	.03150	.984	239.60	392.20	1.0511	1.3441
110.20	62.00	.03162	.958	240.80	392.70	1.0534	1.3438
113.60	64.00	.03174	.932	242.00	393.10	1.0556	1.3435
117.10	66.00	.03185	.906	243.20	393.50	1.0579	1.3433
120.60	68.00	.03197	.880	244.40	394.00	1.0601	1.3430
124.30	70.00	.03209	.854	245.70	394.40	1.0624	1.3427
127.90	72.00	.03221	.832	246.90	394.80	1.0647	1.3424

131.70	74.00	.03233	.810	249.10	395.20	1.0669	1.3421
135.60	76.00	.03245	.788	249.40	395.60	1.0692	1.3419
139.60	78.00	.03257	.766	250.20	396.00	1.0714	1.3416
143.60	80.00	.03269	.745	251.90	396.40	1.0737	1.3413
147.70	82.00	.03281	.725	253.10	396.80	1.0760	1.3410
151.80	84.00	.03293	.704	254.40	397.20	1.0782	1.3408
156.20	86.00	.03305	.684	255.60	397.60	1.0805	1.3405
160.60	88.00	.03317	.663	256.90	398.00	1.0827	1.3403
165.00	90.00	.03329	.643	258.20	398.30	1.0850	1.3400
169.60	92.00	.03341	.626	259.50	398.70	1.0873	1.3398
174.20	94.00	.03353	.609	260.80	399.10	1.0895	1.3395
178.90	96.00	.03366	.592	262.10	399.60	1.0918	1.3393
183.70	98.00	.03378	.575	263.30	399.90	1.0940	1.3390
188.70	100.00	.03390	.558	264.60	400.20	1.0963	1.3388
193.80	102.00	.03402	.544	265.90	400.50	1.0986	1.3386
198.90	104.00	.03415	.530	267.20	400.90	1.1010	1.3384
204.10	106.00	.03427	.516	268.50	401.20	1.1033	1.3382
207.30	108.00	.03439	.502	269.80	401.60	1.1057	1.3380
214.80	110.00	.03452	.487	271.10	401.90	1.1080	1.3378
222.40	112.00	.03468	.475	272.50	402.30	1.1103	1.3376
226.70	114.00	.03484	.463	273.90	402.70	1.1126	1.3374
231.60	116.00	.03500	.451	275.20	403.00	1.1149	1.3372
237.30	118.00	.03516	.439	276.60	403.40	1.1172	1.3370
243.40	120.00	.03532	.426	278.00	403.80	1.1195	1.3368
249.70	122.00	.03548	.415	279.40	404.10	1.1218	1.3366
255.70	124.00	.03564	.404	280.90	404.50	1.1241	1.3363
261.70	126.00	.03580	.393	282.30	404.80	1.1264	1.3361
267.90	128.00	.03596	.382	283.80	405.20	1.1287	1.3358
274.50	130.00	.03612	.370	285.20	405.40	1.1310	1.3356
281.10	132.00	.03630	.360	286.70	405.70	1.1334	1.3353
287.90	134.00	.03648	.350	288.20	406.10	1.1358	1.3350
294.70	136.00	.03666	.340	289.70	406.40	1.1382	1.3348
301.40	138.00	.03684	.330	291.20	406.70	1.1406	1.3345
308.40	140.00	.03702	.320	292.70	407.00	1.1430	1.3342
315.50	142.00	.03725	.312	294.20	407.30	1.1454	1.3339
322.80	144.00	.03748	.303	295.70	407.60	1.1479	1.3336
330.20	146.00	.03771	.295	297.20	407.80	1.1503	1.3332
337.60	148.00	.03794	.286	298.60	408.00	1.1528	1.3329
345.40	150.00	.03817	.278	300.20	408.20	1.1552	1.3326
352.90	152.00	.03846	.270	301.80	408.40	1.1578	1.3321
360.30	154.00	.03875	.263	303.40	408.60	1.1603	1.3317
368.60	156.00	.03904	.255	305.10	408.70	1.1629	1.3312
376.60	158.00	.03933	.248	306.80	408.80	1.1654	1.3308
385.10	160.00	.03962	.240	308.40	408.80	1.1680	1.3303
392.90	162.00	.03996	.234	310.20	408.80	1.1707	1.3297
401.00	164.00	.04030	.227	312.00	408.90	1.1734	1.3291
409.30	166.00	.04064	.221	313.90	408.90	1.1762	1.3284
417.80	168.00	.04098	.214	315.70	408.80	1.1789	1.3278
426.70	170.00	.04132	.208	317.50	408.60	1.1816	1.3272
436.40	172.00	.04179	.202	319.50	408.60	1.1847	1.3262
445.90	174.00	.04226	.197	321.50	408.60	1.1878	1.3252
455.20	176.00	.04273	.191	323.50	408.40	1.1908	1.3243
464.10	178.00	.04320	.186	325.50	408.20	1.1939	1.3233
473.20	180.00	.04367	.180	327.50	407.60	1.1970	1.3223
483.00	182.00	.04436	.174	329.80	407.40	1.2004	1.3210
492.90	184.00	.04505	.168	332.20	407.10	1.2038	1.3196
503.10	186.00	.04574	.161	334.50	406.60	1.2072	1.3183
512.80	188.00	.04643	.155	336.90	405.90	1.2106	1.3169
523.40	190.00	.04712	.149	339.20	404.60	1.2140	1.3156
575.00	200.00	.05210	.113	353.50	398.30	1.2360	1.3040

Table 3-8
Saturation Temperature Table for the Pseudo-Fluid; 65% by Mole Propane, 25% Propylene, and 10% N-Butane

THERMODYNAMIC PROPERTIES OF PROPANE-PROPYLENE-N-BUTANE MIXTURE,(65-25-10), AS GIVEN BY STARLINGS EQUATION OF STATE

P	T	VF	VG	HF	HG	SF	SG
PSIA	DEG F	FT3/LBM	FT3/LBM	BTU/LBM	BTU/LBM	BTU/LBM/DEG F	BTU/LBM/DEG F
14.93	-50.	.0275966239	6.2484217286	-482.083885193	-304.993247986	.79951701313	1.23148171604
15.70	-48.	.0276602299	5.9578067660	-480.983879089	-304.489253998	.80222719163	1.23061810434
16.50	-46.	.0277242146	5.6878599524	-479.882522583	-303.983795166	.80492661148	1.22980894148
17.32	-44.	.0277885848	5.4327580929	-478.779750824	-303.479232788	.80761541426	1.22901740670
18.18	-42.	.0278533513	5.1915348172	-477.675521851	-302.975620270	.81029377878	1.22824302316
19.07	-40.	.0279185246	4.9633057117	-476.569801331	-302.472995758	.81296189129	1.22748537362
20.00	-38.	.0279841162	4.7472503781	-475.462543488	-301.971401215	.81561994553	1.22674408555
20.96	-36.	.0280501375	4.5426073074	-474.353706360	-301.470874786	.81826812029	1.22601875663
21.95	-34.	.0281166001	4.3486689925	-473.243247986	-300.971466064	.82090660185	1.22530899942
22.98	-32.	.0281835163	4.1647779346	-472.131126404	-300.473209381	.82353559136	1.22461447120
24.05	-30.	.0282508985	3.9903225005	-471.017292023	-299.976180513	.82615525275	1.22393481433
25.15	-28.	.0283187591	3.8247334361	-469.901702881	-299.480335236	.82876578718	1.22326964140
26.29	-26.	.0283871114	3.6674805284	-468.784309387	-298.985801697	.83136736602	1.22261860967
27.47	-24.	.0284559689	3.5180697441	-467.665065765	-298.492599487	.83396018296	1.22198140621
28.70	-22.	.0285253455	3.3760403991	-466.543926239	-298.000770569	.83654441684	1.22135765851
29.96	-20.	.0285952552	3.2409626544	-465.420837402	-297.510356903	.83912025392	1.22074705362
31.26	-18.	.0286657128	3.1124351621	-464.295749664	-297.021404266	.84168786556	1.22014927864
32.61	-16.	.0287367336	2.9900830686	-463.168609619	-296.533962250	.84424745291	1.21956397593
34.00	-14.	.0288083327	2.8735559583	-462.039371490	-296.048076630	.84679917991	1.21899084747
35.44	-12.	.0288805265	2.7625261843	-460.907974243	-295.563796997	.84934324026	1.21842959523
36.92	-10.	.0289533315	2.6566870213	-459.774368286	-295.081161499	.85187981278	1.21787990630
38.45	-8.	.0290267647	2.5557514429	-458.638492584	-294.600231171	.85440907627	1.21734146774
40.03	-6.	.0291008437	2.4594504535	-457.500297546	-294.121047974	.85693120956	1.21681398153
41.65	-4.	.0291755868	2.3675319850	-456.359722137	-293.643669128	.85944640636	1.21629716456
43.33	-2.	.0292510125	2.2797596157	-455.216705322	-293.168136597	.86195483059	1.21579071879
45.05	0.	.0293271407	2.1959115267	-454.071189880	-292.694511414	.86445666850	1.21529437602
46.83	2.	.0294039913	2.1157794595	-452.923114777	-292.222846985	.86695211381	1.21480782330
48.66	4.	.0294815851	2.0391678512	-451.772415161	-291.753192902	.86944133043	1.21433079243
50.54	6.	.0295599438	1.9658928514	-450.619026184	-291.285606384	.87192451209	1.21386301517
52.48	8.	.0296390895	1.8957816958	-449.462886810	-290.820152283	.87440184504	1.21340420842
54.47	10.	.0297190456	1.8286717981	-448.303924561	-290.356880188	.87687350065	1.21295410395
56.51	12.	.0297998360	1.7644101530	-447.142070770	-289.895854950	.87933966517	1.21251241863
58.62	14.	.0298814855	1.7028527111	-445.977260590	-289.437137604	.88180053234	1.21207888424
60.78	16.	.0299640202	1.6438637823	-444.809421539	-288.980789185	.88425628096	1.21165326238
63.01	18.	.0300474667	1.5873154551	-443.638473511	-288.526882172	.88670709729	1.21123524010
65.29	20.	.0301318534	1.5330871195	-442.464351654	-288.075477600	.88915317506	1.21082459390
67.63	22.	.0302172091	1.4810650200	-441.286968231	-287.626644135	.89159470052	1.21042104065
70.04	24.	.0303035644	1.4311417937	-440.106250763	-287.180454254	.89403186738	1.21002431214
72.51	26.	.0303909504	1.3832160681	-438.922115326	-286.736984253	.89646486193	1.20963416994
75.05	28.	.0304794002	1.3371920586	-437.734477997	-286.296306610	.89889388531	1.20925031602
77.65	30.	.0305689482	1.2929792851	-436.543251038	-285.858497620	.90131913126	1.20887252688
80.31	32.	.0306596302	1.2504922003	-435.348350525	-285.423641205	.90374080092	1.20850050449
83.05	34.	.0307514837	1.2096498609	-434.149681091	-284.991821289	.90615910292	1.20813401043
85.85	36.	.0308445478	1.1703756899	-432.947151184	-284.563117981	.90857423097	1.20777276158
88.73	38.	.0309388633	1.1325972229	-431.740661621	-284.137630463	.91098639369	1.20741650462
91.67	40.	.0310344733	1.0962457955	-430.530117035	-283.715442657	.91339581460	1.20706495643
94.69	42.	.0311314228	1.0612563640	-429.315406799	-283.296653748	.91580270231	1.20671786368
97.78	44.	.0312297586	1.0275672972	-428.096427917	-282.881362915	.91820727289	1.20637494326
100.94	46.	.0313295308	.9951201454	-426.873069763	-282.469673157	.92060975730	1.20603592694
104.20	48.	.0314306677	.9626218379	-425.645122528	-282.078701019	.92300935599	1.20562948287
107.52	50.	.0315334573	.9324769899	-424.412658691	-281.675773621	.92540824413	1.20529377460
110.92	52.	.0316378474	.9034249634	-423.175457001	-281.276721954	.92780575901	1.20496150851
114.39	54.	.0317438971	.8754093274	-421.933387756	-280.881801605	.93020213395	1.20463187993

Table 3-8 (continued)

117.95		56.	.0318516702	.8483849168	-420.686321259	-280.491138458	.93259761482	1.20430457592
121.59		58.	.0319612352	.8223088905	-419.434116364	-280.104873657	.93499246240	1.20397928357
125.31	*	60.	.0320726628	.7971405014	-418.176624298	-279.723144531	.93738695234	1.20365568998
129.11		62.	.0321860285	.7728409842	-416.913696289	-279.346103668	.93978135288	1.20333346725
133.00		64.	.0323014129	.7493734732	-415.645172119	-278.973903656	.94217596203	1.20301230252
136.97		66.	.0324189006	.7267028540	-414.370887756	-278.606712341	.94457106292	1.20269185305
141.03		68.	.0325385826	.7047956884	-413.090663910	-278.244701385	.94696698338	1.20237176120
145.18		70.	.0326605542	.6836201176	-411.804317474	-277.888050079	.94936402887	1.20205168426
149.42		72.	.0327849179	.6631457731	-410.511657715	-277.536945343	.95176254213	1.20173123479
153.75	*	74.	.0329117831	.6433437094	-409.212478638	-277.191585541	.95416288078	1.20141004026
158.18		76.	.0330412667	.6241863072	-407.906562805	-276.852188110	.95656540245	1.20108769834
162.69		78.	.0331734936	.6056472063	-406.593688965	-276.518966675	.95897050202	1.20076380670
167.31		80.	.0333085977	.5877012387	-405.273609161	-276.192157745	.96137857437	1.20043794811
172.01		82.	.0334467236	.5703243688	-403.946071625	-275.872005463	.96379005909	1.20010967553
176.82		84.	.0335880248	.5534936339	-402.610801697	-275.558773041	.96620540321	1.19977851212
181.72		86.	.0337326699	.5371870622	-401.267513275	-275.252735138	.96862509102	1.19944399595
186.73		88.	.0338808382	.5213836581	-399.915889740	-274.954185486	.97104962170	1.19910562038
191.83		90.	.0340327257	.5060633123	-398.555606842	-274.663436890	.97347954661	1.19876284897
197.04		92.	.0341885448	.4912067764	-397.186302185	-274.380809784	.97591543943	1.19841513038
202.36		94.	.0343485256	.4767956138	-395.807594299	-274.106666565	.97835792601	1.19806186855
207.77		96.	.0345129203	.4628121369	-394.419075012	-273.841373444	.98080766946	1.19770248234
213.30		98.	.0346820042	.4492393956	-393.020290375	-273.585334778	.98326539248	1.19733630121
218.93		100.	.0348560791	.4360611066	-391.610755920	-273.338973999	.98573186994	1.19696262479
224.68		102.	.0350354780	.4232616350	-390.189949036	-273.102748871	.98820794374	1.19658073783
230.53		104.	.0352205676	.4108259454	-388.757293701	-272.877151489	.99069454521	1.19618985057
236.50		106.	.0354117542	.3987395801	-387.312156677	-272.662704468	.99319267273	1.19578915834
242.58		108.	.0356094902	.3869886063	-385.853839874	-272.459980011	.99570342898	1.19537775218
248.78		110.	.0358142527	.3755429573	-384.381622314	-272.270729065	.99822788686	1.19491187700
255.09		112.	.0360266920	.3644387014	-382.894535065	-272.092235565	1.00076782703	1.19451880455
261.53		114.	.0362473656	.3536160551	-381.391738892	-271.928462982	1.00332434475	1.19406946003
268.19		116.	.0364755662	.3424628600	-379.874206543	-271.828617096	1.00589250028	1.19348956645
274.87		118.	.0367147652	.3321596198	-378.337032318	-271.700370789	1.00848662853	1.19299754500
281.68		120.	.0369647085	.3221304677	-376.780529022	-271.587677002	1.01110322773	1.19248978794
288.61		122.	.0372264455	.3123503141	-375.203205109	-271.492706299	1.01374453306	1.19196210802
295.67		124.	.0375012313	.3028078228	-373.603309631	-271.416660309	1.01641334593	1.19141267240
302.86		126.	.0377905373	.2934922613	-371.978805542	-271.360820770	1.01911289990	1.19083955884
310.18		128.	.0380961038	.2843931019	-370.327320099	-271.326610565	1.02184693515	1.19024063647
317.62		130.	.0384200066	.2754999883	-368.646057129	-271.315593719	1.02461989224	1.18961356580
325.20		132.	.0387647538	.2668027058	-366.931682587	-271.329521179	1.02743709087	1.18895575404
332.91		134.	.0391334132	.2582911439	-365.180179596	-271.370338440	1.03030489385	1.18826432526
340.76		136.	.0395297920	.2499553002	-363.386634827	-271.440212250	1.03323113918	1.18753606081
348.74		138.	.0399586945	.2417852469	-361.544940948	-271.541572571	1.03622554243	1.18676739931
356.85		140.	.0404263046	.2337711602	-359.647365570	-271.677127838	1.03930045664	1.18595436215
365.10		142.	.0409407634	.2259033844	-357.683917999	-271.849899292	1.04247181118	1.18509256840
373.48		144.	.0415130798	.2181725670	-355.641349792	-272.063243866	1.04576081038	1.18417716026
382.20		146.	.0421470013	.2099750899	-353.519069672	-272.426555634	1.04916253686	1.18300352991
390.87		148.	.0428830287	.2024082728	-351.263584137	-272.754455566	1.05277328193	1.18192644417
399.66		150.	.0437463853	.1949721612	-348.850097656	-273.133697510	1.05662813783	1.18078210950
408.55		152.	.0447887629	.1876391042	-346.223587036	-273.573070526	1.06081500649	1.17955651879
417.54		154.	.0460975915	.1804122683	-343.295482635	-274.076004028	1.06547580659	1.17824578285
426.59		156.	.0478240862	.1733127143	-339.924861908	-274.641769409	1.07083603740	1.17685337365
435.65		158.	.0502032982	.1663919091	-335.929080963	-275.260917664	1.07718642056	1.17539751530
445.00		160.	.0532284598	.1589275412	-331.469123840	-276.131080627	1.08425247669	1.17353974283
454.02		162.	.0568909664	.1523445472	-326.679569244	-276.878929138	1.09182469547	1.17192585766

Table 3-8 (continued)

THERMODYNAMIC PROPERTIES OF PROPANE-PROPYLENE-N-BUTANE MIXTURE,(65-25-10), AS PREDICTED BY STARLINGS EQUATION OF STATE

P	T	CPF	CPG	CVF	CVG	ASF	ASG
PSIA	DEG F	BTU/LBM/DEG F	BTU/LBM/DEG F	BTU/LBM/DEG F	BTU/LBM/DEG F	FT/SEC	FT/SEC
14.93	-50.	.2772147879	.3335496336	.315243408	.277397230	98714.4443	703.0037
15.70	-48.	.2814155184	.3354583159	.317031059	.278893791	98119.8867	703.5343
16.50	-46.	.2854723223	.3373655342	.318791680	.280391052	97467.3691	704.0500
17.32	-44.	.2893914059	.3392874002	.320526391	.281895678	96762.3125	704.5312
18.18	-42.	.2931785509	.3412243687	.322236199	.283407636	96009.5625	704.9777
19.07	-40.	.2968392856	.3431768380	.323922079	.284926876	95213.5937	705.3894
20.00	-38.	.3003789149	.3451451845	.325584967	.286453355	94378.5449	705.7663
20.96	-36.	.3038025163	.3471297808	.327225767	.287987024	93508.2383	706.1083
21.95	-34.	.3071149625	.3491309769	.328845356	.289527830	92606.2109	706.4153
22.98	-32.	.3103209250	.3511491157	.330444582	.291075725	91675.7334	706.6870
24.05	-30.	.3134248778	.3531845175	.332024254	.292630665	90719.8291	706.9232
25.15	-28.	.3164311200	.3552374877	.333585165	.294192597	89741.2988	707.1238
26.29	-26.	.3193437681	.3573083207	.335128080	.295761477	88742.7305	707.2885
27.47	-24.	.3221667670	.3593972884	.336653732	.297337256	87726.5205	707.4170
28.70	-22.	.3249039166	.3615046479	.338162839	.298919890	86694.8867	707.5090
29.96	-20.	.3275588453	.3636306301	.339656085	.300509326	85649.8799	707.5641
31.26	-18.	.3301350437	.3657754585	.341134138	.302105524	84593.3994	707.5820
32.61	-16.	.3326358609	.3679393232	.342597645	.303708434	83527.2012	707.5622
34.00	-14.	.3350645080	.3701224029	.344047230	.305318013	82452.9111	707.5043
35.44	-12.	.3374240734	.3723248467	.345483501	.306934219	81372.0332	707.4078
36.92	-10.	.3397175148	.3745467812	.346907038	.308557004	80285.9580	707.2721
38.45	-8.	.3419476785	.3767883070	.348318409	.310186330	79195.9727	707.0968
40.03	-6.	.3441172987	.3790494911	.349718172	.311822150	78103.2646	706.8812
41.65	-4.	.3462289907	.3813303784	.351106852	.313464433	77008.9346	706.6247
43.33	-2.	.3482852764	.3836309761	.352484971	.315113131	75913.9980	706.3266
45.05	0.	.3502885774	.3859512582	.353853028	.316768207	74819.3936	705.9862
46.83	2.	.3522412218	.3882911578	.355211515	.318429627	73725.9873	705.6026
48.66	4.	.3541454375	.3906505778	.356560905	.320097353	72634.5801	705.1752
50.54	6.	.3560033813	.3930293694	.357901655	.321771357	71545.9082	704.7029
52.48	8.	.3578171097	.3954273425	.359234218	.323451597	70460.6523	704.1850
54.47	10.	.3595886156	.3978442550	.360559024	.325138051	69379.4404	703.6205
56.51	12.	.3613198064	.4002798125	.361876503	.326830681	68302.8496	703.0083
58.62	14.	.3630125187	.4027336724	.363187067	.328529466	67231.4111	702.3473
60.78	16.	.3646685183	.4052054174	.364491120	.330234379	66165.6133	701.6365
63.01	18.	.3662895113	.4076945744	.365789056	.331945397	65105.9062	700.8746
65.29	20.	.3678771295	.4102006033	.367081258	.333662491	64052.7021	700.0605
67.63	22.	.3694329560	.4127228893	.368368108	.335385654	63006.3794	699.1928
70.04	24.	.3709585033	.4152607322	.369649973	.337114859	61967.2852	698.2701
72.51	26.	.3724552356	.4178133607	.370927211	.338850092	60935.7368	697.2910
75.05	28.	.3739245646	.4203799032	.372200184	.340591349	59912.0244	696.2541
77.65	30.	.3753678538	.4229594022	.373469234	.342338610	58896.4141	695.1577
80.31	32.	.3767864071	.4255508035	.374734707	.344091874	57889.1475	694.0003
83.05	34.	.3781814948	.4281529412	.375996944	.345851131	56890.4448	692.7801
85.85	36.	.3795543425	.4307645410	.377256274	.347616389	55900.5078	691.4953
88.73	38.	.3809061199	.4333842173	.378513031	.349387642	54919.5186	690.1442
91.67	40.	.3822379783	.4360104613	.379767537	.351164900	53947.6421	688.7249
94.69	42.	.3835510202	.4386416450	.381020121	.352948166	52985.0293	687.2353
97.78	44.	.3848463073	.4412759952	.382271104	.354737461	52031.8154	685.6735
100.94	46.	.3861248791	.4439116232	.383520801	.356532793	51088.1226	684.0374
104.20	48.	.3873894736	.4466450401	.384769917	.358371057	50155.9312	682.1615
107.52	50.	.3886377178	.4492827170	.386018027	.360180963	49231.7432	680.3571
110.92	52.	.3898721635	.4519145042	.387265809	.361996826	48317.3706	678.4722
114.39	54.	.3910937384	.4545386396	.388513595	.363818955	47412.9067	676.5031
117.95	56.	.3923033401	.4571524821	.389761701	.365647390	46518.4253	674.4476
121.59	58.	.3935018443	.4597532488	.391010460	.367482185	45633.9902	672.3030

