Thermodynamic and Transport Properties of Isobutane:

A Survey of Available Data.

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Abstract

The report contains an extensive compilation of the available equilibrium and transport properties of isobutane (2-methyl propane). It also lists the available correlations of the thermodynamic properties of isobutane, makes the statement that these correlations do not agree among themselves, and that none is obviously superior to the others. This makes it likely that a new correlation as an aid for the design of geothermal installations will be required. The present compilation of available experimental data on equilibrium properties (up to 1978) is a preparatory step towards the formulation of a new, more accurate correlation. A complete bibliography is included.

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PART I

SCOPE

1. Introduction

Isobutane ($i\text{-C}_4\text{H}_{10}$) appears to be the most likely candidate for use in binary geothermal power installations. For this reason, a reliable formulation of the thermodynamic (and to a lesser degree, transport) properties of this substance is indispensable. At present there exist three more or less complete such formulations.

{1} A modified Benedict-Webb-Rubin (MBWR) equation of state developed by K. E. Starling [1]. This equation contains eleven numerical constants - three more than the original BWR equation. Starling and coworkers [1, 2] provided two sets of constants for isobutane:

{1a} The set given in ref. [1] and listed in Table 1 of the present report.

{1b} An improved set communicated to us by Professor K. E. Starling and included in ref. [2]. This set is listed in Table 2.

The MBWR thermal equation of state (P, v, T equation) needs to be augmented by the ideal gas properties recommended in API Research Project 44 [3] in order to complete the formulation of a *fundamental equation* for isobutane (See Kestin, vol. 2 [4]). This formulation is used as a basis for a complete, thermodynamically consistent, tabulation of the equilibrium properties of isobutane [1] in which the saturation properties have been determined by equating the fugacities of the saturated liquid and vapor phase. The constants for the ideal-gas correlations can be found in Table 3.

{2} A so-called Differential-Regional BWR equation developed by P. T. Eubank *et al* [5], which consists of a set of two adjoining BWR equations each containing eight numerical constants. This served as a basis for the calculation of departure functions [5] in the region extending down to the vapor saturation line. The departure functions are supplemented by the

ideal-gas properties of API Research Project 44 [3] in order to obtain the properties in the vapor and supercritical regions. The vapor-pressure line is represented by an independent empirical correlation whose degree of compatibility with the P, v, T equation is not known. The liquid properties are also obtained from an independent tabulation and are not derivable from the equation of state. The constants of the two BWR equations are listed in Table 4 and those for the vapor-pressure correlation are given in Table 5 together with the constants of the correlation for the density of the saturated liquid.

{3} A revised Martin-Hou equation developed by Milora *et al* [6, 7]. It contains a total of twenty-one dimensionless numerical constants. The ideal-gas specific heats, C_p^0 , to be used with this equation is represented by a polynomial in temperature. Like Eubank's formulation, the vapor-pressure line is given by an independent empirical correlation. Consequently, Milora's formulation may not be thermodynamically consistent. A correlation for the saturated liquid density is also provided [7, 8]. The constants for Milora's formulation are given in Tables 6, 7, and 8. Reference [8] contains a complete tabulation of the thermodynamic properties of isobutane based on the preceding correlation of Milora *et al*.

The four formulations {1a}, {1b}, {2} and {3} are not equivalent although each one claims to reproduce the experimental data to within their average uncertainty. The discrepancies between any two of them are not uniform over the domain of independent variables. The discrepancies between Starling's two correlations are less pronounced as would be expected from two formulations completed by the same author. A documented, detailed evaluative comparison will be given in another report. At this stage we simply mention that all preceding formulations assume an analytic critical point and none is clearly superior to the others. It should be pointed

out, however, that due to their internal thermodynamic consistency, Starling's formulations may be less cumbersome to use for the optimization of isobutane Rankine cycles by computer.

The designer of a geothermal power plant of the binary type is, therefore, faced with a dilemma as to which formulation to adopt. Furthermore, the uncertainties inherent in the available formulations, as compared with the original experimental data, and the lack of consistency between overlapping sets of measurements performed by different investigators, make it likely that a new, improved formulation will become necessary eventually.