Table 3-8 (continued)

125.31	60.	.3946901001	.4623379931	.392260198	.369323395	44759.6611	670.0670
129.11	62.	.3958689421	.4649036303	.393511258	.371171080	43895.4893	667.7372
133.00	* 64.	.3970391899	.4674469344	.394763973	.373025313	43041.5225	665.3110
136.97	66.	.3982016444	.4699645378	.396018703	.374886163	42197.8027	662.7860
141.03	68.	.3993570916	.4724529535	.397275794	.376753718	41364.3691	660.1598
145.18	70.	.4005063102	.4749085642	.398535620	.378628064	40541.2568	657.4300
149.42	72.	.4016500711	.4773276672	.399798557	.380509298	39728.4971	654.5943
153.75	* 74.	.4027891383	.4797064550	.401064996	.382397532	38926.1211	651.6506
158.18	76.	.4039242640	.4820410535	.402335342	.384292878	38134.1558	648.5966
162.69	78.	.4050562084	.4843275473	.403610013	.386195462	37352.6289	645.4306
167.31	80.	.4061857276	.4865619838	.404889453	.388105422	36581.5659	642.1507
172.01	82.	.4073135778	.4887404218	.406174116	.390022904	35820.9922	638.7555
176.82	84.	.4084405266	.4908589348	.407464486	.391948070	35070.9341	635.2435
181.72	86.	.4095673524	.4929136671	.408761073	.393881086	34331.4175	631.6138
186.73	88.	.4106948376	.4949008524	.410064414	.395822145	33602.4692	627.8658
191.83	90.	.4118237942	.4968168512	.411375079	.397771440	32884.1191	623.9991
197.04	92.	.4129550457	.4986581914	.412693676	.399729196	32176.3970	620.0138
202.36	94.	.4140894450	.5004216060	.414020855	.401695643	31479.3359	615.9106
207.77	96.	.4152278826	.5021040589	.415357310	.403671026	30792.9717	611.6905
213.30	98.	.4163712822	.5037028044	.416703798	.405655630	30117.3433	607.3553
218.93	100.	.4175206125	.5052154213	.418061122	.407649737	29452.4932	602.9075
224.68	102.	.4186769016	.5066398308	.419430166	.409653667	28798.4685	598.3501
230.53	104.	.4198412374	.5079743490	.420811892	.411667764	28155.3203	593.6870
236.50	106.	.4210147820	.5092177093	.422207352	.413692392	27523.1055	588.9232
242.58	108.	.4221987948	.5103690997	.423617695	.415727958	26901.8860	584.0645
248.78	110.	.4233947098	.5114296749	.425044160	.417776890	26291.8523	579.1052
255.09	112.	.4246037826	.5123952031	.426488284	.419833761	25692.7207	574.0907
261.53	114.	.4258278683	.5132705867	.427951533	.421904754	25104.9187	568.9949
268.19	116.	.4270714894	.5140964389	.429433238	.424072497	24533.5298	563.3102
274.87	118.	.4283311702	.5147898048	.430939771	.426178705	23968.9819	558.0559
281.68	120.	.4296117835	.5153952762	.432471465	.428297713	23415.8650	552.7804
288.61	122.	.4309159555	.5159164742	.434030842	.430432186	22874.4124	547.4892
295.67	124.	.4322466254	.5163566247	.435620863	.432583012	22344.7559	542.2015
302.86	126.	.4336071871	.5167193934	.437244970	.434751127	21827.0334	536.9403
310.18	128.	.4350016043	.5170088634	.438907187	.436937541	21321.3914	531.7319
317.62	130.	.4364345558	.5172295347	.440612275	.439143367	20827.9836	526.6065
325.20	132.	.4379116409	.5173862800	.442365907	.441369824	20346.9690	521.5995
332.91	134.	.4394396320	.5174842700	.444174957	.443618242	19878.5061	516.7516
340.76	136.	.4410268702	.5175289586	.446047835	.445890076	19422.7446	512.1102
348.74	138.	.4426837750	.5175260231	.447995014	.448186908	18979.8120	507.7309
356.85	140.	.4444236495	.5174813420	.450029757	.450510442	18549.7871	503.6784
365.10	142.	.4462638237	.5174008980	.452169206	.452862483	18132.6562	500.0290
373.48	144.	.4482275024	.5172907859	.454436060	.455244884	17728.2336	496.8724
382.20	146.	.4503318630	.5171182081	.456833187	.457808524	17344.1973	493.7994
390.87	148.	.4526432790	.5169580802	.459448151	.460284892	16964.5139	491.9585
399.66	150.	.4552196264	.5167878866	.462323833	.462793626	16593.4885	491.0364
408.55	152.	.4581626207	.5166124329	.465551015	.465341277	16226.7069	491.1959
417.54	154.	.4616370238	.5164384246	.469271004	.467925992	15853.8495	492.6493
426.59	156.	.4659079202	.5162736550	.473692700	.470539641	15451.3324	495.6315
435.65	158.	.4713182487	.5161278769	.479025215	.473162752	14966.5192	500.3694
445.00	160.	.4775765315	.5159433410	.484766260	.476023924	14352.3871	507.5135
454.02	162.	.4842072017	.5158449784	.490332853	.478660148	13533.0383	516.6721

*The lack of values for entropy and enthalpy departures and for specific heat references does not permit an accurate calculation of the shown thermodynamic properites in this temperature range.

Table 3-9
Saturation Temperature Table for Propylene
Calculated from Starling's Equation of State

THERMODYNAMIC PROPERTIES OF PROPYLENE AS PREDICTED BY STARLINGS EQUATION OF STATE

P	T	VF	VG	HF	HG	SF	SG
PSIA	DEG F	FT3/LBM	FT3/LBM	BTU/LBM	BTU/LBM	BTU/LBM/DEG F	BTU/LBM/DEG F
16.42	-50.	.0273020898	6.0678675771	253.602664948	440.241577148	.83344855160	1.28866788745
17.25	-48.	.0273698268	5.7947438359	254.626317978	440.655906677	.83608666807	1.28762111068
18.11	-46.	.0274378350	5.5361309648	255.652408600	441.069850922	.83871483803	1.28658974171
19.01	-44.	.0275061228	5.2915633321	256.680942535	441.483638763	.84133318067	1.28557749093
19.94	-42.	.0275746984	5.0601493716	257.711921692	441.897224426	.84394181520	1.28458394110
20.90	-40.	.0276435702	4.8410605192	258.745357513	442.310554504	.84654086083	1.28360868990
21.90	-38.	.0277127465	4.6335276365	259.781257629	442.723583221	.84913044423	1.28265132010
22.93	-36.	.0277822362	4.4368359447	260.819633484	443.136264801	.85171068460	1.28171141446
24.01	-34.	.0278520479	4.2503209710	261.860496521	443.548542023	.85428170115	1.28078858554
25.12	-32.	.0279221907	4.0733645558	262.903858185	443.960376740	.85684362054	1.27988246083
26.27	-30.	.0279926739	3.9053911865	263.949737549	444.371711731	.85939656943	1.27899262309
27.46	-28.	.0280635071	3.7458649278	264.998142242	444.782505035	.86194067448	1.27811874449
28.69	-26.	.0281346997	3.5942860842	266.049091339	445.192707062	.86447605491	1.27726043761
29.96	-24.	.0282062618	3.4501887262	267.102603912	445.602268219	.86700285226	1.27641734481
31.27	-22.	.0282782034	3.3131380081	268.158695221	446.011135101	.86952118576	1.27558913827
32.63	-20.	.0283505351	3.1827279031	269.217384338	446.419269562	.87203118205	1.27477544546
34.03	-18.	.0284232674	3.0585791171	270.278690338	446.826614380	.87453297526	1.27397596836
35.48	-16.	.0284964109	2.9403369725	271.342636108	447.233127594	.87702669203	1.27319034934
36.98	-14.	.0285699773	2.8276698291	272.409240723	447.638751984	.87951246649	1.27241826057
38.52	-12.	.0286439774	2.7202672362	273.478527069	448.043449402	.88199043274	1.27165941894
40.11	-10.	.0287184233	2.6178385317	274.550521851	448.447158813	.88446070999	1.27091349661
41.74	-8.	.0287933273	2.5201113522	275.625247955	448.849842072	.88692343980	1.27018018067
43.43	-6.	.0288687011	2.4268304408	276.702732086	449.251441956	.88937875628	1.26945917308
45.17	-4.	.0289445575	2.3377563357	277.782997131	449.651912689	.89182677865	1.26875019073
46.96	-2.	.0290209099	2.2526643276	278.866073608	450.051204681	.89426765591	1.26805295050
48.80	0.	.0290977715	2.1713435054	279.951988220	450.449264526	.89670150727	1.26736715436
50.70	2.	.0291751556	2.0935956836	281.040771484	450.846042633	.89912846684	1.26669251919
52.65	4.	.0292530768	2.0192346275	282.132453918	451.241489410	.90154867619	1.26602877676
54.66	6.	.0293315493	1.9480852336	283.227062225	451.635551453	.90396226943	1.26537567377
56.73	8.	.0294105883	1.8799827248	284.324634552	452.028179169	.90636937320	1.26473291218
58.85	10.	.0294902087	1.8147720695	285.425201416	452.419319153	.90877012908	1.26410025358
61.03	12.	.0295704268	1.7523072362	286.528800964	452.808917999	.91116466373	1.26347742975
63.27	14.	.0296512584	1.6924506873	287.635459900	453.196922302	.91355311871	1.26286418736
65.57	16.	.0297327205	1.6350727677	288.745223999	453.583278656	.91593562812	1.26226027310
67.93	18.	.0298148300	1.5800512135	289.858127594	453.967929840	.91831232607	1.26166544855
70.36	20.	.0298976055	1.5272707045	290.974208832	454.350822449	.92068334669	1.26107944548
72.85	22.	.0299810646	1.4766223580	292.093505859	454.731903076	.92304883897	1.26050204039
75.40	24.	.0300652266	1.4280034006	293.216060638	455.111106873	.92540892959	1.25993299484
78.02	26.	.0301501108	1.3813167363	294.341918945	455.488380432	.92776376009	1.25937207043
80.71	28.	.0302357378	1.3364706039	295.471118927	455.863666534	.93011347204	1.25881901383
83.46	30.	.0303221280	1.2933782488	296.603713989	456.236904144	.93245820701	1.25827360153
86.29	32.	.0304093033	1.2519576102	297.739738464	456.608028412	.93479809910	1.25773562491
89.18	34.	.0304972860	1.2121310532	298.879253387	456.976978302	.93713328987	1.25720481575
92.14	36.	.0305860990	1.1738250554	300.022296906	457.343696594	.93946392089	1.25668096542
95.18	38.	.0306757663	1.1369700432	301.168926239	457.708106995	.94179014862	1.25616386533
98.29	40.	.0307663127	1.1015000343	302.319190979	458.070152283	.94411209971	1.25565324724
101.47	42.	.0308577640	1.0673525482	303.473144531	458.429763794	.94642993063	1.25514893234
104.73	44.	.0309501465	1.0344683230	304.630844116	458.786869049	.94874379039	1.25465065241
108.06	46.	.0310434881	1.0027911365	305.792350769	459.141395569	.95105382800	1.25415822864
111.48	48.	.0311378171	.9722676650	306.957714081	459.493274689	.95336018503	1.25367139280
114.96	50.	.0312331636	.9428472817	308.127006531	459.842430115	.95566301793	1.25318995118
118.53	52.	.0313295582	.9144819081	309.300285339	460.188785553	.95796248317	1.25271368027

Table 3-9 (continued)

122.21	54.	.0314269168	.8859851658	310.477741241	460.513038635	.96025756001	1.25216493011
125.94	56.	.0315254941	.8595803156	311.659191132	460.852264404	.96255066246	1.25169458985
129.75	58.	.0316252206	.8341090232	312.844833374	461.188537598	.96484086663	1.25122924149
133.65	60.	.0317261303	.8095231578	314.034736633	461.521621704	.96712833643	1.25076803565
137.64	62.	.0318282624	.7857853249	315.228977203	461.851421356	.96941322833	1.25031074882
141.71	64.	.0319316550	.7628599852	316.427631378	462.177837372	.97169572115	1.24985712767
145.86	66.	.0320363506	.7407133058	317.630783081	462.500774384	.97397597134	1.24940693378
150.11	68.	.0321423905	.7193130851	318.838516235	462.820133209	.97625416517	1.24895995855
154.44	70.	.0322498209	.6986286193	320.050914764	463.135803223	.97853048146	1.24851591885
158.86	72.	.0323586878	.6786306575	321.268066406	463.447681427	.98080509156	1.24807459116
163.38	74.	.0324690412	.6592913121	322.490074158	463.755649567	.98307818919	1.24763572216
167.99	76.	.0325809317	.6405839846	323.717025757	464.059589386	.98534996063	1.24719904363
172.69	78.	.0326944138	.6224833056	324.949028015	464.359382629	.98762060702	1.24676431715
177.48	80.	.0328095439	.6049650535	326.186187744	464.654895782	.98989031464	1.24633125961
182.37	82.	.0329263816	.5880061090	327.428611755	464.946002960	.99215930700	1.24589960277
187.36	84.	.0330449897	.5715843886	328.676414490	465.232559204	.99442778528	1.24546907842
192.45	86.	.0331654334	.5556787997	329.929721832	465.514423370	.99669597298	1.24503938854
197.64	88.	.0332877822	.5402691811	331.188655853	465.791446686	.99896408617	1.24461025000
202.92	90.	.0334121096	.5253362581	332.453350067	466.063468933	1.00123235583	1.24418137968
208.31	92.	.0335384919	.5108615831	333.723937988	466.330322266	1.00350104272	1.24375243485
213.80	94.	.0336670117	.4968275316	335.000568390	466.591838837	1.00577038527	1.24332313240
219.40	96.	.0337977540	.4832172170	336.283390045	466.847831726	1.00804062188	1.24289312959
225.10	98.	.0339308111	.4700144716	337.572563171	467.098117828	1.01031205058	1.24246208370
230.90	100.	.0340662790	.4572038166	338.868259430	467.342491150	1.01258493960	1.24202963710
236.81	102.	.0342042609	.4447704144	340.170650482	467.580745697	1.01485958695	1.24159544706
242.84	104.	.0343448655	.4327000417	341.479919434	467.812656403	1.01713627577	1.24115912616
248.97	106.	.0344882095	.4209790640	342.796272278	468.037990570	1.01941534877	1.24072027206
255.21	108.	.0346344165	.4095943943	344.119907379	468.256507874	1.02169713378	1.24027848244
261.57	110.	.0347836190	.3985334709	345.451049805	468.467941284	1.02398198843	1.23983334005
268.04	112.	.0349359573	.3877842352	346.789928436	468.672019958	1.02627027035	1.23938436806
274.62	114.	.0350915841	.3773350976	348.136798859	468.868450165	1.02856236696	1.23893110454
281.32	116.	.0352506605	.3671749160	349.491916656	469.056926727	1.03085871041	1.23847307265
288.14	118.	.0354133616	.3572929837	350.855564117	469.237117767	1.03315971792	1.23800973594
295.07	120.	.0355798751	.3476789892	352.228042603	469.408679962	1.03546586633	1.23754055798
302.13	122.	.0357504035	.3383230008	353.609668732	469.571239471	1.03777763247	1.23706495762
309.30	124.	.0359251653	.3292154558	355.000789642	469.724403381	1.04009556770	1.23658232391
316.60	126.	.0361043978	.3203471340	356.401775360	469.867752075	1.04242020845	1.23609200120
324.02	128.	.0362883583	.3117091283	357.813014984	470.000831604	1.04475216568	1.23559331894
331.71	130.	.0364760333	.3027526475	359.233181000	470.068168640	1.04708531499	1.23496077955
339.25	132.	.0366715104	.2950521335	360.667884827	470.230205536	1.04944020510	1.23455885053
347.21	134.	.0368699087	.2865220271	362.110427856	470.270000458	1.05179052055	1.23389911652
355.15	136.	.0370755959	.2786884196	363.566932678	470.350017548	1.05415768921	1.23334601521
363.23	138.	.0372877168	.2710596174	365.036243439	470.418285370	1.05653610826	1.23278351128
371.44	140.	.0375066693	.2636129931	366.518939972	470.472373962	1.05892653763	1.23220677674
379.78	142.	.0377329406	.2563408017	368.015727997	470.511413574	1.06133002043	1.23161448538
388.26	144.	.0379670737	.2492359616	369.527378082	470.534530640	1.06374770403	1.23100532591
396.88	146.	.0382096749	.2422915678	371.054759979	470.540760040	1.06618086994	1.23037791252
405.63	148.	.0384614239	.2355008461	372.598819733	470.529060364	1.06863094866	1.22973071039
414.53	150.	.0387230865	.2288571410	374.160629272	470.498279572	1.07109951973	1.22906202078
423.57	152.	.0389955291	.2223538943	375.741378784	470.447158813	1.07358835638	1.22837002575
432.75	154.	.0392797398	.2159846202	377.342411041	470.374301910	1.07609945536	1.22765268385
442.08	156.	.0395768499	.2097428832	378.965259552	470.278175354	1.07863509655	1.22690778971
451.55	158.	.0398881640	.2036222816	380.611667633	470.157070160	1.08119787276	1.22613283992
461.17	160.	.0402152007	.1976164132	382.283638000	470.009090424	1.08379079401	1.22532510757
470.94	162.	.0405597389	.1917188577	383.983505249	469.832115173	1.08641730249	1.22448153794
480.87	164.	.0409238855	.1859231554	385.713996887	469.623779297	1.08908149600	1.22359870374
491.23	166.	.0413026819	.1797047053	387.466117859	469.261459351	1.09176245332	1.22245407104
501.51	168.	.0417120527	.1740253456	389.264831543	468.959701538	1.09451122582	1.22144290805
511.93	170.	.0421502683	.1684490517	391.105880737	468.620948792	1.09731550515	1.22038641572
522.50	172.	.0426215054	.1629433539	392.994277954	468.235137939	1.10018241605	1.21926790476
533.24	174.	.0431314670	.1574985050	394.936958313	467.796836853	1.10312238336	1.21807938814
544.14	176.	.0436875666	.1521059144	396.942844391	467.300205231	1.10614882410	1.21681246161
555.19	178.	.0442996714	.1467569359	399.023662567	466.738613129	1.10927939415	1.21545761824
566.40	180.	.0449813511	.1414431352	401.195327759	466.104595184	1.11253815889	1.21400420368

Table 3-9 (continued)

578.17	182.	.0457225563	.1355320774	403.436302185	465.170604706	1.11588267982	1.21207548678
589.78	184.	.0465958691	.1301136166	405.846279144	464.296611786	1.11948116124	1.21027815342
601.49	186.	.0476291790	.1247372432	408.449573517	463.325920105	1.12336365879	1.20835095644
613.33	188.	.0489002964	.1193717867	411.331172943	462.237632751	1.12765885890	1.20626208186

Table 3-9 (continued)

THERMODYNAMIC PROPERTIES OF PROPYLENE AS PREDICTED BY STARLINGS EQUATION OF STATE

P	T	CPF	CPG	CVF	CVG	ASF	ASG
PSIA	DEG F	BTU/LBM/DEG F	BTU/LBM/DEG F	BTU/LBM/DEG F	BTU/LBM/DEG F	FT/SEC	FT/SEC
16.42	-50.	-.0501384321	.3151082247	.178970020	.234879892	.0000	767.2394
17.25	-48.	-.0393306459	.3170396835	.183070473	.236851834	.0000	766.8944
18.11	-46.	-.0288237836	.3189903796	.187094918	.238825332	.0000	766.5393
19.01	-44.	-.0186075114	.3209585696	.191045472	.240799442	.0000	766.1759
19.94	-42.	-.0086718703	.3229443841	.194924198	.242774067	.0000	765.8037
20.90	-40.	.0009927217	.3249479644	.198733089	.244749112	575.1569	765.4223
21.90	-38.	.0103954860	.3269694299	.202474080	.246724488	5820.1032	765.0310
22.93	-36.	.0195452983	.3290089034	.206149042	.248700105	10581.3647	764.6293
24.01	-34.	.0284507030	.3310664892	.209759781	.250675879	14903.0537	764.2166
25.12	-32.	.0371199274	.3331422918	.213308061	.252651729	18824.6064	763.7923
26.27	-30.	.0455608945	.3352363966	.216795577	.254627571	22381.3652	763.3559
27.46	-28.	.0537812347	.3373488821	.220223980	.256603338	25605.0784	762.9067
28.69	-26.	.0617882996	.3394798115	.223594870	.258578945	28524.3274	762.4441
29.96	-24.	.0695891725	.3416292369	.226909798	.260554332	31164.8965	761.9674
31.27	-22.	.0771906795	.3437971994	.230170265	.262529422	33550.0933	761.4759
32.63	-20.	.0845993990	.3459837139	.233377730	.264504153	35701.0239	760.9690
34.03	-18.	.0918216724	.3481887840	.236533612	.266478464	37636.8379	760.4460
35.48	-16.	.0988636157	.3504124023	.239639280	.268452294	39374.9351	759.9061
36.98	-14.	.1057311250	.3526545279	.242696073	.270425580	40931.1533	759.3486
38.52	-12.	.1124298871	.3549151048	.245705284	.272398278	42319.9307	758.7727
40.11	-10.	.1189653883	.3571940519	.248668171	.274370324	43554.4458	758.1776
41.74	-8.	.1253429204	.3594912663	.251585957	.276341677	44646.7471	757.5625
43.43	-6.	.1315675937	.3618066162	.254459832	.278312284	45607.8623	756.9266
45.17	-4.	.1376443356	.3641399369	.257290948	.280282103	46447.8979	756.2689
46.96	-2.	.1435779035	.3664910384	.260080427	.282251094	47176.1279	755.5885
48.80	0.	.1493728925	.3688596860	.262829367	.284219213	47801.0718	754.8847
50.70	2.	.1550337393	.3712456189	.265538827	.286186423	48330.5630	754.1562
52.65	4.	.1605647299	.3736485355	.268209841	.288152695	48771.8145	753.4023
54.66	6.	.1659699976	.3760680854	.270843420	.290117994	49131.4712	752.6218
56.73	8.	.1712535452	.3785038777	.273440544	.292082291	49415.6631	751.8137
58.85	10.	.1764192358	.3809554763	.276002165	.294045556	49630.0503	750.9769
61.03	12.	.1814708021	.3834223896	.278529219	.296007767	49779.8604	750.1103
63.27	14.	.1864118557	.3859040700	.281022608	.297968902	49869.9307	749.2126
65.57	16.	.1912458837	.3883999139	.283483222	.299928941	49904.7358	748.2828
67.93	18.	.1959762629	.3909092620	.285911925	.301887862	49888.4214	747.3194
70.36	20.	.2006062567	.3934313767	.288309556	.303845659	49824.8306	746.3213
72.85	22.	.2051390223	.3959654644	.290676940	.305802312	49717.5278	745.2871
75.40	24.	.2095776144	.3985106498	.293014884	.307757813	49569.8208	744.2154
78.02	26.	.2139249928	.4010659829	.295324165	.309712157	49384.7832	743.1048
80.71	28.	.2181840166	.4036304355	.297605559	.311665334	49165.2705	741.9539
83.46	30.	.2223574575	.4062028937	.299859811	.313617341	48913.9395	740.7611
86.29	32.	.2264479995	.4087821543	.302087657	.315568183	48633.2617	739.5290
89.18	34.	.2304582410	.4113669209	.304289818	.317517858	48325.5381	738.2438
92.14	36.	.2343907021	.4139558040	.306466997	.319466367	47992.9121	736.9161
95.18	38.	.2382478192	.4165473171	.308619879	.321413726	47637.3818	735.5400
98.29	40.	.2420319617	.4191398658	.310749143	.323359933	47260.8110	734.1140
101.47	42.	.2457454223	.4217317551	.312855456	.325305004	46864.9380	732.6363
104.73	44.	.2493904233	.4243211821	.314939465	.327248953	46451.3853	731.1050
108.06	46.	.2529691234	.4269062318	.317001805	.329191796	46021.6685	729.5185
111.48	48.	.2564836182	.4294848815	.319043111	.331133548	45577.2031	727.8748
114.96	50.	.2599359415	.4320549928	.321063905	.333074234	45119.3135	726.1721
118.53	52.	.2633280605	.4346143231	.323065069	.335013878	44649.2373	724.4085
122.21	54.	.2666630745	.4372715913	.325047221	.336997263	44169.8042	722.4090
125.94	56.	.2699405588	.4398078658	.327012453	.338937629	43678.8813	720.5052
129.75	58.	.2731634229	.4423251227	.328955635	.340876795	43179.0215	718.5356

Table 3-9 (continued)

133.65	60.	.2763334401	.4448215291	.330883339	.342815142	42671.1890	716.4968
137.64	62.	.2794523202	.4472942948	.332794137	.344752714	42156.2754	714.3871
141.71	64.	.2825217359	.4497405291	.334688582	.346689560	41635.1162	712.2045
145.86	66.	.2855433077	.4521572590	.336567227	.348625716	41108.4956	709.9474
150.11	68.	.2885186151	.4545414299	.338430621	.350561243	40577.1484	707.6139
154.44	70.	.2914492041	.4568899199	.340279307	.352496184	40041.7661	705.2024
158.86	72.	.2943365760	.4591995589	.342113619	.354430597	39502.9966	702.7114
163.38	74.	.2971821986	.4614671320	.343934696	.356364541	38961.4497	700.1394
167.99	76.	.2999875024	.4636893980	.345742468	.358298074	38417.6982	697.4851
172.69	78.	.3027538918	.4658631161	.347537663	.360231265	37872.2808	694.7473
177.48	80.	.3054827340	.4679850489	.349320803	.362164181	37325.7051	691.9251
182.37	82.	.3081753738	.4700519964	.351092424	.364096887	36778.4482	689.0175
187.36	84.	.3108331189	.4720608145	.352853041	.366029464	36230.9600	686.0242
192.45	86.	.3134572580	.4740084261	.354603186	.367961988	35683.6641	682.9446
197.64	88.	.3160490617	.4758918658	.356343385	.369894542	35136.9604	679.7787
202.92	90.	.3186097629	.4777082913	.358074166	.371827208	34591.2271	676.5267
208.31	92.	.3211405911	.4794550091	.359796058	.373760078	34046.8193	673.1892
213.80	94.	.3236427456	.4811295010	.361509603	.375693250	33504.0742	669.7670
219.40	96.	.3261174187	.4827294573	.363215335	.377626814	32963.3105	666.2614
225.10	98.	.3285657763	.4842527919	.364913799	.379560880	32424.8296	662.6740
230.90	100.	.3309889808	.4856976755	.366605554	.381495550	31888.9167	659.0069
236.81	102.	.3333881833	.4870625474	.368291155	.383430935	31355.8428	655.2628
242.84	104.	.3357645273	.4883461446	.369971171	.385367155	30825.8645	651.4445
248.97	106.	.3381191418	.4895475283	.371646188	.387304328	30299.2261	647.5558
255.21	108.	.3404531628	.4906660803	.373316798	.389242586	29776.1592	643.6007
261.57	110.	.3427677229	.4917015322	.374983609	.391182058	29256.8845	639.5840
268.04	112.	.3450639471	.4926539771	.376647241	.393122882	28741.6128	635.5110
274.62	114.	.3473429792	.4935238659	.378308337	.395065203	28230.5447	631.3878
281.32	116.	.3496059589	.4943120256	.379967563	.397009172	27723.8713	627.2210
288.14	118.	.3518540449	.4950196370	.381625600	.398954943	27221.7764	623.0182
295.07	120.	.3540884033	.4956482612	.383283157	.400902685	26724.4351	618.7875
302.13	122.	.3563102297	.4961997941	.384940982	.402852565	26232.0151	614.5381
309.30	124.	.3585207276	.4966764897	.386599835	.404804759	25744.6780	610.2798
316.60	126.	.3607211448	.4970809184	.388260536	.406759460	25262.5781	606.0238
324.02	128.	.3629127592	.4974159636	.389923930	.408716854	24785.8640	601.7817
331.71	130.	.3650964163	.4977111965	.391587511	.410775345	24320.0469	597.0469
339.25	132.	.3672748245	.4978923388	.393262167	.412647657	23849.5505	593.3558
347.21	134.	.3694470823	.4980557300	.394935034	.414718352	23395.5754	588.7015
355.15	136.	.3716167063	.4981431141	.396617919	.416699257	22942.3989	584.6128
363.23	138.	.3737846278	.4981784299	.398308601	.418681428	22495.1316	580.6321
371.44	140.	.3759524524	.4981663227	.400008187	.420668110	22054.0557	576.7644
379.78	142.	.3781219237	.4981110394	.401717987	.422659714	21619.2905	573.0316
388.26	144.	.3802949004	.4980168901	.403439432	.424656563	21190.9446	569.4580
396.88	146.	.3824733831	.4978881851	.405174080	.426658992	20769.1196	566.0703
405.63	148.	.3846595287	.4977292307	.406923641	.428667344	20353.9114	562.8979
414.53	150.	.3868556954	.4975442737	.408689987	.430681989	19945.4070	559.9730
423.57	152.	.3890644610	.4973374717	.410475198	.432703294	19543.6848	557.3311
432.75	154.	.3912886791	.4971128479	.412281595	.434731640	19148.8115	555.0114
442.08	156.	.3935315236	.4968742765	.414111771	.436767418	18760.8396	553.0572
451.55	158.	.3957965598	.4966254123	.415968668	.438811015	18379.8042	551.5163
461.17	160.	.3980878256	.4963696897	.417855624	.440862816	18005.7180	550.4419
470.94	162.	.4004099406	.4961102605	.419776481	.442923177	17638.5645	549.8931
480.87	164.	.4027682506	.4958499484	.421735693	.444992427	17278.2878	549.9355
491.23	166.	.4051512554	.4955527261	.423715584	.447236873	16934.3157	550.3912
501.51	168.	.4075963609	.4952908196	.425761934	.449351180	16588.9446	551.8989
511.93	170.	.4100998677	.4950356148	.427865393	.451468714	16249.5599	554.2845
522.50	172.	.4126714431	.4947861582	.430033602	.453597527	15916.2396	557.6466
533.24	174.	.4153240360	.4945424721	.432277258	.455738053	15588.4620	562.1106
544.14	176.	.4180741310	.4943038300	.434609972	.457689844	15265.4155	567.8204
555.19	178.	.4209432080	.4940684550	.437049393	.460051715	14945.8883	574.9406
566.40	180.	.4239601791	.4938332513	.439619176	.462221358	14628.0417	583.6585
578.17	182.	.4270890467	.4935321063	.442273106	.464628857	14323.4670	595.2204
589.78	184.	.4305027425	.4932613336	.445179682	.466857873	14003.1516	608.4099
601.49	186.	.4342454895	.4929687046	.448362164	.469062157	13669.4210	624.0320

Table 3-9 (Continued)

513.33	188.	.4384646490	.4926364720	.451935295	.471235741	13308.9474	642.4411

*The lack of values for entropy and enthalpy departures and for specific heat references does not permit an accurate calculation of the shown thermodynamic properties in this temperature range.

Table 3-10
Saturation Temperature Table for N-Butane
Calculated from Starling's Equation of State

THERMODYNAMIC PROPERTIES OF N-BUTANE AS PREDICTED BY STARLINGS EQUATION OF STATE

P PSIA	T DEG F	VF FT3/LBM	VG FT3/LBM	HF BTU/LBM	HG BTU/LBM	SF BTU/LBM/DEG F	SG BTU/LBM/DEG F
1.80	-50.	.0251652952	41.5668420792	116.374057770	299.312355042	.71006752551	1.15624165535
1.92	-48.	.0252048254	39.2093157768	117.495242119	299.947948456	.71281599253	1.15568469465
2.05	-46.	.0252444332	36.9699954987	118.615131378	300.584304810	.71554767340	1.15511028469
2.18	-44.	.0252841217	34.8826065063	119.733782768	301.221931658	.71826290339	1.15455690026
2.32	-42.	.0253238943	32.9357118607	120.851260185	301.860816956	.72096198052	1.15402446687
2.46	-40.	.0253637547	31.1184713840	121.967626572	302.500938416	.72364521772	1.15351256728
2.62	-38.	.0254037059	29.4209756851	123.082945824	303.142269135	.72631289065	1.15302078426
2.78	-36.	.0254437514	27.8341631889	124.197278023	303.784786224	.72896531224	1.15254870057
2.95	-34.	.0254838946	26.3497393131	125.310686111	304.428474426	.73160274327	1.15209589899
3.12	-32.	.0255241387	24.9601058960	126.423230171	305.073307037	.73422548175	1.15166200697
3.31	-30.	.0255644876	23.6582965851	127.534970284	305.719257355	.73683379591	1.15124663711
3.50	-28.	.0256049444	22.4379186630	128.645965576	306.366310120	.73942794651	1.15084938705
3.71	-26.	.0256455131	21.2931013107	129.756275177	307.014442444	.74200820178	1.15046989918
3.92	-24.	.0256861968	20.2184493542	130.865955353	307.663627625	.74457482249	1.15010780096
4.14	-22.	.0257269982	19.1891186237	131.975080490	308.312889099	.74712804705	1.14972643554
4.37	-20.	.0257679229	18.2407000065	133.083681107	308.964046478	.74966814369	1.14939694107
4.62	-18.	.0258089737	17.3487014771	134.191825867	309.616184235	.75219535083	1.14908379319
4.87	-16.	.0258501542	16.5092365742	135.299570084	310.269287109	.75470990688	1.14878664911
5.13	-14.	.0258914684	15.7187252045	136.406970978	310.923332214	.75721205026	1.14850518107
5.41	-12.	.0259329199	14.9738624096	137.514081955	311.578292847	.75970200449	1.14823909104
5.69	-10.	.0259745126	14.2715942860	138.620956421	312.234149933	.76217999309	1.14798805118
5.99	-8.	.0260162503	13.6090970039	139.727651596	312.890880585	.76464624703	1.14775176346
6.30	-6.	.0260581370	12.9837579727	140.834218979	313.548461914	.76710098237	1.14752992988
6.63	-4.	.0261001764	12.3931580782	141.940711975	314.206871033	.76954441518	1.14732223749
6.96	-2.	.0261423730	11.8350557089	143.047183990	314.866092682	.77197674662	1.14712843299
7.31	0.	.0261847307	11.3073728085	144.153686523	315.526096344	.77439819276	1.14694823325
7.68	2.	.0262272535	10.8081812859	145.260269165	316.186866760	.77680894732	1.14678134024
8.06	4.	.0262699455	10.3356910944	146.366987228	316.848381042	.77920921892	1.14662750065
8.45	6.	.0263128113	9.8882393837	147.473888397	317.510616302	.78159920126	1.14648644626
8.86	8.	.0263558549	9.4642803669	148.581024170	318.173549652	.78397908062	1.14635792375
9.28	10.	.0263990809	9.0623762608	149.688446045	318.837158203	.78634905070	1.14624169469
9.72	12.	.0264424935	8.6811888218	150.796201706	319.501426697	.78870929778	1.14613747597
10.17	14.	.0264860971	8.3194719553	151.904340744	320.166328430	.79106000811	1.14604505897
10.64	16.	.0265298965	7.9760641456	153.012912750	320.831844330	.79340135306	1.14596420527
11.13	18.	.0265738964	7.6498827338	154.121967316	321.497951508	.79573351145	1.14589466155
11.63	20.	.0266181012	7.3399175406	155.231550217	322.164627075	.79805665463	1.14583620429
12.16	22.	.0266625155	7.0452255011	156.341711044	322.831855774	.80037095398	1.14578862488
12.70	24.	.0267071447	6.7649259567	157.452497482	323.499607086	.80267658830	1.14575168490
13.26	26.	.0267519932	6.4981957674	158.563957214	324.167869568	.80497370660	1.14572517574
13.84	28.	.0267970662	6.2442652583	159.676136017	324.836612701	.80726248026	1.14570890367
14.43	30.	.0268423690	6.0024144450	160.789081573	325.505821228	.80954306573	1.14570264518
15.05	32.	.0268879062	5.7719694376	161.902841568	326.175468445	.81181561947	1.14570619166
15.69	34.	.0269336835	5.5522989035	163.017459869	326.845539093	.81408029795	1.14571936429
16.35	36.	.0269797063	5.3428113461	164.132986069	327.516006470	.81633725762	1.14574193954
17.03	38.	.0270259797	5.1429523826	165.249462128	328.186847687	.81858664006	1.14577375352
17.73	40.	.0270725095	4.9522017241	166.369335730	328.858047485	.82082860172	1.14581459761
18.46	42.	.0271193013	4.7700713277	167.485452652	329.529579163	.82306327671	1.14586430788
19.20	44.	.0271663608	4.5961027741	168.605058670	330.201423645	.82529082149	1.14592267573
19.97	46.	.0272136936	4.4298655987	169.725795746	330.873558044	.82751136273	1.14598953724
20.77	48.	.0272613061	4.2709550261	170.847713470	331.545959473	.82972505689	1.14606472850
21.58	50.	.0273092042	4.1189907193	171.970853806	332.218608856	.83193202317	1.14614804089
22.43	52.	.0273573939	3.9736145735	173.095262527	332.891479492	.83413241059	1.14623935521

Table 3-10 (continued)

23.29	54.	.0274058818	3.8344897628	174.220983505	333.564548492	.83632634580	1.14633846283
24.19	56.	.0274546742	3.7012990713	175.348062515	334.237800598	.83851396292	1.14644521475
25.11	58.	.0275037780	3.5737436414	176.476543427	334.911205292	.84069538862	1.14655944705
26.05	60.	.0275531996	3.4515418112	177.606470108	335.584743500	.84287075698	1.14668C99582
27.02	62.	.0276029457	3.3344280720	178.737888336	336.258392334	.84504018724	1.14680972693
28.02	64.	.0276530238	3.2221519053	179.870840073	336.932125092	.84720380604	1.14694546163
29.05	66.	.0277034407	3.1144769192	181.005373001	337.605922699	.84936174005	1.14708806574
30.11	68.	.0277542041	3.0111799538	182.141527176	338.279762268	.85151410848	1.14723737538
31.19	70.	.0278053212	2.9120501876	183.279352188	338.953613281	.85366103798	1.14739325643
32.31	72.	.0278567998	2.8168885112	184.418888092	339.627456665	.85580263287	1.14755554497
33.46	74.	.0279086474	2.7255066335	185.560180664	340.301269531	.85793902725	1.14772412181
34.63	76.	.0279608727	2.6377265453	186.703273773	340.975021362	.86007032543	1.14789883792
35.84	78.	.0280134834	2.5533797741	187.848213196	341.648693085	.86219664663	1.14807954431
37.08	80.	.0280664880	2.4723069370	188.995042801	342.322254181	.86431811005	1.14826610684
38.35	82.	.0281198951	2.3943571150	190.143808365	342.995681763	.86643482000	1.14845840633
39.66	84.	.0281737139	2.3193874061	191.294553757	343.668949127	.86854689568	1.14865627885
40.99	86.	.0282279530	2.2472623587	192.447322845	344.342029572	.87065444142	1.14885962009
42.37	88.	.0282826221	2.1778535545	193.602165222	345.014892578	.87275756896	1.14906828105
43.77	90.	.0283377303	2.1110393405	194.759120941	345.687519073	.87485638261	1.14928214252
45.21	92.	.0283932877	2.0467042029	195.918237686	346.359874725	.87695100158	1.14950105548
46.69	94.	.0284493044	1.9847386181	197.079563141	347.031932831	.87904153019	1.14972493052
48.21	96.	.0285057905	1.9250385463	198.243141174	347.703666687	.88112806529	1.14995360374
49.76	98.	.0285627565	1.8675052524	199.409019470	348.375045776	.88321071863	1.15018698573
51.34	100.	.0286202137	1.8120449036	2C0.577243805	349.046035767	.88528960198	1.15042491257
52.97	102.	.0286781730	1.7585683763	2C1.747861862	349.716609955	.88736480474	1.15066730976
54.63	104.	.0287366458	1.7069908977	202.920921326	350.386741638	.88943643868	1.15091401339
56.34	106.	.0287956442	1.6572319120	204.096467972	351.056388855	.89150460809	1.15116491914
58.08	108.	.0288551804	1.6092147678	205.274553299	351.725528717	.89356941730	1.15141990781
59.87	110.	.0289152665	1.5628665239	206.455224991	352.394123077	.89563096315	1.15167886019
61.69	112.	.0289759159	1.5181177557	2C7.638528824	353.062137604	.89768934995	1.15194165707
63.56	114.	.0290371417	1.4749023467	208.824520111	353.729541779	.89974467456	1.15220817924
65.47	116.	.0290989578	1.4331573695	210.013242722	354.396297455	.90179704875	1.15247830749
67.42	118.	.0291613780	1.3928228021	211.204753876	355.062366486	.90384656936	1.15275192261
69.41	120.	.0292244172	1.3538414985	212.399099350	355.727710724	.90589333326	1.15302892029
71.45	122.	.0292880903	1.3161589354	213.596334457	356.392299652	.90793744475	1.15330916643
73.53	124.	.0293524128	1.2797231376	214.796510696	357.056087494	.90997900814	1.15359255672
75.66	126.	.0294174009	1.2444845289	215.999683380	357.719036102	.91201812029	1.15387897193
77.84	128.	.0294830711	1.2103957683	217.205904007	358.381103516	.91405487806	1.15416830778
80.06	130.	.0295494404	1.1774116904	218.415227890	359.042247772	.91608939320	1.15446041524
82.33	132.	.0296165266	1.1454891860	219.627712250	359.702426910	.91812177002	1.15475520492
84.64	134.	.0296843483	1.1145870537	220.843414307	360.361591339	.92015209794	1.15505255759
87.01	136.	.0297529241	1.0846659243	222.062391281	361.019702911	.92218048871	1.15535235405
89.42	138.	.0298222739	1.0556882173	223.284700394	361.676704407	.92420703918	1.15565446019
91.89	140.	.0298924181	1.0276179612	224.510402679	362.332553864	.92623186111	1.15595878661
94.40	142.	.0299633776	1.0004207939	225.739559174	362.987201691	.92825505883	1.15626518428
96.97	144.	.0300351745	.9740638360	226.972232819	363.640594482	.93027672917	1.15657354891
99.58	146.	.0301078313	.9485156089	228.208484650	364.292675018	.93229699135	1.15688376129
102.25	148.	.0301813718	.9237460271	229.448383331	364.943393707	.93431594223	1.15719570220
104.98	150.	.0302558204	.8997262567	230.691993713	365.592689514	.93633369356	1.15750925243
107.75	152.	.0303312025	.8764287084	231.939382553	366.240505219	.93835035712	1.15782426298
110.59	154.	.0304075447	.8538269550	233.190618515	366.886783600	.94036604464	1.15814C62953
113.47	156.	.0304848747	.8318956569	234.445775986	367.531455994	.94238086790	1.15845823288
116.42	158.	.0305632208	.8106105700	235.704925537	368.174457550	.94439493865	1.15877692401
119.42	160.	.0306426135	.7899484113	236.968141556	368.815727234	.94640838355	1.15909658372
122.47	162.	.0307230833	.7698868811	238.235502243	369.455188751	.94842130691	1.15941707790
125.59	164.	.0308046632	.7504045814	239.507087708	370.092777252	.95043384284	1.15973827243
128.76	166.	.0308873870	.7314810008	240.782978058	370.728408813	.95244610310	1.16006C03320
132.03	168.	.0309711159	.7121785358	242.063331604	371.344814301	.95445713401	1.16032706201
135.29	170.	.0310564002	.6951865554	243.348012924	371.992622375	.95647026598	1.16070188582
138.68	172.	.0311425806	.6769392937	244.637384415	372.603763580	.95848128945	1.16096812487
142.10	174.	.0312302317	.6600441635	245.931346893	373.229557037	.96049365401	1.16128788888
145.58	176.	.0313192219	.6436270103	247.230056763	373.853141785	.96250640601	1.16160808504
149.13	178.	.0314095938	.6276615188	248.533615112	374.474208832	.96451967210	1.16192787886
152.74	180.	.0315013928	.6121321023	249.842123032	375.092658997	.96653360873	1.16224712133