The present report collects all known experimental determinations of the equilibrium and transport properties of isobutane. We believe that the compilation is complete as of 1978 with the possible omission of some inaccessible dissertations and proprietary data of some industrial organizations.

All measurements are listed first in the units employed by the author in the original publication and, secondly, in SI units. The latter task proved to be more tedious than might have been expected because of the changes in the accepted temperature scale and modifications in the definition of units that took place over the years. Moreover, not all authors provided the required information about the particular units adopted for their publications. Bearing in mind the limited accuracy of most published data, we employed the simplified conversion factors listed in Table 9.

The experimental data are available on a magnetic tape (No. C125BK of Brown University) on request. A somewhat less elaborate set of punched cards is also available. The numbering code for the data entries is explained in the next section.

2. Organization of Data

The remainder of the report is arranged as follows:

Part II: A listing of the available experimental data on (a) equilibrium properties, and (b) transport properties of isobutane. The data are given first in the original units of their source and secondly in SI units as converted by the present authors.

Part III: A listing of all the references (data sources) that appeared in Part II, displayed in chronological order.

Part IV: A listing of the references in alphabetical order by first author's name. Part III and IV are linked by cross numbering.

The data entries in Part II are arranged chronologically. Each entry has a code number which is displayed as follows:

(1) No.: W·X·Y·Z

Here W, X and Z are, each, a two-digit integer, whereas Y is a single digit integer.

W is the reference number as it appears in the chronological list of Part III.

X is a file number which is used to identify the files within the same reference.

Y is a code to identify the units

Y=1 indicates original units for equilibrium properties.

Y=2 indicates SI units for equilibrium properties.

Y=3 indicates original units for transport properties.

Y=4 indicates SI units for transport properties.

Z is a page number within the sequence of pages on which the data taken from a given reference are listed.

The code No.: 17.01.2.02, for example, designates the second page (Z = 02) of a listing of equilibrium properties in SI units (Y=2) of file no. 01 (X = 01) taken from reference [17] (W = 17) of the chronological list.

The second item on each page identifies the thermophysical properties reported in the reference under consideration and is explained on the first page (Z = 01) of each entry. The other items (3) through (8) are self-explanatory. Item (7) gives the reference number in the alphabetical list of Part IV.

We note that the serial numbers of the references in the chronological list in the case of equilibrium properties are independent of those for transport properties. It is also noted that the page number which appears on the top right corner of each page in Part II refers to the pagination in Part II and is independent of the pagination of the whole report.

A large number format has been used to accommodate the property values because of their wide range. At times, redundant zeros to the right could not be avoided. These zeros should not be interpreted as reflecting the accuracy of the measurements which is indicated in item (6) whenever it is stated or implied in the original publication.

3. References cited in Part I

- [1] Starling, K. E., "Fluid Thermodynamic Properties for Light Petroleum Systems". Gulf Publishing Co., Houston, Texas (1973).
- [2] Starling, K. E., Sliepcevich, C. M., Fish, L. W., Goin, K. M., Aboul-Foutoh, K. H., Kumar, K. H., Lee, T. J., Milani, J. S. and Zemp, K. L., "Development of Working Fluid Thermodynamic Properties Information for Geothermal Cycles - Phase I". University of Oklahoma Report No. ORO-5249-2 (1978).
- [3] API Research Project Number 44, "Selected Values of Physical and Thermodynamic Properties of Hydrocarbons and Related Compounds". Carnegie Press, Carnegie Institute of Technology, Pittsburgh, Pennsylvania (1953), pp. 560, 582-583, 596, 705.
- [4] Kestin, J., "A Course in Thermodynamics, Vol. II". Blaisdell, Waltham, Massachusetts (1968).
- [5] Das, T. R., Reed, C. O. and Eubank, P. T., "P, v, T Surface and Thermodynamic Properties of Isobutane". J. Chem. Eng. Data, vol. 18 (1973), pp. 253-262.
- [6] Milora, S. L. and Tester, J. W., "Geothermal Energy as a Source of Electric Power - Thermodynamic and Economic Design Criteria". MIT Press, Cambridge, Massachusetts (1976).
- [7] Milora, S. L. and Combs, S. K., "Thermodynamic Representations of Ammonia and Isobutane". Oak-Ridge National Lab. Report No. ORNL/TM-5847 (1977).
- [8] IUPAC, Division of Phys. Chem. Commission on Thermodynamic and Thermochemistry Tables Project (1971).