Table 3-10 (continued)

156.41	182.	.0315946694	.5970238671	251.155683517	375.708381653	.96854836494	1.16256561875
160.15	184.	.0316894739	.5823225006	252.474407196	376.321273804	.97056407481	1.16288323700
163.96	186.	.0317858611	.5680142492	253.798406601	376.931217194	.97258091718	1.16319978237
167.84	188.	.0318838875	.5540858507	255.127801895	377.538093567	.97459904850	1.16351506114
171.78	190.	.0319836135	.5405245572	256.462715149	378.141780853	.97661863267	1.16382889450
175.79	192.	.0320851025	.5273180902	257.803272247	378.742141724	.97863984853	1.16414110363
179.88	194.	.0321884206	.5144546106	259.149612427	379.339050293	.98066288233	1.16445146501
184.03	196.	.0322936396	.5019227341	260.501869202	379.932357788	.98268791288	1.16475978494
188.25	198.	.0324008339	.4897114746	261.860187531	380.521911621	.98471514881	1.16506585479
192.55	200.	.0325100827	.4778102338	263.224727631	381.107563019	.98674479127	1.16536943614
196.92	202.	.0326214698	.4662087969	264.595645905	381.689144135	.98877704889	1.16567030549
201.37	204.	.0327350851	.4548973180	265.973106384	382.266475677	.99081214517	1.16596822461
205.89	206.	.0328510231	.4438662753	267.357295990	382.839385986	.99285031855	1.16626293957
210.49	208.	.0329693849	.4331064858	268.748390198	383.407676697	.99489182234	1.16655416787
215.16	210.	.0330902790	.4226090796	270.146595001	383.971145630	.99693690240	1.16684167087
219.91	212.	.0332138194	.4123654738	271.552112579	384.529586792	.99898583442	1.16712513566
224.75	214.	.0333401300	.4023673870	272.965164185	385.082767487	1.00103890896	1.16740427911
229.66	216.	.0334693422	.3926067874	274.385986328	385.630451202	1.00309643149	1.16767875850
234.65	218.	.0336015979	.3830759190	275.814823151	386.172389984	1.00515872240	1.16794827580
239.72	220.	.0337370485	.3737672605	277.251934052	386.708312988	1.00722610950	1.16821244359
244.88	222.	.0338758584	.3646735288	278.697608948	387.237945557	1.00929898024	1.16847091913
250.12	224.	.0340182045	.3557876535	280.152141571	387.760974884	1.01137770712	1.16872331500
255.45	226.	.0341642769	.3471027873	281.615852356	388.277091980	1.01346272230	1.16896919906
260.86	228.	.0343142827	.3386122659	283.089084625	388.785933522	1.01555444300	1.16920813918
266.36	230.	.0344684473	.3303096183	284.572212219	389.287193298	1.01765334606	1.16943967342
271.94	232.	.0346270143	.3221885562	286.065631866	389.780426025	1.01975996792	1.16966331005
277.62	234.	.0347902514	.3142429404	287.569774628	390.265239716	1.02187485993	1.16987851262
283.39	236.	.0349584501	.3064667992	289.085102081	390.741184235	1.02399858832	1.17008472979
289.24	238.	.0351319308	.2988542989	290.612125397	391.207786560	1.02613183856	1.17028135061
295.19	240.	.0353110465	.2913997322	292.151397705	391.664531708	1.02827531099	1.17046773434
301.24	242.	.0354961860	.2840975188	293.703517914	392.110862732	1.03042978048	1.17064318061
307.38	244.	.0356877819	.2769421861	295.269149780	392.546188354	1.03259609640	1.17080692947
313.75	246.	.0358844385	.2694143839	296.846176147	392.918743134	1.03476819396	1.17086343467
320.10	248.	.0360901272	.2625016309	298.440567017	393.324150085	1.03696006536	1.17099168897
326.54	250.	.0363039104	.2557353489	300.050922394	393.717689514	1.03916704655	1.17110812664
333.08	252.	.0365264011	.2490942348	301.678138733	394.096889496	1.04139015079	1.17120870948
339.73	254.	.0367583549	.2425724249	303.323314667	394.460720062	1.04363080859	1.17129212618
346.48	256.	.0370006352	.2361646295	304.987689972	394.808120728	1.04589059949	1.17135702074
353.33	258.	.0372542297	.2298655696	306.672668457	395.137916565	1.04817135632	1.17140193284
360.29	260.	.0375202764	.2236699238	308.379852295	395.448810577	1.05047512054	1.17142528296
367.35	262.	.0378000950	.2175723035	310.111072540	395.739356995	1.05280426145	1.17142523825
374.53	264.	.0380952302	.2115672287	311.868446350	396.007949829	1.05516153574	1.17139981687
381.81	266.	.0384075032	.2056490853	313.654449463	396.252780914	1.05755011737	1.17134676874
389.21	268.	.0387390843	.1998121031	315.471984863	396.471828461	1.05997379124	1.17126357555
396.71	270.	.0390925887	.1940502990	317.324504852	396.662807465	1.06243702769	1.17114742100
404.33	272.	.0394712058	.1883574482	319.216175079	396.823116302	1.06494523585	1.17099505663
412.07	274.	.0398788825	.1827270351	321.152061462	396.949802399	1.06750500202	1.17080283165
419.91	276.	.0403205841	.1771522071	323.138450623	397.039497375	1.07012450695	1.17056655884
428.13	278.	.0407916009	.1710954271	325.165470123	396.977752686	1.07278551161	1.17011280358
436.26	280.	.0413185745	.1655263696	327.273044586	396.957088470	1.07554987073	1.16973888874
444.48	282.	.0419049580	.1600118950	329.462142944	396.888622284	1.07841470838	1.16930906475
452.82	284.	.0425652331	.1545136105	331.749542236	396.759639740	1.08140166104	1.16880586743
461.27	286.	.0433210013	.1490187366	334.160049438	396.561660767	1.08454321325	1.16821868718
469.82	288.	.0442049955	.1435168833	336.730354309	396.285518646	1.08788743615	1.16753625870
478.46	290.	.0452700299	.1380006913	339.517974854	395.921501160	1.09150980413	1.16674685478
487.53	292.	.0465435525	.1317647286	342.532356262	395.241024017	1.09541550279	1.16553163528
496.39	294.	.0482772989	.1260181349	346.059757233	394.591705322	1.09999281168	1.16438572109

Table 3-10 (continued)

THERMODYNAMIC PROPERTIES OF N-BUTANE AS PREDICTED BY STARLINGS EQUATION OF STATE

P		T	CPF	CPG	CVF	CVG	ASF	ASG
PSIA		DEG F	BTU/LBM/DEG F	BTU/LBM/DEG F	BTU/LBM/DEG F	BTU/LBM/DEG F	FT/SEC	FT/SEC
1.80		-50.	.7312700227	.3320119008	.394566767	.296747003	417384.7422	620.6709
1.92		-48.	.7262382284	.3334838673	.395002294	.297949739	409391.3828	622.0126
2.05		-46.	.7212918252	.3349398449	.395438053	.299155988	401588.9648	623.3132
2.18		-44.	.7164301276	.3363780566	.395874359	.300364215	393971.9687	624.5793
2.32	*	-42.	.7116524577	.3378001079	.396311514	.301574443	386535.1133	625.8125
2.46		-40.	.7069581375	.3392075710	.396749809	.302786693	379273.3008	627.0141
2.62		-38.	.7023464665	.3406019434	.397189517	.304001004	372181.6016	628.1852
2.78		-36.	.6978167146	.3419846632	.397630896	.305217404	365255.2383	629.3272
2.95		-34.	.6933681592	.3433570936	.398074191	.306435917	358489.5937	630.4410
3.12		-32.	.6890000552	.3447205462	.398519628	.307656575	351880.1953	631.5276
3.31		-30.	.6847116351	.3460762575	.398967423	.308879405	345422.7148	632.5882
3.50		-28.	.6805021390	.3474254236	.399417780	.310104437	339112.9531	633.6236
3.71		-26.	.6763707772	.3487691656	.399870891	.311331697	332946.8477	634.6346
3.92	*	-24.	.6723167673	.3501085639	.400326937	.312561210	326920.4570	635.6220
4.14		-22.	.6683393791	.3514505289	.400786113	.313795581	321030.0859	636.5773
4.37		-20.	.6644376591	.3527846746	.401248533	.315029856	315271.7930	637.5190
4.62		-18.	.6606108621	.3541174047	.401714366	.316266473	309642.1055	638.4392
4.87		-16.	.6568581536	.3554496020	.402183753	.317505453	304137.5312	639.3384
5.13		-14.	.6531787142	.3567820899	.402656831	.318746816	298754.6953	640.2171
5.41		-12.	.6495717019	.3581156507	.403133720	.319990590	293490.3164	641.0759
5.69		-10.	.6460362747	.3594510294	.403614540	.321236797	288341.2109	641.9151
5.99		-8.	.6425715834	.3607829228	.404099397	.322485458	283304.2891	642.7353
6.30	*	-6.	.6391767859	.3621299863	.404588398	.323736593	278376.5508	643.5366
6.63		-4.	.6358510107	.3634748422	.405081633	.324990220	273555.0820	644.3196
6.96		-2.	.6325934157	.3648240790	.405579194	.326246362	268837.0547	645.0844
7.31		0.	.6294031367	.3661782332	.406081166	.327505037	264219.7187	645.8313
7.68		2.	.6262793094	.3675378263	.406587623	.328766264	259700.4141	646.5606
8.06		4.	.6232210696	.3689033352	.407098636	.330030061	255276.5410	647.2723
8.45		6.	.6202275604	.3702752069	.407614280	.331296444	250945.5859	647.9668
8.86		8.	.6172979176	.3716538548	.408134609	.332565427	246705.0996	648.6440
9.28		10.	.6144312769	.3730396740	.408659685	.333837025	242552.7090	649.3040
9.72		12.	.6116267741	.3744330145	.409189563	.335111260	238486.1035	649.9470
10.17		14.	.6088835523	.3758342117	.409724288	.336388137	234503.0371	650.5730
10.64		16.	.6062007546	.3772435673	.410263903	.337667678	230601.3301	651.1820
11.13		18.	.6035775170	.3786613606	.410808459	.338949893	226778.8652	651.7740
11.63		20.	.6010129899	.3800878488	.411357984	.340234790	223033.5820	652.3488
12.16		22.	.5985063240	.3815232553	.411912519	.341522388	219363.4766	652.9066
12.70		24.	.5960566625	.3829677925	.412472092	.342812695	215766.6055	653.4471
13.26		26.	.5936631709	.3844216429	.413036734	.344105717	212241.0781	653.9703
13.84		28.	.5913250074	.3858849667	.413606465	.345401470	208785.0566	654.4761
14.43		30.	.5890413374	.3873579130	.414181314	.346699961	205396.7539	654.9643
15.05		32.	.5868113264	.3888406008	.414761301	.348001201	202074.4336	655.4347
15.69		34.	.5846341550	.3903331347	.415346436	.349305194	198816.4082	655.8872
16.35		36.	.5825089961	.3918355964	.415936746	.350611947	195621.0371	656.3215
17.03		38.	.5804359451	.3933480531	.416532233	.351921476	192486.7266	656.7375
17.73		40.	.5784114823	.3948705569	.417132918	.353233777	189411.9277	657.1349
18.46		42.	.5764375180	.3964031301	.417738803	.354548860	186395.1328	657.5135
19.20		44.	.5745123476	.3979457952	.418349696	.355866734	183434.8770	657.8729
19.97		46.	.5726351887	.3994985446	.418966204	.357187398	180529.7402	658.2130
20.77		48.	.5708052590	.4010613598	.419587735	.358510859	177678.3359	658.5334
21.58		50.	.5690217763	.4026342072	.420214485	.359837122	174879.3223	658.8337
22.43		52.	.5672839880	.4042170346	.420846459	.361166187	172131.3926	659.1138
23.29		54.	.5655911267	.4058097824	.421483651	.362498064	169433.2754	659.3732
24.19		56.	.5639424473	.4074123614	.422126066	.363832746	166783.7402	659.6115
25.11		58.	.5623371974	.4090246782	.422773696	.365170244	164181.5840	659.8285

Table 3-10 (continued)

26.05	60.	.5607746542	.4106466211	.423426539	.366510551	161625.6426	660.0238
27.02	62.	.5592540801	.4122780673	.424084589	.367853679	159114.7852	660.1968
28.02	64.	.5577747598	.4139188677	.424747840	.369199619	156647.9102	660.3474
29.05	66.	.5563359931	.4155688733	.425416283	.370548379	154223.9492	660.4749
30.11	68.	.5549370721	.4172279052	.426089909	.371899955	151841.8613	660.5791
31.19	70.	.5535773113	.4188957810	.426768713	.373254348	149500.6387	660.6594
32.31	72.	.5522560254	.4205722958	.427452683	.374611557	147199.3008	660.7154
33.46	74.	.5509725362	.4222572297	.428141806	.375971578	144936.8926	660.7466
34.63	76.	.5497261807	.4239503518	.428836077	.377334420	142712.4922	660.7526
35.84	78.	.5485163108	.4256514050	.429535475	.378700070	140525.1973	660.7329
37.08	80.	.5473422855	.4273601286	.430239998	.380068533	138374.1348	660.6870
38.35	82.	.5462034494	.4290762320	.430949621	.381439805	136258.4570	660.[illegible]143
39.66	84.	.5450991988	.4307994135	.431664344	.382813886	134177.3379	660.5143
40.99	86.	.5440289006	.4325293601	.432384141	.384190772	132129.9785	660.3865
42.37	88.	.5429919586	.4342657253	.433109004	.385570459	130115.6025	660.2304
43.77	90.	.5419877693	.4360081591	.433838919	.386952944	128133.4512	660.0453
45.21	92.	.5410157517	.4377562813	.434573870	.388338231	126182.7939	659.8307
46.69	94.	.5400753170	.4395096973	.435313839	.389726307	124262.9170	659.5860
48.21	96.	.5391658992	.4412679933	.436058816	.391117174	122373.1299	659.3107
49.76	98.	.5382869467	.4430307336	.436808780	.392510831	120512.7598	659.0040
51.34	100.	.5374379084	.4447974600	.437563721	.393907271	118681.1562	658.6653
52.97	102.	.5366182402	.4465676919	.438323621	.395306494	116877.6836	658.2941
54.63	104.	.5358274132	.4483409263	.439088464	.396708488	115101.7295	657.8896
56.34	106.	.5350649208	.4501166455	.439858232	.398113262	113352.6953	657.4513
58.08	108.	.5343302339	.4518942982	.440632917	.399520803	111630.0029	656.9784
59.87	110.	.5336228609	.4536733180	.441412494	.400931109	109933.0898	656.4702
61.69	112.	.5329423100	.4554531053	.442196958	.402344182	108261.4092	655.9260
63.56	114.	.5322881043	.4572330453	.442986283	.403760012	106614.4316	655.3452
65.47	116.	.5316597670	.4590125009	.443780463	.405178599	104991.6426	654.7270
67.42	118.	.5310568362	.4607907981	.444579482	.406599939	103392.5430	654.0707
69.41	120.	.5304788575	.4625672475	.445383321	.408024032	101816.6484	653.3755
71.45	122.	.5299253911	.4643411413	.446191970	.409450870	100263.4883	652.6407
73.53	124.	.5293960050	.4661117308	.447005413	.410880450	98732.6064	651.8656
75.66	126.	.5288902745	.4678782597	.447823644	.412312776	97223.5605	651.0493
77.84	128.	.5284077749	.4696399458	.448646639	.413747840	95735.9209	650.1911
80.06	130.	.5279481113	.4713959731	.449474398	.415185645	94269.2705	649.2902
82.33	132.	.5275108814	.4731455185	.450306900	.416626181	92823.2051	648.3460
84.64	134.	.5270956978	.4748877287	.451144140	.418069456	91397.3320	647.3574
87.01	136.	.5267021805	.4766217396	.451986104	.419515464	89991.2715	646.3239
89.42	138.	.5263299644	.4783466607	.452832788	.420964208	88604.6543	645.2447
91.89	140.	.5259786919	.4800615907	.453684181	.422415681	87237.1230	644.1188
94.40	142.	.5256479979	.4817656167	.454540275	.423869893	85888.3291	642.9457
96.97	144.	.5253375471	.4834578075	.455401067	.425326835	84557.9365	641.7245
99.58	146.	.5250470042	.4851372279	.456266545	.426786516	83245.6201	640.4546
102.25	148.	.5247760415	.4868029356	.457136709	.428248934	81951.0615	639.1351
104.98	150.	.5245243460	.4884539805	.458011556	.429714095	80673.9551	637.7654
107.75	152.	.5242915973	.4900894202	.458891086	.431182001	79414.0029	636.3448
110.59	154.	.5240775123	.4917083159	.459775295	.432652652	78170.9170	634.8727
113.47	156.	.5238817930	.4933097251	.460664183	.434126060	76944.4189	633.3484
116.42	158.	.5237041614	.4948927276	.461557757	.435602229	75734.2363	631.7712
119.42	160.	.5235443041	.4964564182	.462456018	.437081162	74540.1084	630.1407
122.47	162.	.5234019980	.4979999103	.463358972	.438562866	73361.7803	628.4564
125.59	164.	.5232769698	.4995223433	.464266628	.440047357	72199.0059	626.7177
128.76	166.	.5231689736	.5010228828	.465178996	.441534638	71051.5479	624.9243
132.03	168.	.5230796486	.5025392100	.466096427	.443051588	69922.1035	622.8761
135.29	170.	.5230031908	.5039570481	.467017934	.444518998	68801.8154	621.1615
138.68	172.	.5229468420	.5054242462	.467944853	.446042724	67702.0400	618.9899
142.10	174.	.5229047388	.5068301857	.468876217	.447542988	66613.8193	616.9596
145.58	176.	.5228785127	.5082101896	.469812375	.449045841	65539.8047	614.8753
149.13	178.	.5228679776	.5095641166	.470753346	.450551629	64479.8364	612.7345
152.74	180.	.5228729472	.5108915046	.471699167	.452060379	63433.7275	610.5371
156.41	182.	.5228932351	.5121919438	.472649861	.453572113	62401.2949	608.2835
160.15	184.	.5229286626	.5134650990	.473605469	.455086857	61382.3623	605.9738
163.96	186.	.5229790583	.5147107020	.474566028	.456604637	60376.7593	603.6085

Table 3-10 (continued)

167.84	188.	.5230442584	.5159285963	.475531578	.458125491	59384.3223	601.1879
171.78	190.	.5231241211	.5171186924	.476502165	.459649444	58404.8931	598.7127
175.79	192.	.5232184827	.5182809904	.477477841	.461176537	57438.3174	596.1837
179.88	194.	.5233272240	.5194155797	.478458662	.462706804	56484.4492	593.6016
184.03	196.	.5234502107	.5205226466	.479444694	.464240286	55543.1460	590.9676
188.25	198.	.5235873237	.5216024816	.480435997	.465777028	54614.2715	588.2827
192.55	200.	.5237384588	.5226554573	.481432650	.467317078	53697.6929	585.5483
196.92	202.	.5239035040	.5236820281	.482434735	.468860488	52793.2842	582.7660
201.37	204.	.5240823850	.5246827751	.483442333	.470407311	51900.9238	579.9374
205.89	206.	.5242750049	.5256583318	.484455545	.471957602	51020.4941	577.0644
210.49	208.	.5244813114	.5266094506	.485474471	.473511428	50151.8833	574.1492
215.16	210.	.5247012302	.5275369510	.486499228	.475068856	49294.9824	571.1940
219.91	212.	.5249347165	.5284417495	.487529937	.476629954	48449.6885	568.2014
224.75	214.	.5251817405	.5293248221	.488566734	.478194799	47615.9023	565.1744
229.66	216.	.5254422650	.5301872417	.489609767	.479763478	46793.5278	562.1161
234.65	218.	.5257162973	.5310301334	.490659188	.481336072	45982.4736	559.0298
239.72	220.	.5260038301	.5318546817	.491715178	.482912682	45182.6528	555.9195
244.88	222.	.5263048857	.5326621309	.492777921	.484493408	44393.9805	552.7893
250.12	224.	.5266194940	.5334537923	.493847631	.486078355	43616.3760	549.6439
255.45	226.	.5269477069	.5342309922	.494924527	.487667639	42849.7622	546.4883
260.86	228.	.5272896066	.5349951237	.496008854	.489261389	42094.0635	543.3280
266.36	230.	.5276452675	.5357475877	.497100893	.490859736	41349.2090	540.1694
271.94	232.	.5280148163	.5364898145	.498200934	.492462821	40615.1270	537.0191
277.62	234.	.5283983871	.5372232571	.499309301	.494070798	39891.7505	533.8846
283.39	236.	.5287961438	.5379493533	.500426352	.495683838	39179.0122	530.7744
289.24	238.	.5292082876	.5386696532	.501552492	.497302108	38476.8462	527.6974
295.19	240.	.5296350420	.5393855274	.502688147	.498925805	37785.1851	524.6641
301.24	242.	.5300766826	.5400984660	.503833801	.500555135	37103.9624	521.6855
307.38	244.	.5305335149	.5408099219	.504989989	.502190314	36433.1089	518.7745
313.75	246.	.5310101882	.5415178314	.506155826	.503890343	35780.0229	515.5208
320.10	248.	.5314989090	.5422303230	.507334605	.505544022	35130.4614	512.7577
326.54	250.	.5320039392	.5429457873	.508525930	.507202759	34490.8345	510.1239
333.08	252.	.5325259641	.5436654985	.509730577	.508868702	33861.2842	507.6262
339.73	254.	.5330656245	.5443907902	.510949492	.510542296	33241.7178	505.2867
346.48	256.	.5336236581	.5451229736	.512183733	.512223937	32632.0178	503.1307
353.33	258.	.5342009142	.5458633453	.513434500	.513914041	32032.0452	501.1867
360.29	260.	.5347983986	.5466131493	.514703184	.515613094	31441.6331	499.4870
367.35	262.	.5354172662	.5473735929	.515991382	.517321594	30860.5776	498.0683
374.53	264.	.5360588878	.5481458679	.517300941	.519040100	30288.6274	496.9720
381.81	266.	.5367248952	.5489311218	.518634029	.520769231	29725.4668	496.2454
389.21	268.	.5374172106	.5497304574	.519993186	.522509649	29170.6953	495.9422
396.71	270.	.5381381735	.5505449623	.521381453	.524262071	28623.7981	496.1237
404.33	272.	.5388906077	.5513756797	.522802480	.526027292	28084.1050	496.8605
412.07	274.	.5396780223	.5522236153	.524260707	.527806163	27550.7305	498.2333
419.91	276.	.5405047685	.5530897304	.525761634	.529599592	27022.4863	500.3352
428.13	278.	.5413769558	.5539881214	.527298138	.531508148	26510.6213	503.3338
436.26	280.	.5422991216	.5548979416	.528902143	.533352509	25989.7859	507.3682
444.48	282.	.5432819650	.5558285266	.530575514	.535210855	25466.7070	512.5538
452.82	284.	.5443380624	.5567813143	.532332502	.537089802	24937.5095	519.0786
461.27	286.	.5454850197	.5577569380	.534193754	.538990922	24395.3152	527.1635
469.82	288.	.5467486903	.5587555766	.536189191	.540914923	23829.0552	537.0686
478.46	290.	.5481692031	.5597766787	.538364306	.542861134	23219.8926	549.0951
487.53	292.	.5497742221	.5608577430	.540718853	.544982530	22565.3835	565.3478
496.39	294.	.5517223626	.5619306043	.543471642	.547008120	21753.5974	583.6882

*The lack of values for entropy and enthalpy departures and for specific heat references does not permit an accurate calculation of the shown thermodynamic properties in this temperature range.

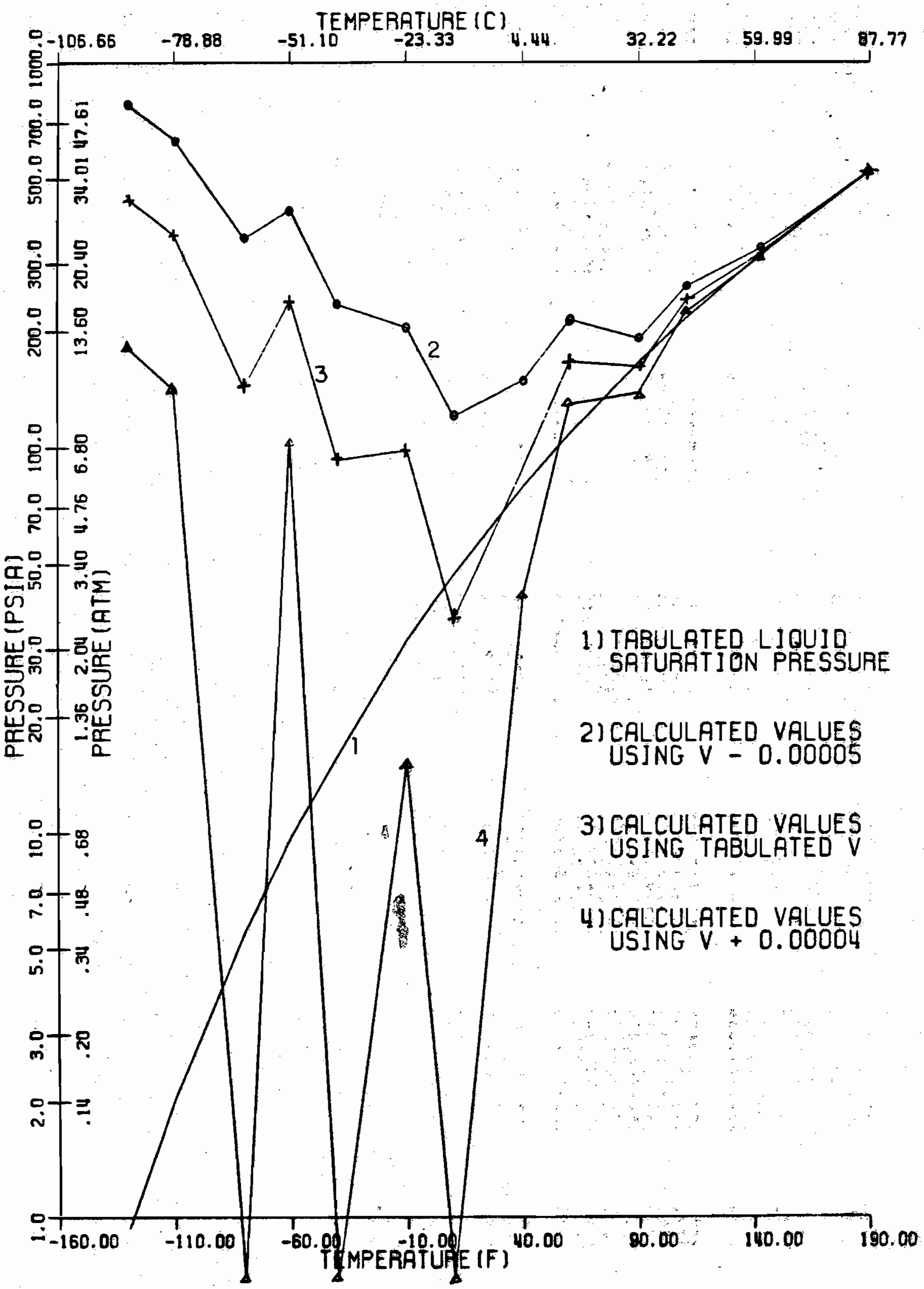


Figure 3-1. Saturation Pressures vs. Saturation Temperatures

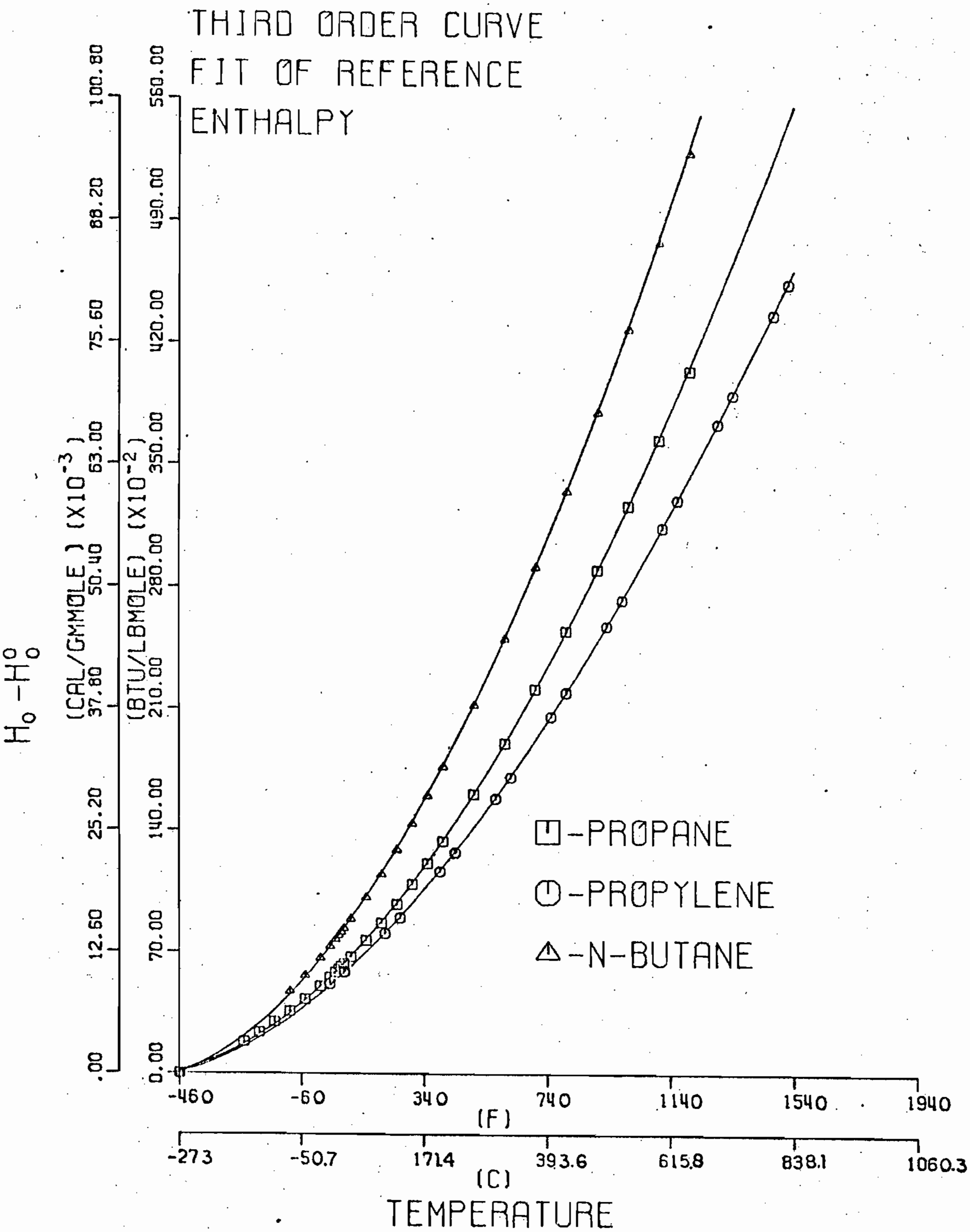


Figure 3-2a. Enthalpy Departures as a Function of Temperature for Propane, Propylene, and N-Butane.

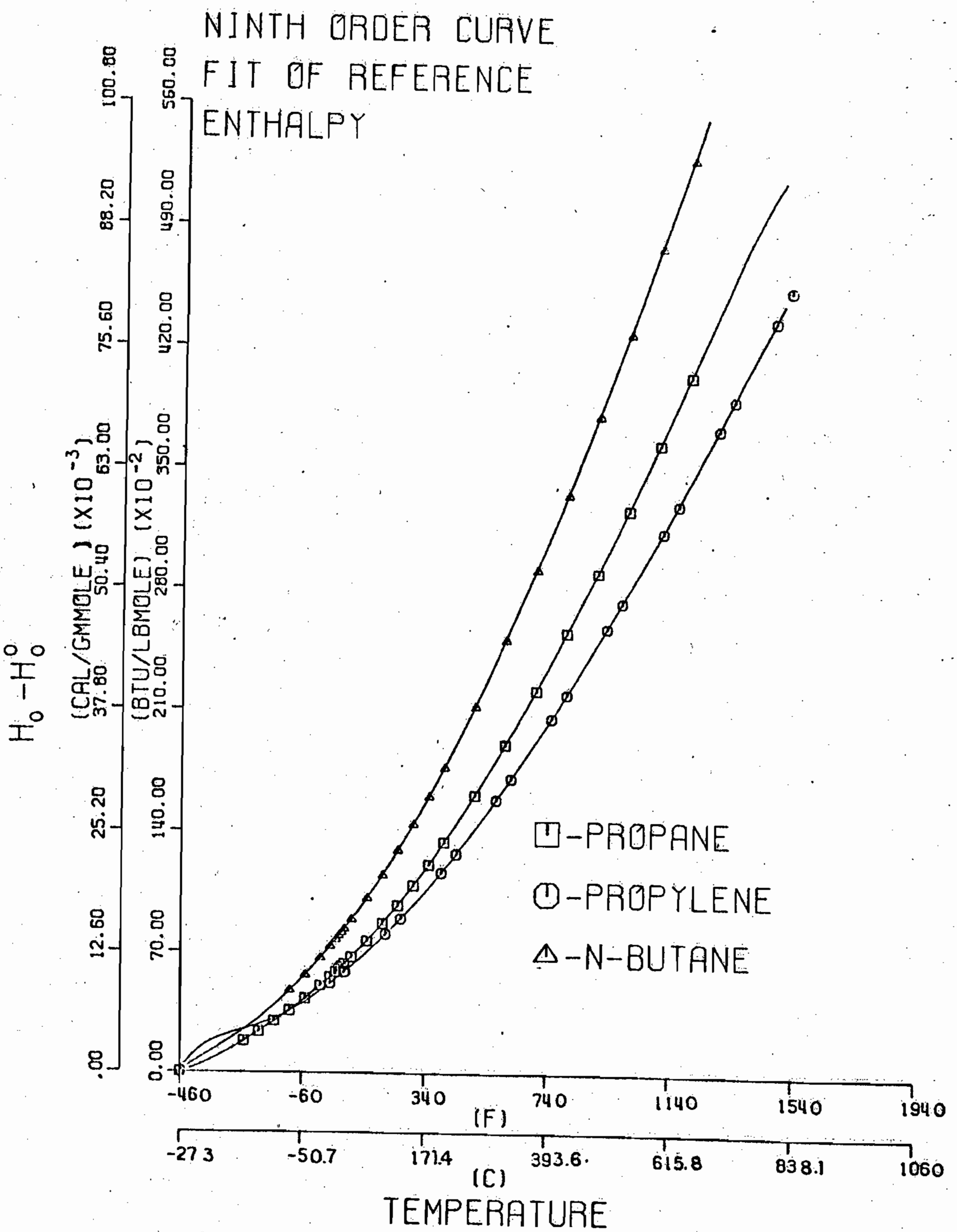


Figure 3-2b. Enthalpy Departures as a Function of Temperature for Propane, Propylene, and N-Butane.

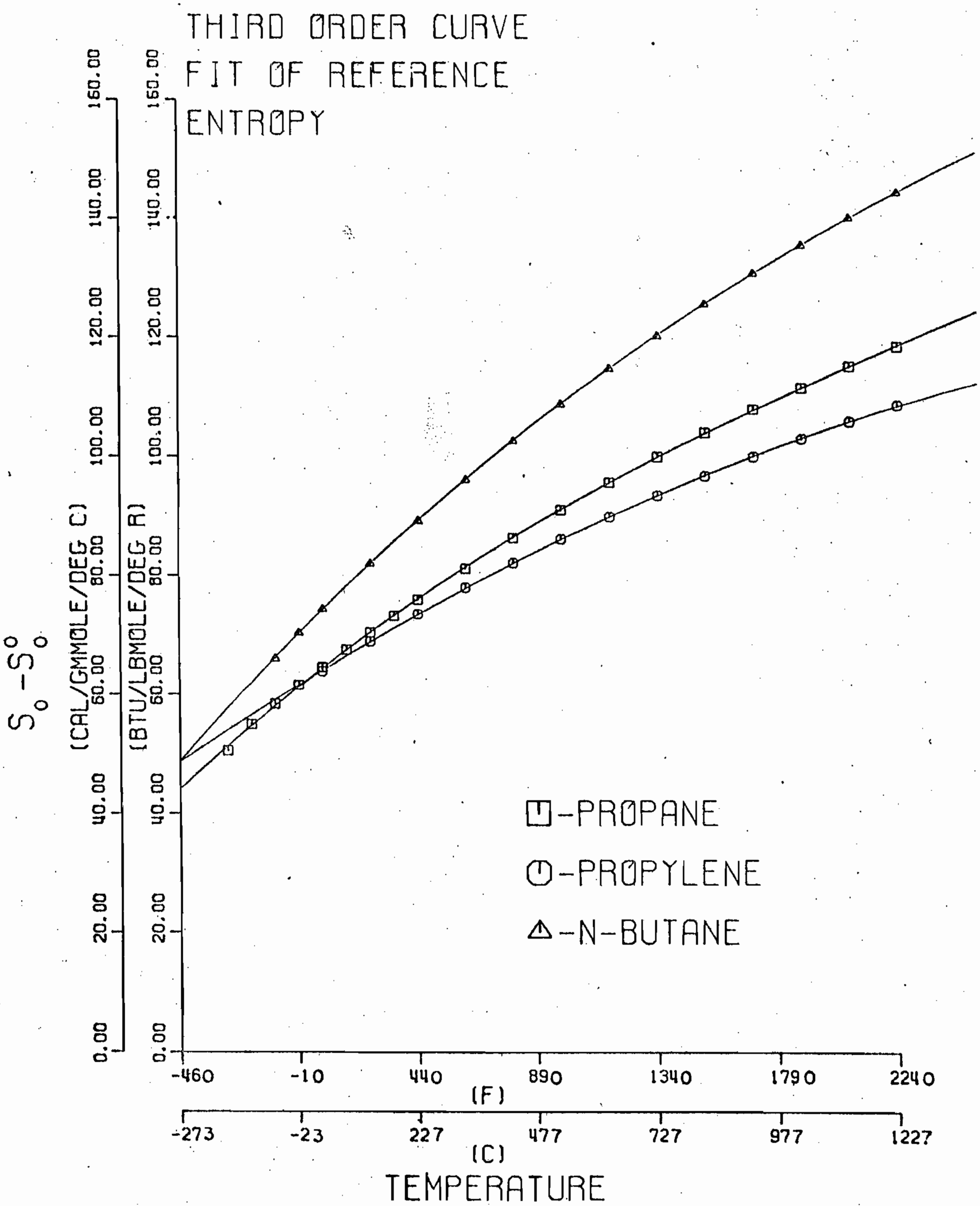


Figure 3-3a. Entropy Departures as a Function of Temperature for Propane, Propylene, and N-Butane.

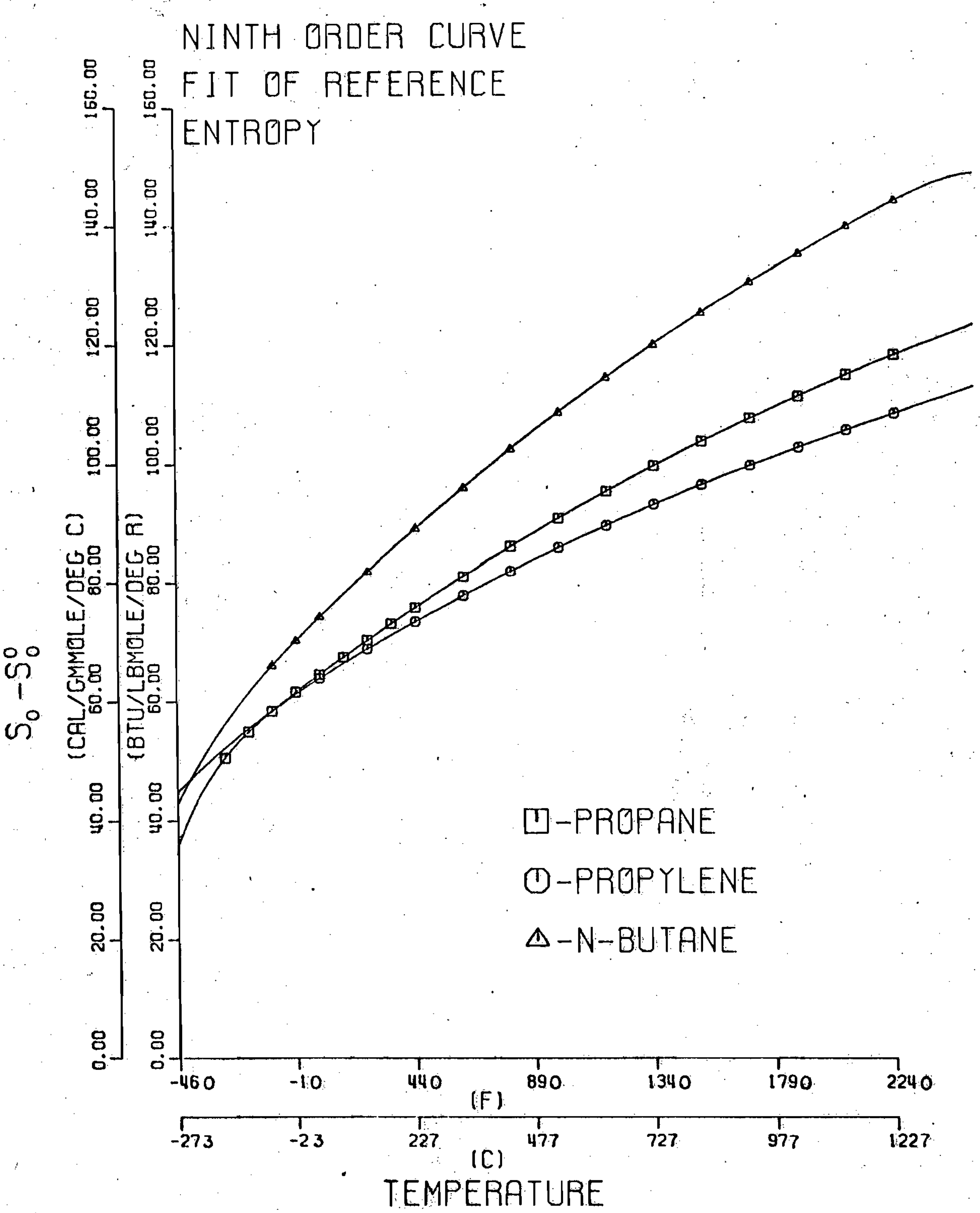


Figure 3-3b. Entropy Departures as a Function of Temperature for Propane, Propylene, and N-Butane.

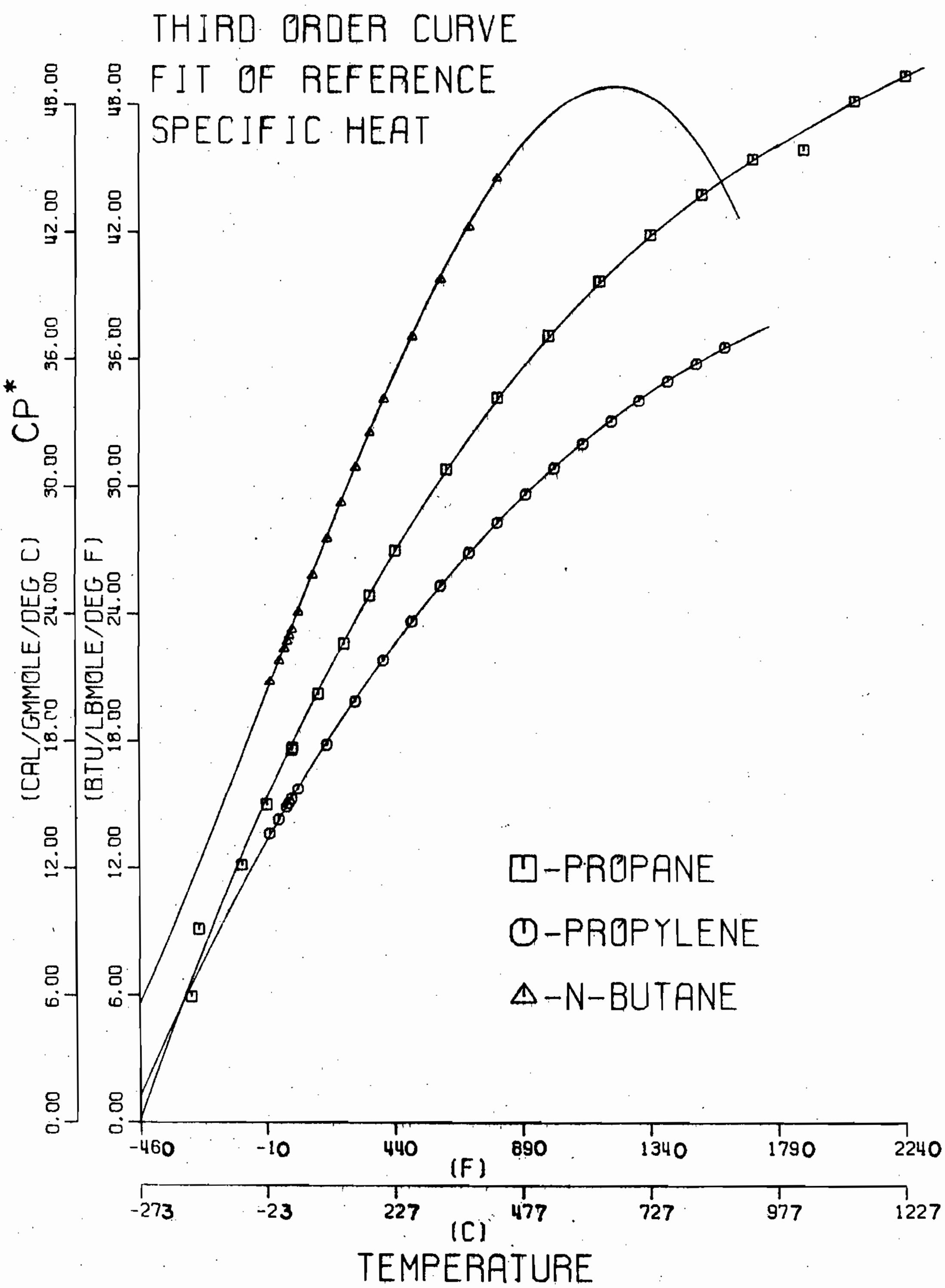


Figure 3-4a. Specific Heat Reference Values as a Function of Temperature for Propane, Propylene, and N-Butane

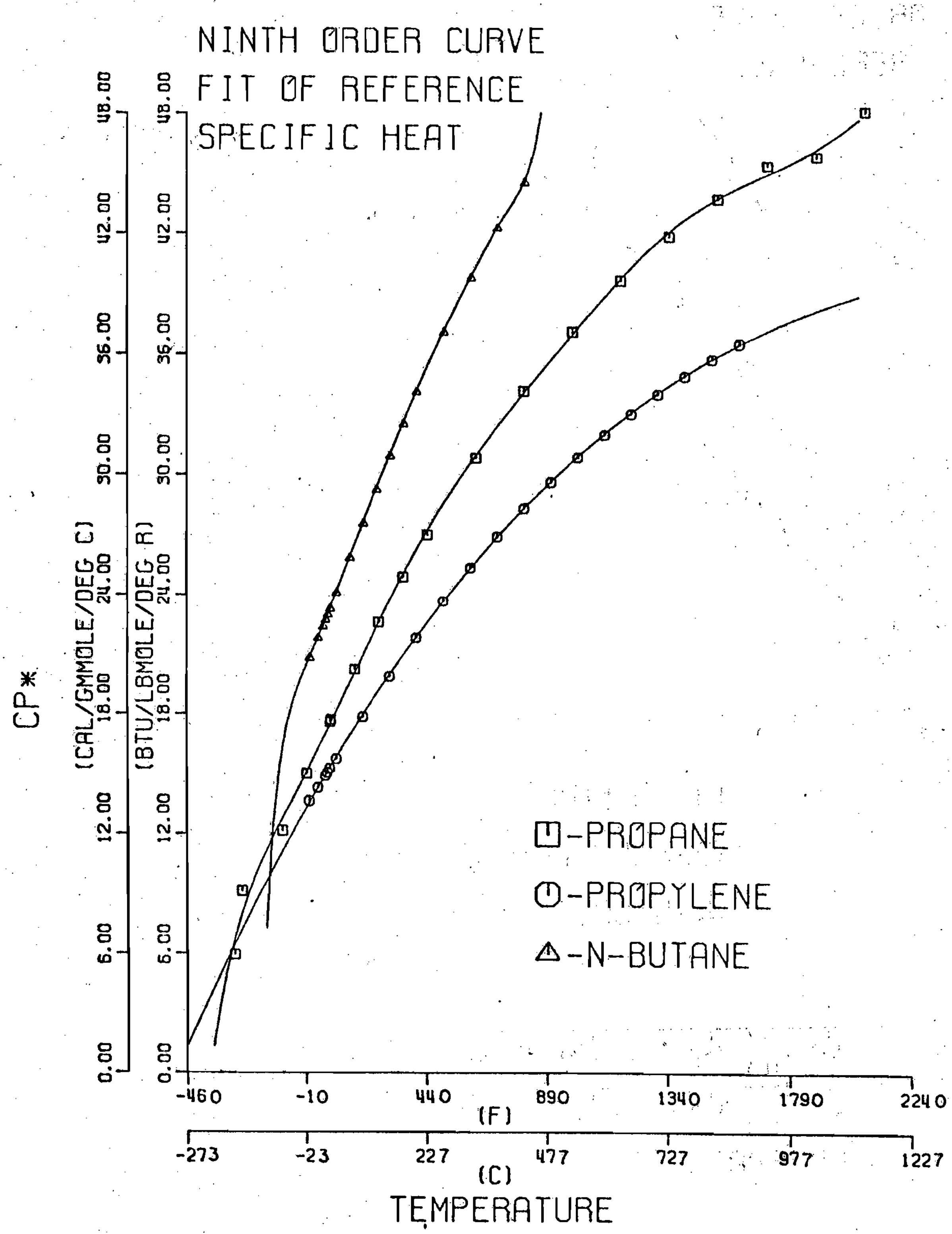


Figure 3-4b. Specific Heat Reference Values as a Function of Temperature for Propane, Propylene, and N-Butane

Figure 3-5. Temperature-Entropy Diagram for Propane Based on the Benedict-Webb-Rubin Equation of State

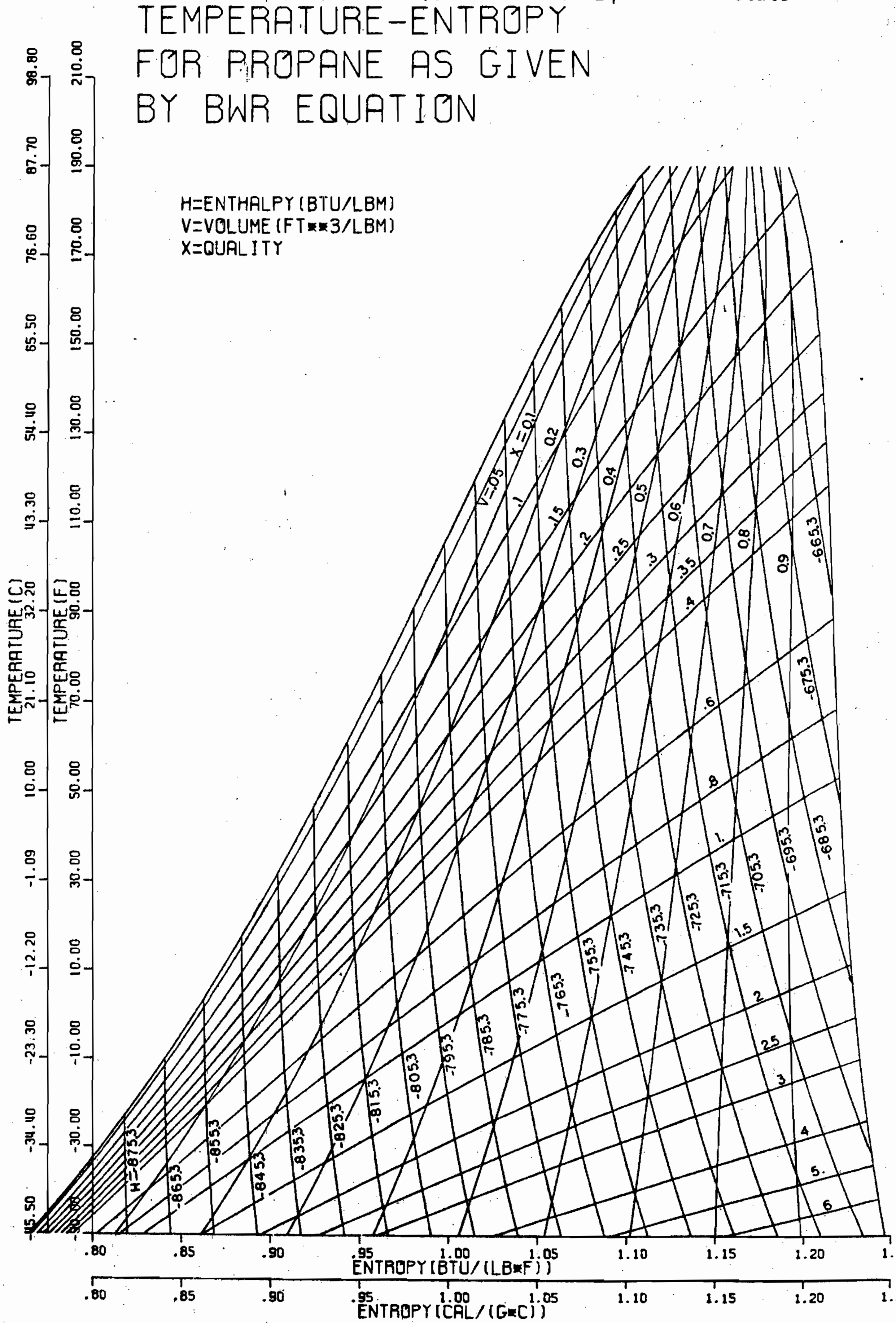


Figure 3-6. Temperature-Entropy Diagram for Propane Based on Starling's Equation of State

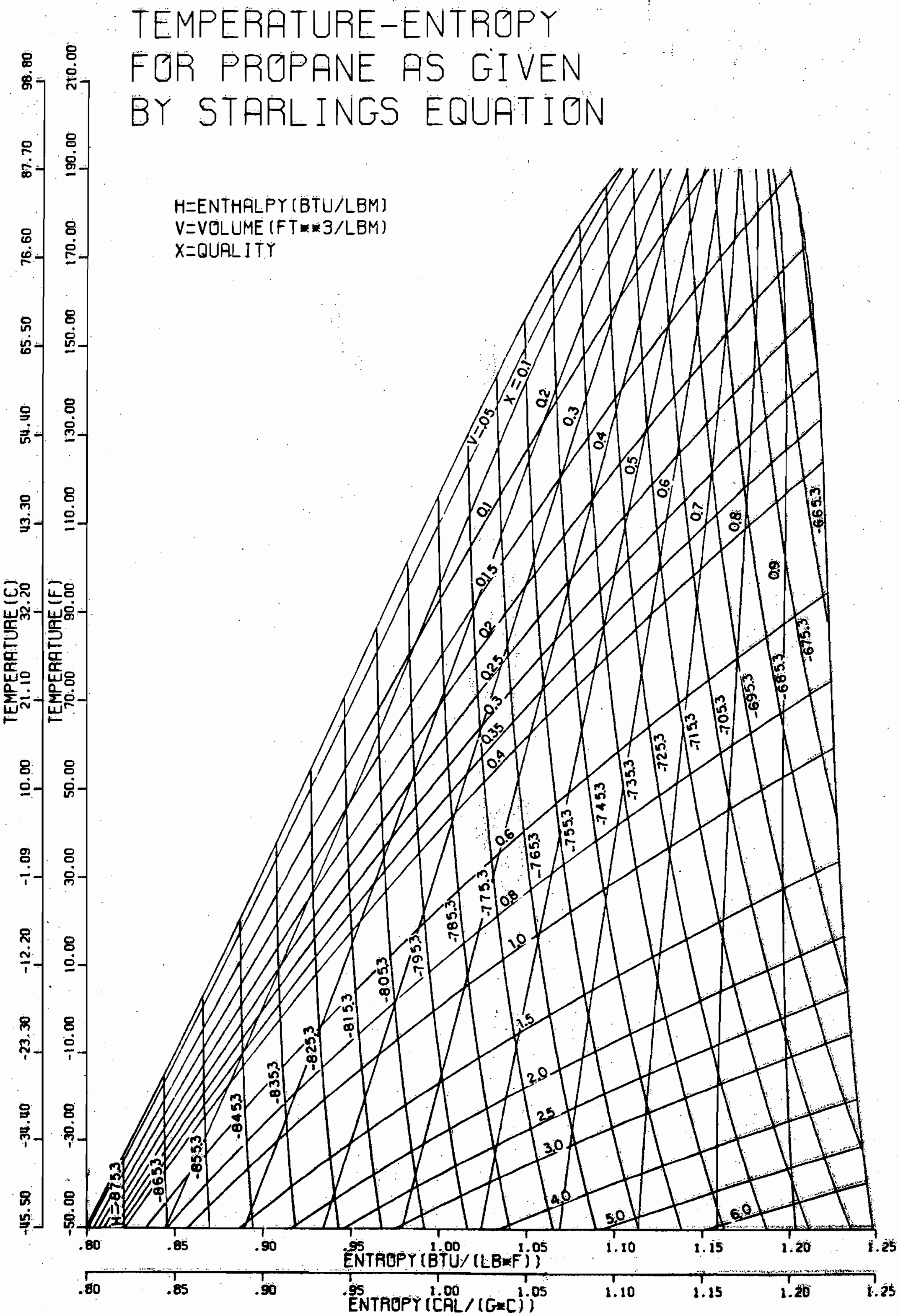


Figure 3-7. Temperature-Entropy Diagram for Propane Based on the Thermodynamic Data Given by Stearns and George

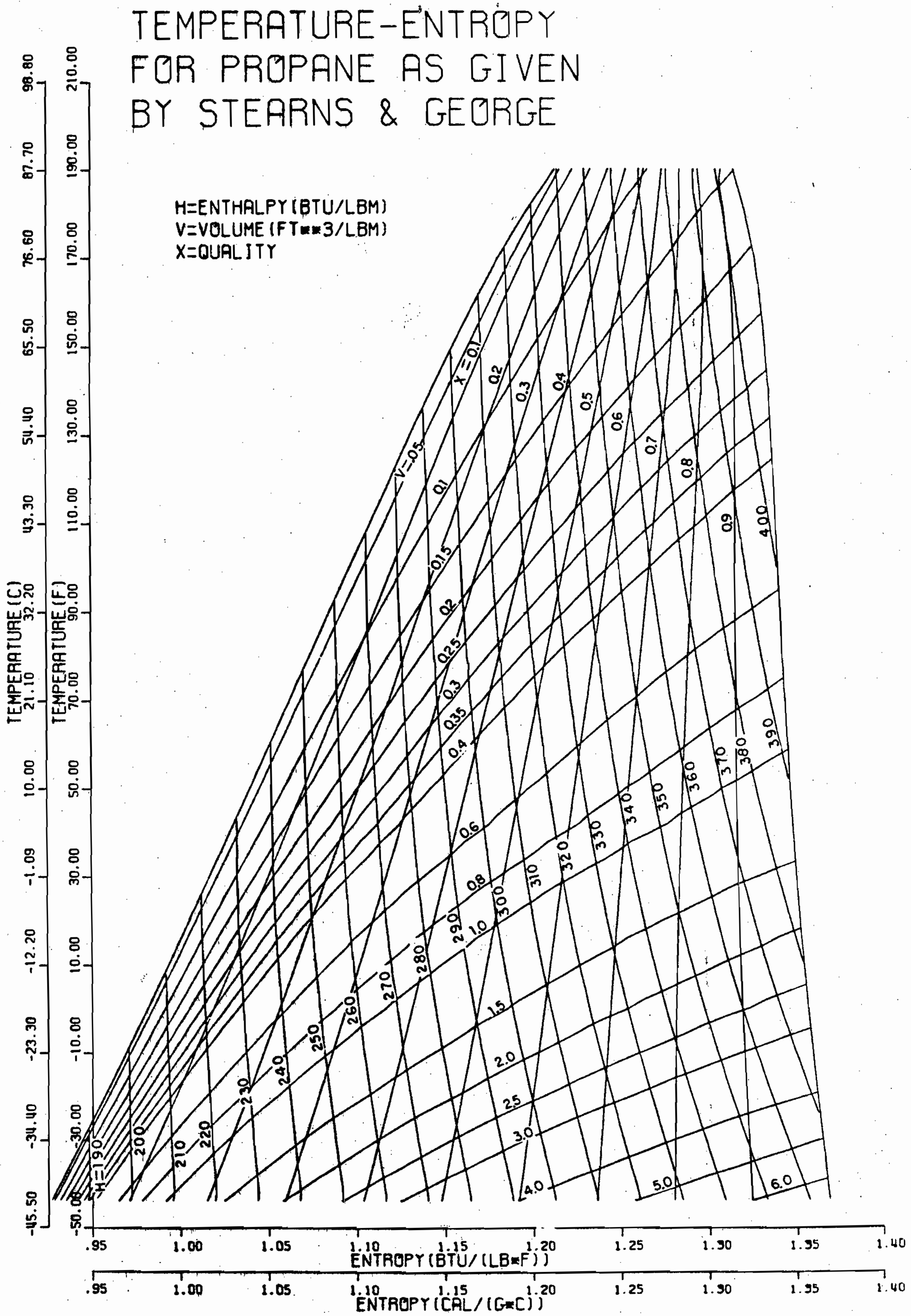


Figure 3-8. Temperature-Entropy Diagram for the Pseudo-Fluid; 65% by Mole Propane, 25% Propylene, 10% N-Butane, Based on Starling's Equation of State

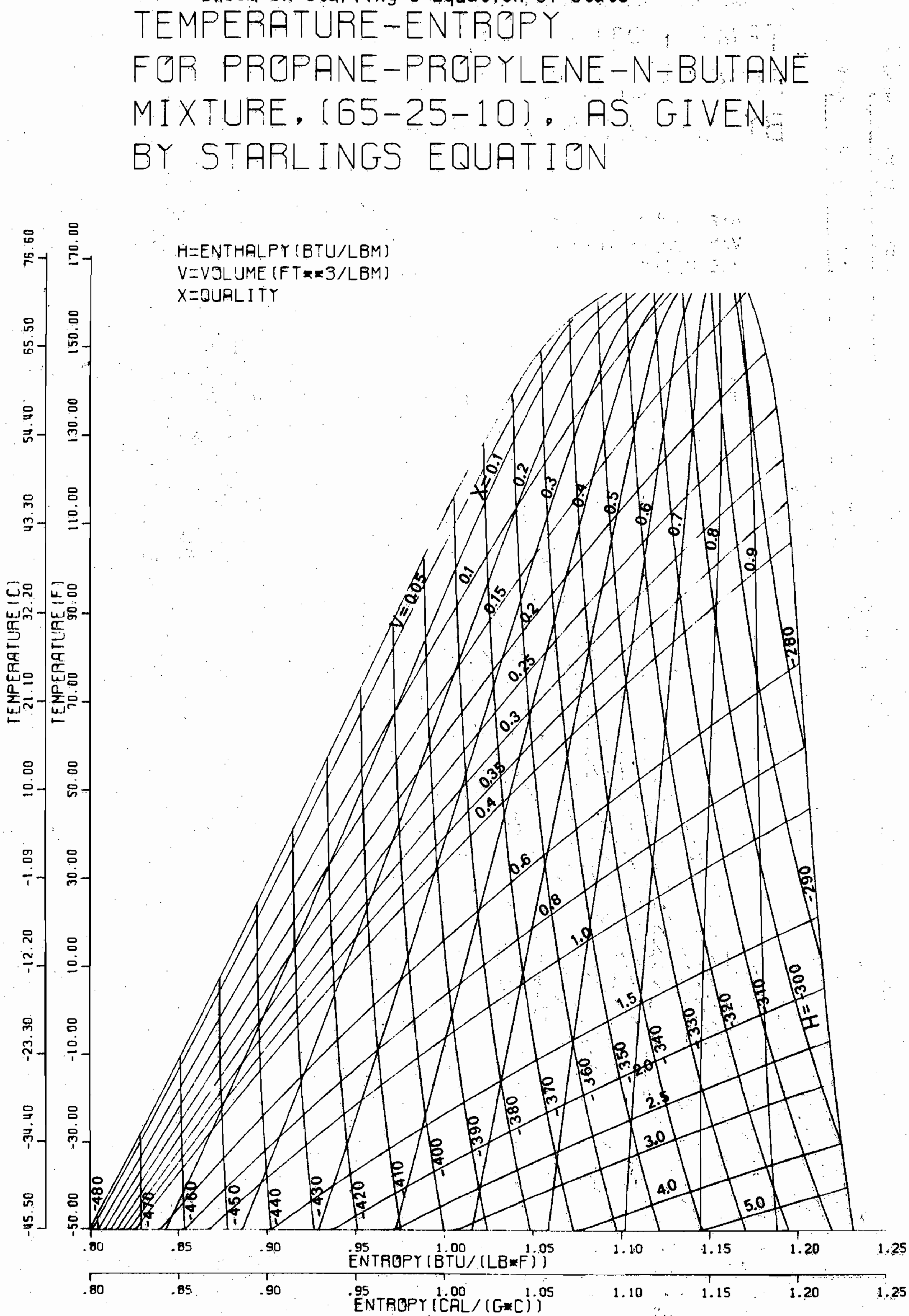
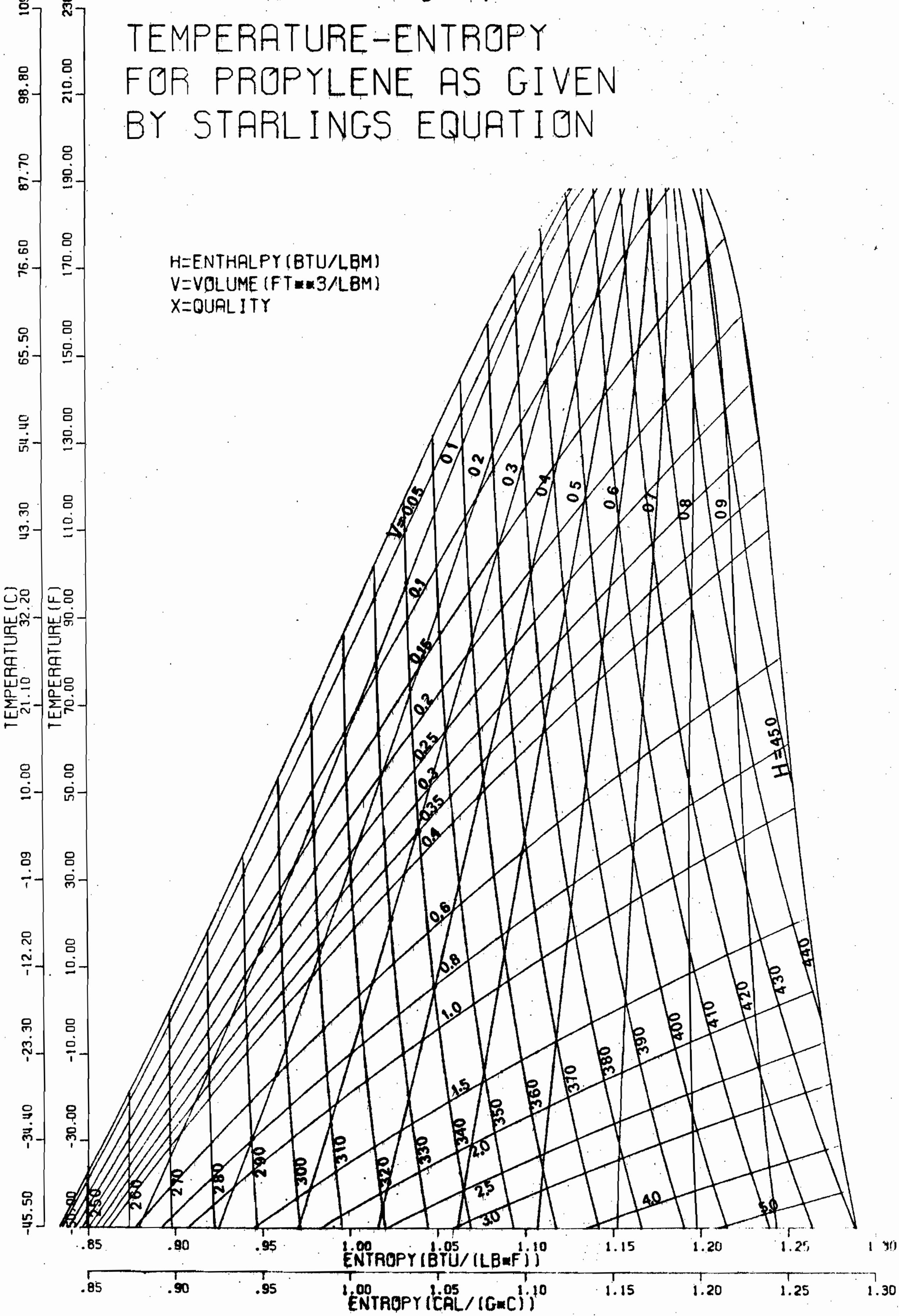


Figure 3-9. **Temperature-Entropy Diagram for Propylene Based on Starling's Equation of State**



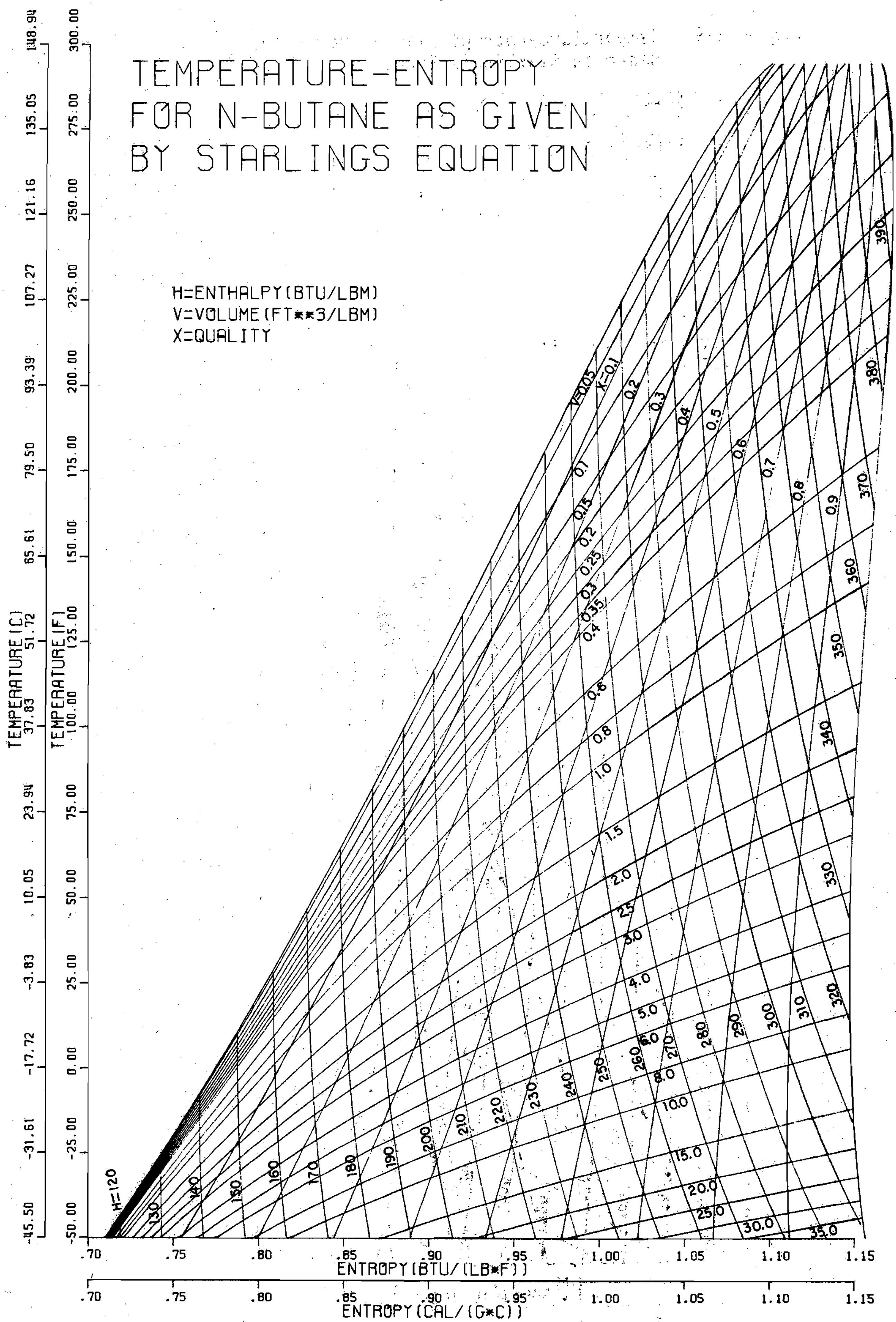


Figure 3-10. Temperature-Entropy Diagram for N-Butane Based on Starling's Equation of State

Chapter 4. Mass Flow Rates of Pure Propane -- Homogenious Isentropic Flow

This chapter on the mass flow rates of propane was added to this report in order to demonstrate the importance of accurate thermodynamic data for the prediction of mass flow rates. This chapter is not a final report on the prediction of mass flow rates for homogenious isentropic propane flow.

The mass flow rate per unit are (mass flux) for homogenious, adiabatic flow (no slip between the phases, the phases are in thermal equilibrium) can be shown to be:

$$G_C = \sqrt{2 g_C J \frac{H_0 - H}{V^2}} \qquad (4\text{-}1)$$

where H_0 is the stagnation enthalpy, H is the enthalpy at the critical section (in this case approximated by the smallest cross-section occurring in the valve) and V is the specific volume of the medium at the critical section. In applying equation (4-1) to calculate the mass flow rates shown in this report, an isentropic process was assumed. It should be pointed out that when slip between the liquid and vapor occurs more information about the flow is needed, such as the slip ratio K . An energy approach will then yield, for instance, the following expression for the mass flux:

$$G_C = \sqrt{\frac{2 G_C J \left[H_0 - H_\ell - \frac{H_g}{S_{\ell g}} (S_0 - S_\ell)\right]}{\left[\frac{K(S_g - S_0)V_f}{S_{\ell g}} + \frac{(S_0 - S_\ell)V_g}{S_{\ell g}}\right]^2 \left[\frac{S_0 - S_\ell}{S_{\ell g}} + \frac{S_g - S_0}{S_{\ell g} K^2}\right]}} \qquad (4\text{-}2)$$

Figure 4-1, 4-3, 4-5, and 4-7 give predicted mass flow rates per unit area at the critical valve section (Critical Mass Flux) based on the customary thermodynamic propane data by Stearns and George, while Figures 4-2, 4-4, 4-6, and 4-8 repeat the same calculations using a virial equation of state for propane (Starling's equation with entropy and enthalpy departures reevaluated by Sallet-Wu, as discussed in Chapter 3). In all shown prediction results (Figures 4-1 to 4-8) homogenious, isentropic flow in thermal equilibrium was assumed. The upstream stagnation condition for the flow calculation shown in

Figures 4-1 through 4-4 was assumed to be saturated liquid. Comparing Figures 4-1 4-3, 4-5, and 4-7 with Figures 4-2, 4-4, 4-6, and 4-8 in general, one finds that the flow rate predictions calculated with Starling's equation is much more consistent and, reasoning with one-phase fluid dynamics, i.e., higher pressures give higher mass flow rates, appear to be correct.

Figure 4-2 shows critical mass flux as a function of critical section pressure, with the upstream (saturated liquid) pressure as a parameter. For example, for saturated liquid propane (pure propane, for mixtures see the last paragraph below) which is at a stagnation pressure of 353.22 psia the maximum critical mass flux (point 1 in Figure 4-2) is approximately 2500 lb/(ft^2-sec). This represents the maximum mass flow rate through the valve only if the pressure at the smallest cross sectional area in the valve is approximately 275 psia. If this critical section pressure is smaller or larger, the maximum mass flow rate through the valve for the given upstream stagnation condition (353.22 psia) will be smaller. For example, if the critical section pressure which establishes itself in the valve is 200 psia, then the maximum mass flux through the valve will drop to approximately 2250 lb/(ft^2-sec), as shown by point 2. The above quantitative example shows the importance of the critical section pressure.

Critical section pressure for a given valve is, however, not a constant which could be obtained from the pressure ratio across the valve for any fluid flow. The following question now becomes of practical importance: What is the maximum mass flow rate for liquid propane, assuming the appropriate critical section pressure does exist? This question can be answered by using the results plotted in Figure 4-4. For example, if the pressure in the tank is 400 psia, then the maximum liquid propane mass flow rate per unit area is 2700 lb/(ft^2-sec). Again it is pointed out that these results are obtained from homogenious isentropic, equilibrium flow theory. All of these assumptions will be carefully examined before final flow rate prediction equations will be published.

Figures 4-6 and 4-8 show how the maximum mass flow rates per unit area change if the reservoir conditions go from saturation liquid (quality equals 0.00) to saturated vapor (quality equals 1.00). Again homogenious, isentropic flow in thermal equilibrium was assumed. While the flow rates shown in Figures 4-6 and 4-8 were calculated using Starling's equation of state (as reevaluated by Sallet-Wu, see Chapter 3), the curves shown in Figures 4-5 and 4-7 are based upon the thermodynamic data by Stearns and George.

As was pointed out during the course of this discussion, the flow calculations given are only valid for pure propane. Mass flow rates of mixtures of propane, butane and propylene resembling commercial propane are currently being calculated. Preliminary results will be available by the time the reader reads this report. A detailed discussion on homogenious mass flow rates will be given in the Final Report of the Safety Valve Study.

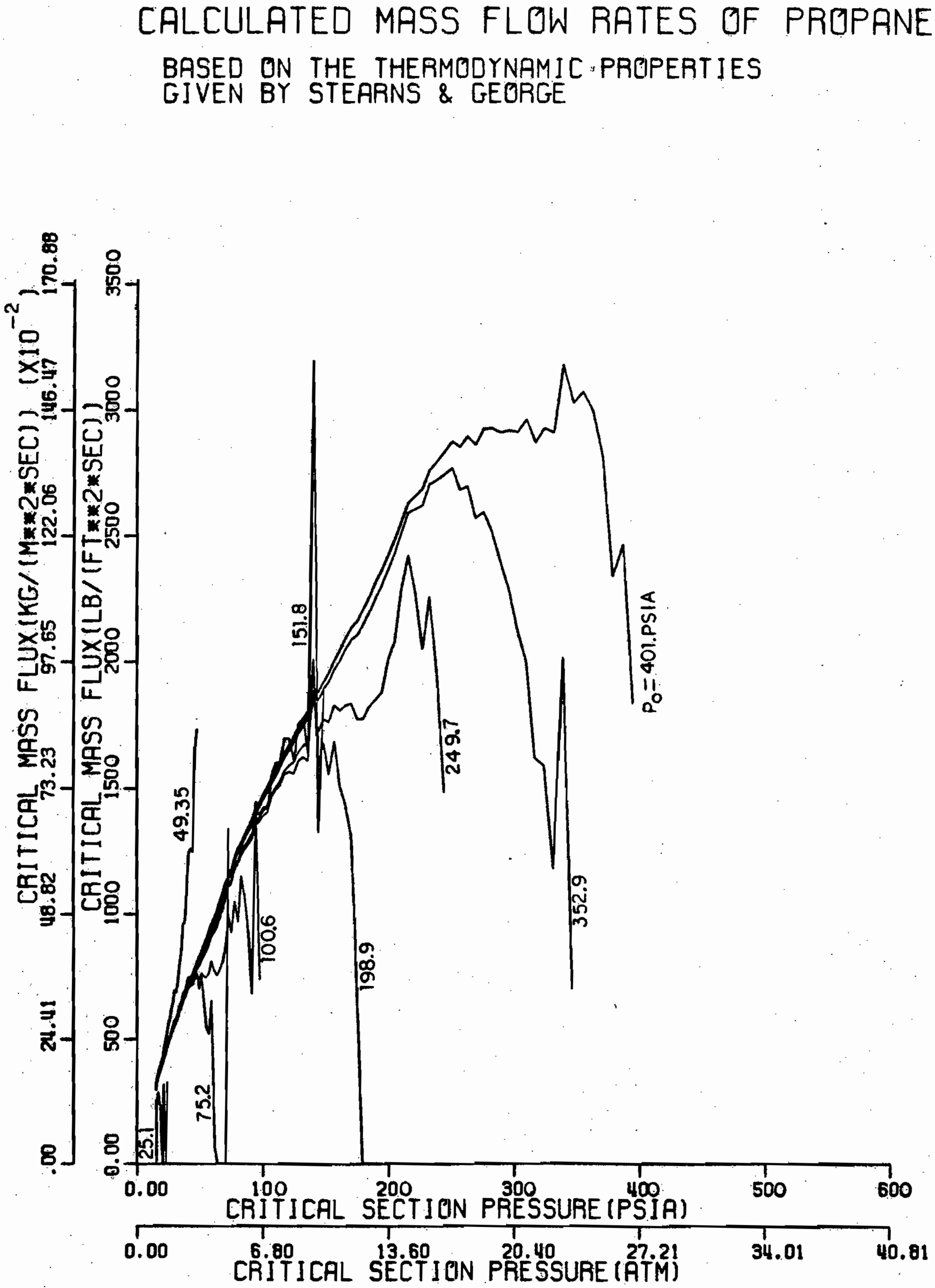


Figure 4-1. Critical Mass Flux of Propane as a Function of Critical Section Pressure (Based on Thermodynamic Data Given by Stearns and George)

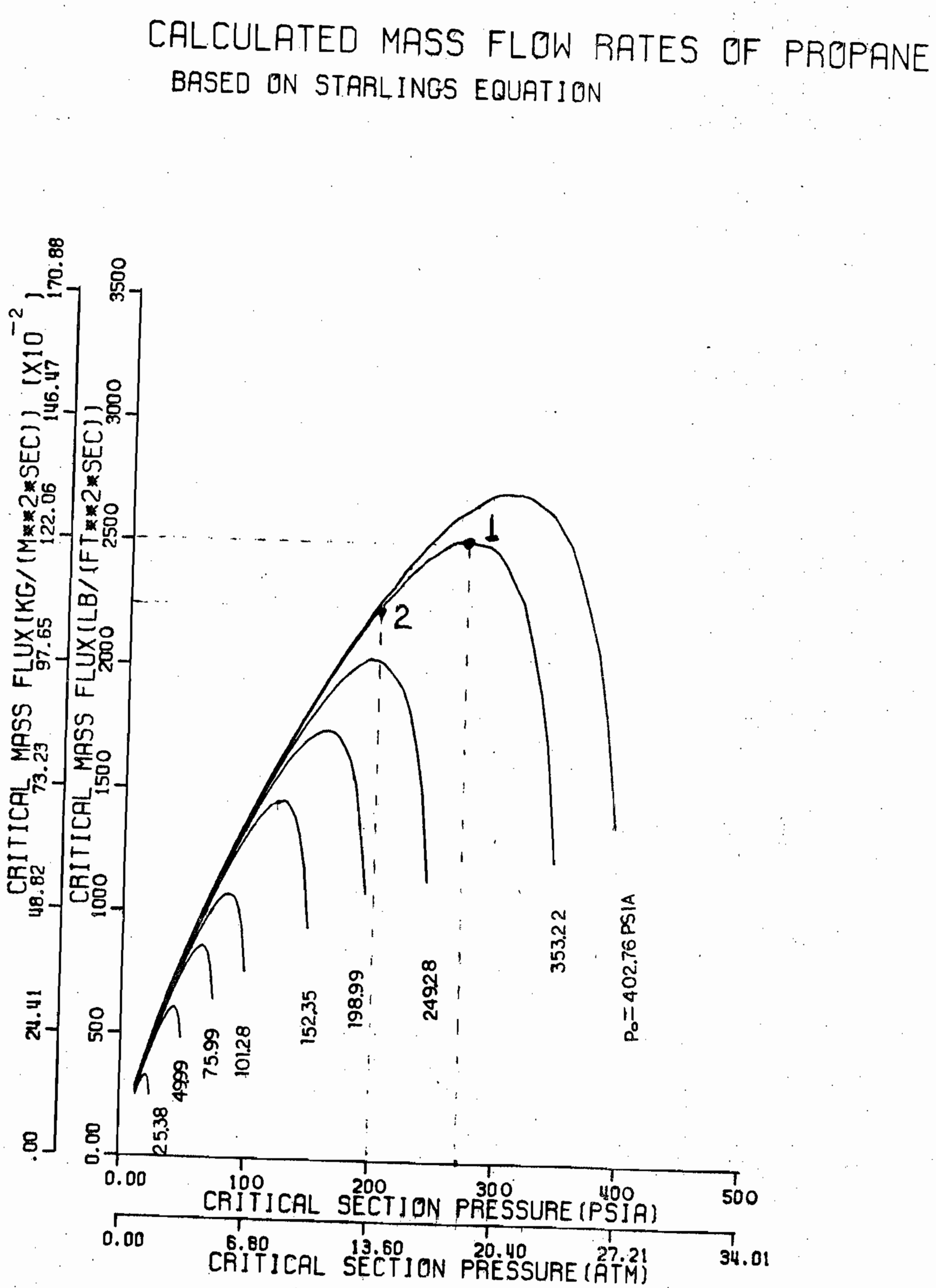


Figure 4-2. Critical Mass Flux of Propane as a Function of Critical Section Pressure (Based on Thermodynamic Data Calculated with Starling's Equation)

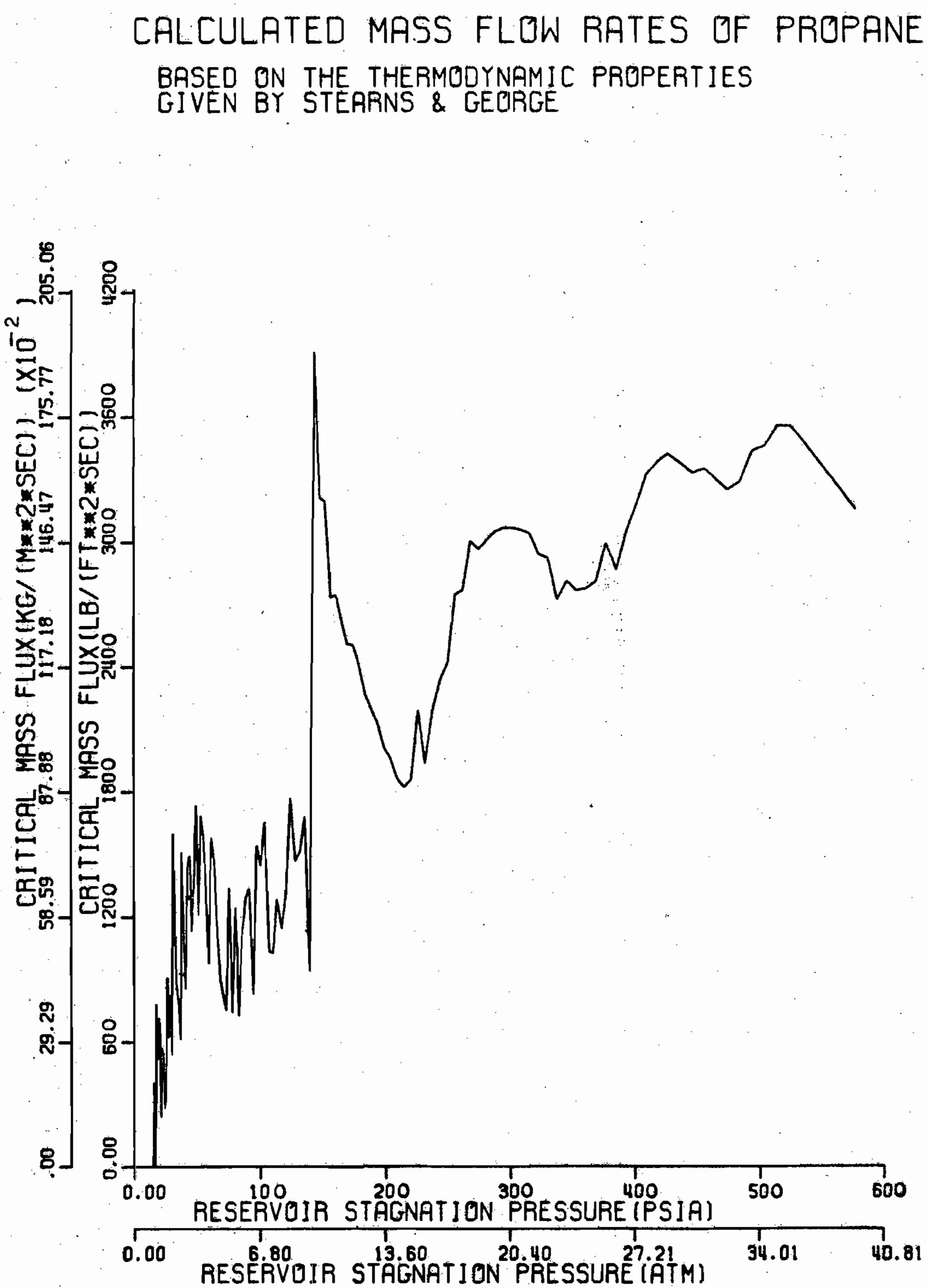


Figure 4-3. Maximum Critical Mass Flux of Propane as a Function of Reservoir Stagnation Pressure (Based on Thermodynamic Data Given by Stearns and George)

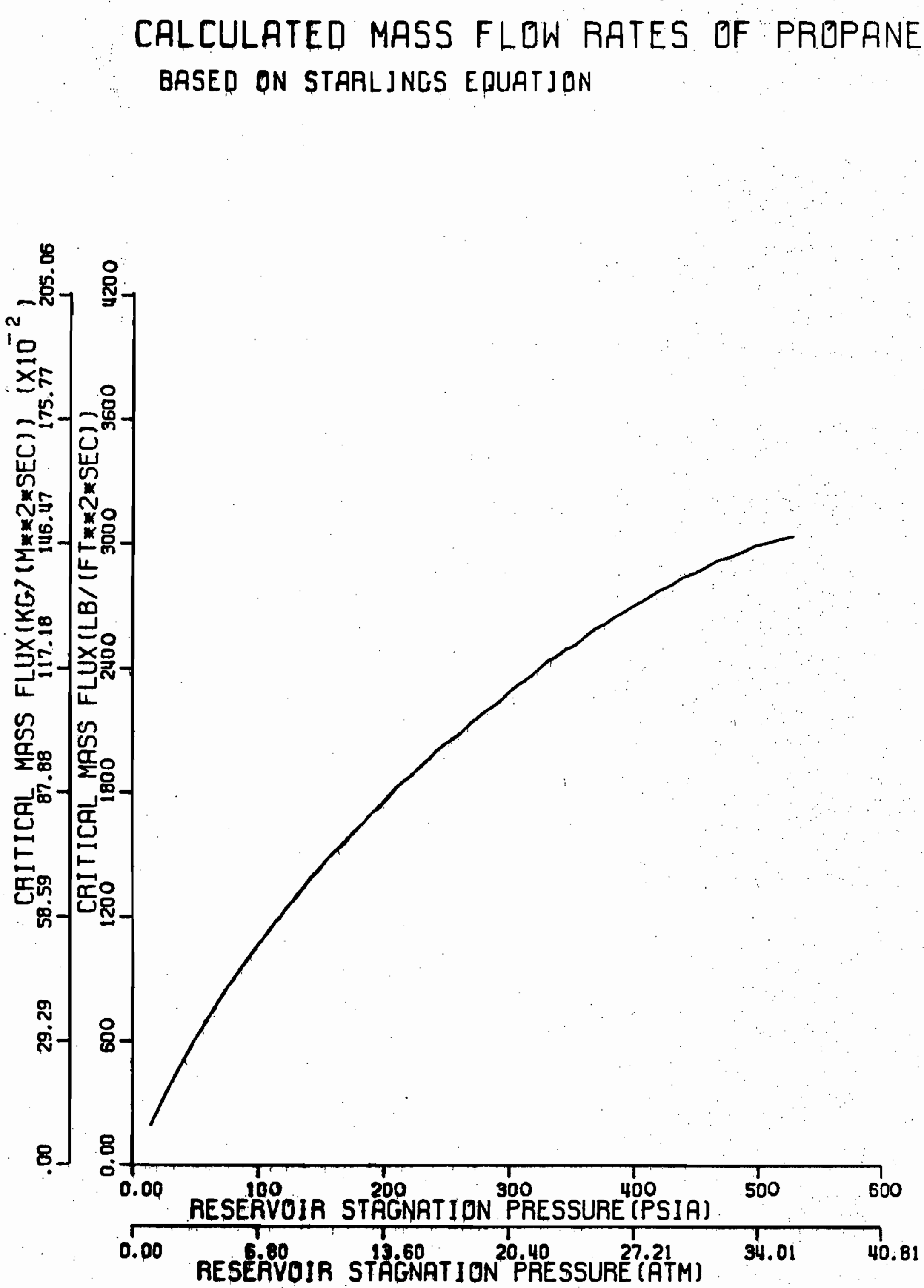


Figure 4-4. Maximum Critical Mass Flux of Propane as a Function of Reservoir Stagnation Pressure (Based on Thermodynamic Data Calculated with Starling's Equation)

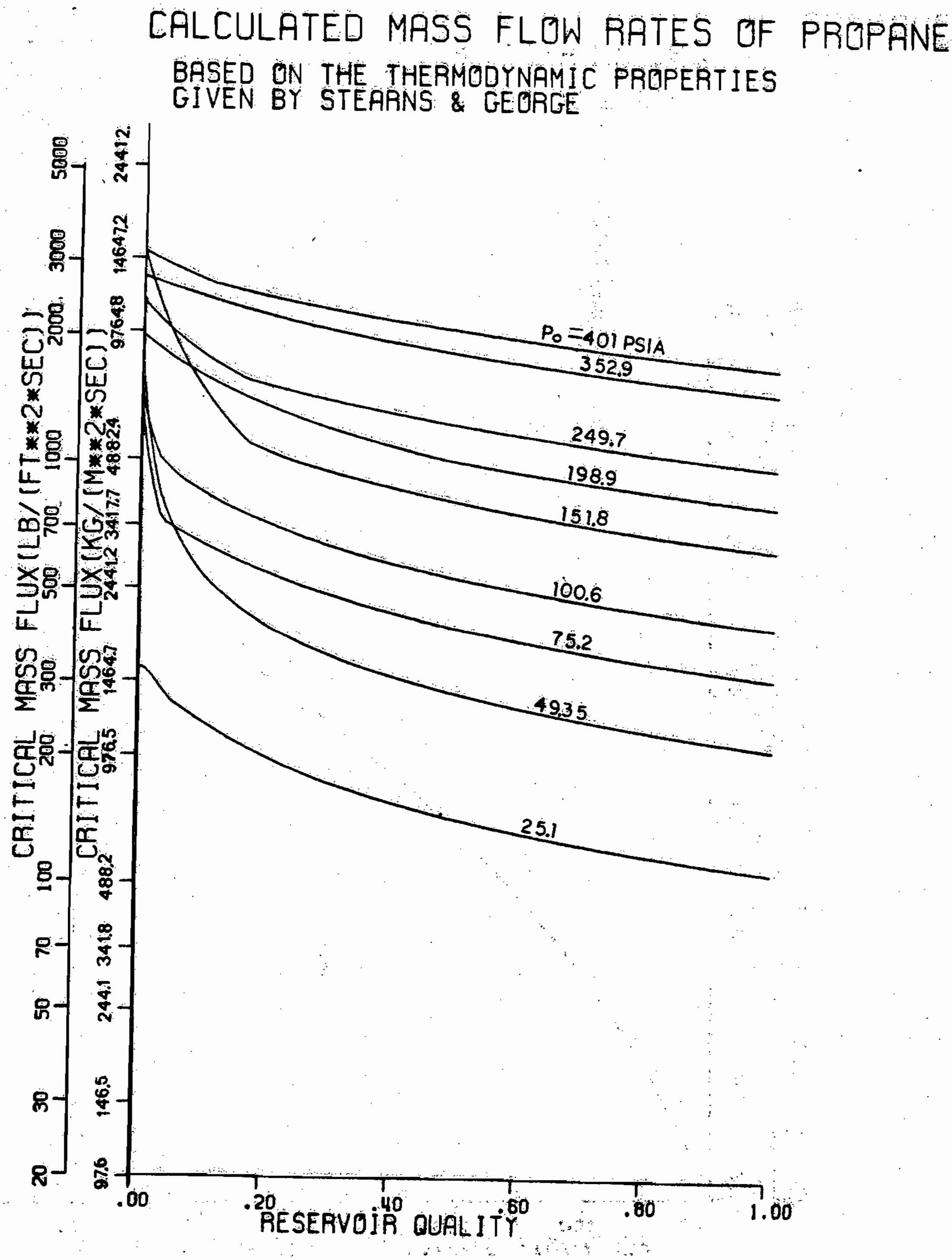


Figure 4-5. Maximum Critical Mass Flux of Propane as a Function of Reservoir Quality (Based on Thermodynamic Data Given by Stearns and George)

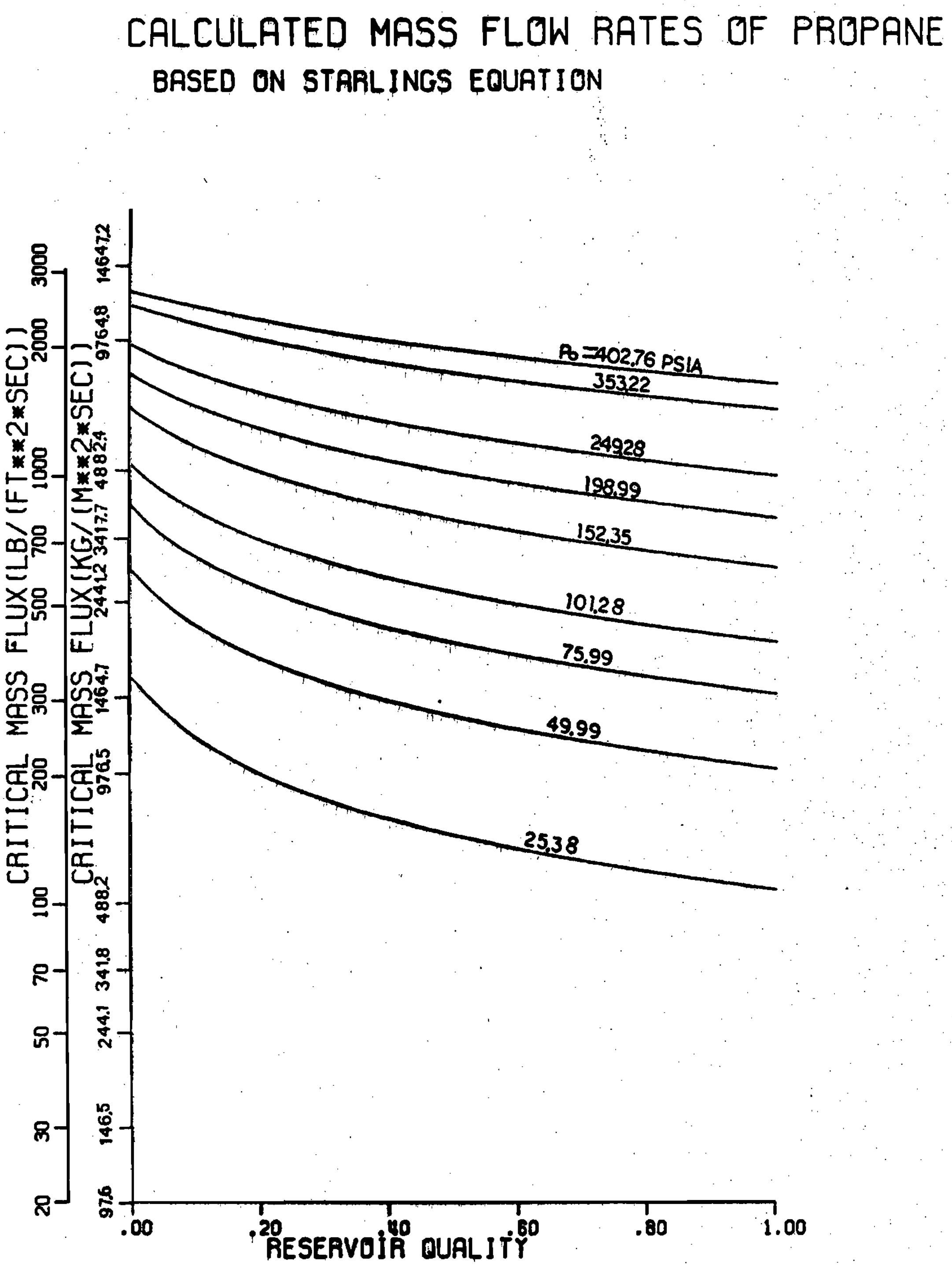


Figure 4-6. **Maximum Critical Mass Flux of Propane as a Function of Reservoir Quality (Based on Thermodynamic Data Calculated with Starling's Equation)**

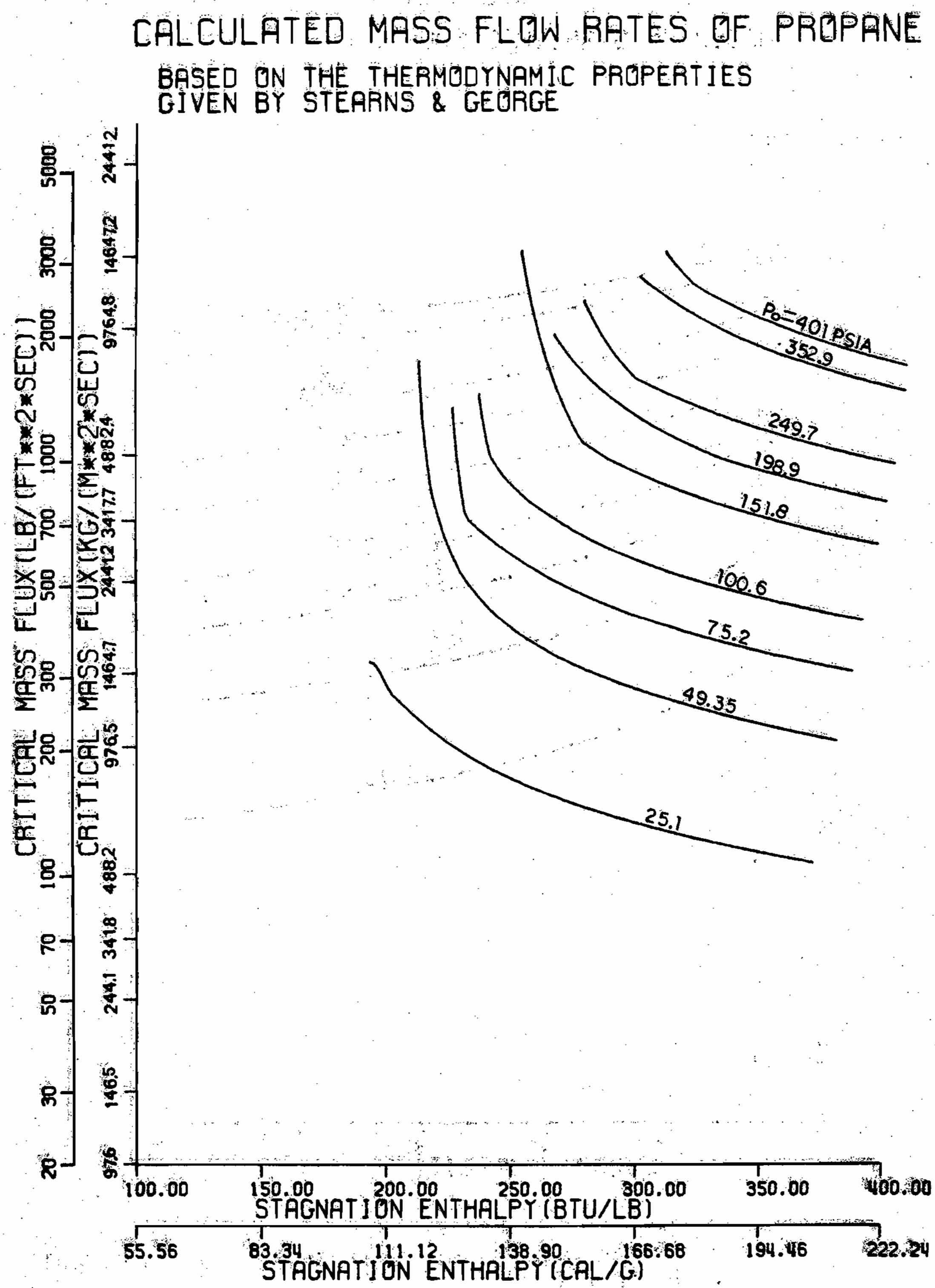


Figure 4-7. Maximum Critical Mass Flux of Propane as a Function of Stagnation Enthalpy (Based on Thermodynamic Data Given by Stearns and George)

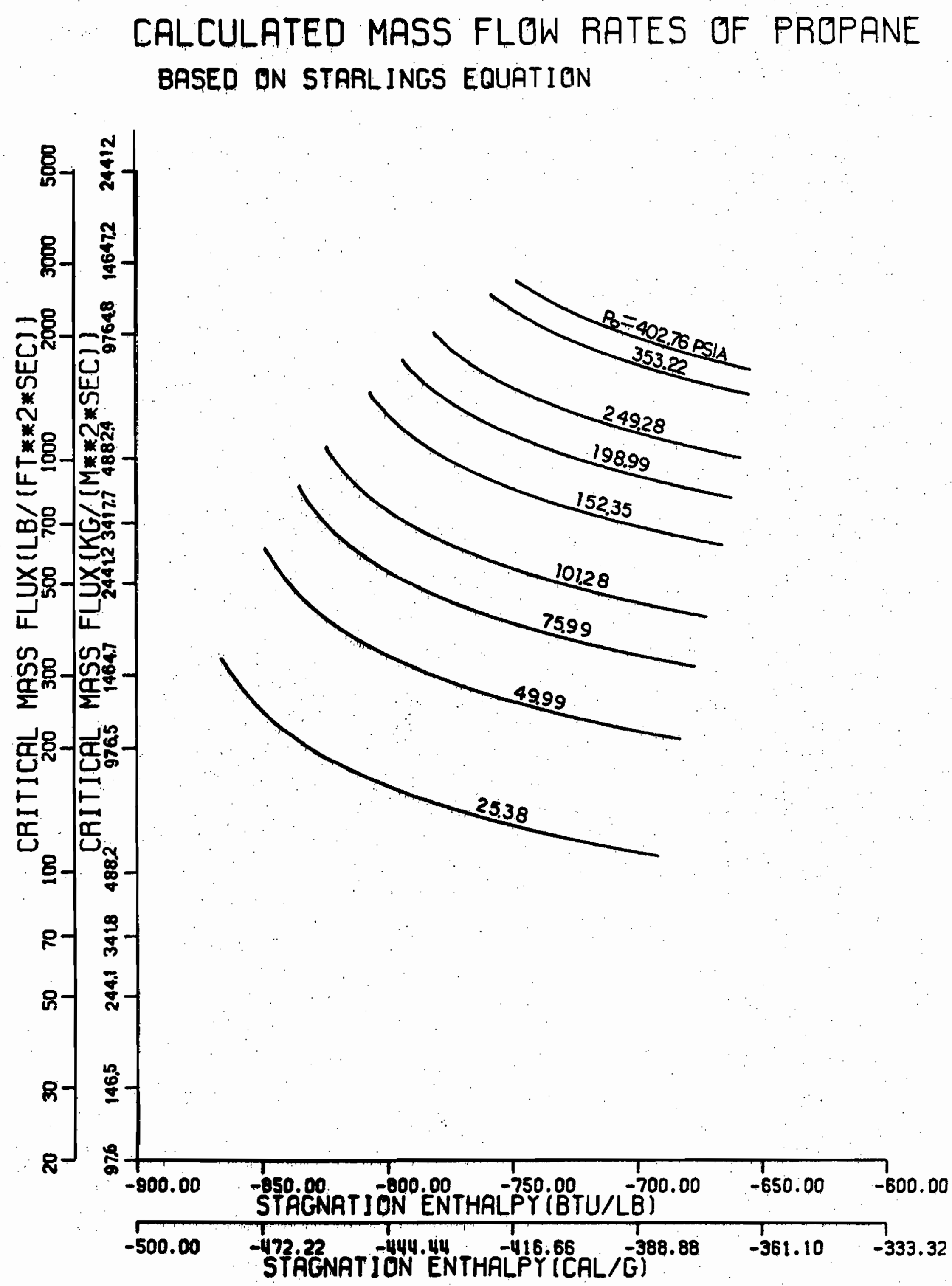


Figure 4-8. Maximum Critical Mass Flux of Propane as a Function of Stagnation Enthalpy (Based on Thermodynamic Data Calculated with Starling's Equation)

Chapter 5. Conclusions

Mass flow rate calculations for propane are very sensitive to the thermodynamic data upon which the calculations are based. Mass flow rates predicted using Stearns and George's data differ for certain conditions by more than 100% from the predictions based on Starling's or Bennedict-Webb-Rubin's equation of state. Because of its good agreement with experimentally measured values on the vapor dome as well as in the subcooled liquid region and because the consistent nature of the mass flow rates which are based upon its result the Starling equation of state should be used for the thermodynamic data of pure propane and propane mixtures.

A major difficult and source of inaccuracy in calculating thermodynamic properties from a virial equation of state such as the Bennedict-Webb-Rubin equation or Starling's equation is posed by the introduction of enthalpy and entropy departures and reference values for the specific heat. Great care was taken in the present investigation to correctly interpolate between the given values by using numerical curve fitting techniques. Because of the lack of data for entropy departures of propylene below 80°F and for enthalpy departures of propylene below 32°F (other than the zero points dictated by the third law of thermodynamics) the thermodynamic data of propylene and of the propane mixture which contains propylene may be incorrect at temperatures below 80°F. The enthalpy values are likely to be accurate down to a temperature of 32°F. A continuation of the present work on the thermodynamics of propane is strongly urged.

References

1. Rossini, F. D., Selected Values of Physical and Thermodynamic Properties of Hydrocarbons and Related Compounds, published for the American Petroleum Institute, Carnegie Press, Pittsburgh, Pennsylvania, 1953, 1050 pages.

2. Beattie, J. A., W. Kay, and J. Kaminsky, "The Compressibility of an Equation of State for Gaseous Propane," Journal of the American Chemical Society, Vol. 59 (1937), pp. 1589-1590.

3. Beattie, J. A., N. Poffenberger, and C. Hadlock, "The Critical Constants of Propane," Journal of Chemical Physics, Vol. 3 (1935), pp. 96-97.

4. Benedict, M., G. W. Webb, and L. C. Rubin, "An Empirical Equation for Thermodynamic Properties of Light Hydrocarbons and Their Mixtures," Journal of Chemical Physics, Vol. 8 (1940), pp. 334-345.

5. Burgoyne, J. H., "Two-Phase Equilibrium in Binary and Ternary Systems," Proceedings Royal Society (London), Vol. A176 (1940), pp. 280-294.

6. Dana, L. I., A. C. Jenkins, J. W. Burdick, and R. C. Timm, "Thermodynamic Properties of Butane, Isobutane, and Propane," Refrigerating Engineering, Vol. 12 (1926), pp. 387-405.

7. Mayer, J., "The Statistical Mechanics of Condensing Systems," Journal of Chemical Physics, Vol. 5 (1937), pp. 67-83.

8. Sage, B. H., J. G. Schaafama, and W. N. Lacey, "Phase Equilibrium in Hydrocarbon Systems," Industrial and Engineering Chemistry, Vol. 26, (1934), pp. 1218-1224.

9. Starling, K. E., Fluid Thermodynamic Properties for Light Petroleum Systems, Gulf Publishing Company, Houston, Texas, 1973, 270 pages.

10. Stearns, W. V. and E. J. George, "Thermodynamic Properties of Propane," Industrial and Engineering Chemistry, Vol. 35 (1943), pp. 602-607.

11. Ursell, H. D., "The Evaluation of Gibbs' Phase-Integral for Imperfect Gases," Proceedings Cambridge Philosophical Society, Vol. 23 (1927), pp. 685-697.