4. List of symbols

C_p	Isobaric specific heat
C_p°	Ideal-state isobaric specific heat
h	Specific enthalpy (per unit mass)
h°	Ideal-state specific enthalpy
h_o°	Specific enthalpy of formation at 0K
M	Molecular weight
P	Pressure
P_c	Critical pressure
R	Universal gas constant
s	Specific entropy
s°	Ideal-state specific entropy
T	Absolute temperature
v	Specific volume
v_c	Critical specific volume
z	Compressibility factor
ρ	Molar density

5. Tables for Part I

Table 1	Constants for Starling's MBWR equation [1] - version {1a}.
Table 2	Constants for Starling's MBWR equation [2] - version {1b}.
Table 3	Constants of polynomial expressions used by Starling [1] to correlate API ideal gas tables [3].
Table 4	Constants for Eubank's differential regional BWR equation [5].
Table 5	Constants for the vapor-pressure and saturated-liquid density correlations recommended by Eubank <i>et al</i> [5].
Table 6	Constants for Milora's revised Martin-Hou equation [7].
Table 7	Constants for the vapor-pressure and saturated-liquid density correlations recommended by Milora [7].
Table 8	Constants used by Milora [7] for the correlation of the ideal-gas properties.
Table 9	Conversion factors [8].

Table 1

Constants for Starling's MBWR equation [1] - version {1a}

$$P = \rho RT + (B_0 RT - A_0 - C_0/T^2 + D_0/T^3 - E_0/T^4) \rho^2 +$$

$$(bRT - a - d/T) \rho^3 + \alpha (a+d/T) \rho^6 +$$

$$(c\rho^3/T^2) (1 + \gamma\rho^2) \exp(-\gamma\rho^2)$$

$$M = 58.121 \text{ kmol/kg}$$

$$R = 8.3103 \text{ kJ/kmol K}$$

A_0	$0.1001305669 \cdot 10^7$	$\text{Jm}^3/(\text{kmol})^2$
B_0	0.11729588	$\text{m}^3/(\text{kmol})$
C_0	$0.841057763 \cdot 10^{11}$	$\text{Jm}^3\text{K}^2/(\text{kmol})^2$
D_0	$0.393095723 \cdot 10^{13}$	$\text{Jm}^3\text{K}^3/(\text{kmol})^2$
E_0	$0.21523401 \cdot 10^{15}$	$\text{Jm}^3\text{K}^4/(\text{kmol})^2$
a	$0.80503249 \cdot 10^5$	$\text{Jm}^6/(\text{kmol})^3$
b	$0.334642417 \cdot 10^{-1}$	$\text{m}^6/(\text{kmol})^2$
c	$0.210597279 \cdot 10^{11}$	$\text{Jm}^6\text{K}^2/(\text{kmol})^3$
d	$0.20210138 \cdot 10^8$	$\text{Jm}^6\text{K}/(\text{kmol})^3$
α	$0.103154909 \cdot 10^{-2}$	$\text{m}^9/(\text{kmol})^3$
γ	$0.277283867 \cdot 10^{-1}$	$\text{m}^6/(\text{kmol})^2$

Table 2

Constants for Starling's MBWR equation - Version {1b}

Equation as in Table 1

A_o	$0.1047421016 \cdot 10^7$	$Jm^3/(kmol)^2$
B_o	0.126488576	$m^3/(kmol)$
C_o	$0.883931153 \cdot 10^{11}$	$Jm^3K^2/(kmol)^2$
D_o	$0.6775161198 \cdot 10^{13}$	$Jm^3K^3/(kmol)^2$
E_o	$0.2299039647 \cdot 10^{15}$	$Jm^3K^4(kmol)^2$
a	$0.6519450092 \cdot 10^5$	$Jm^6/(kmol)^3$
b	$0.2614129432 \cdot 10^{-1}$	$m^6/(kmol)^2$
c	$0.1699341029 \cdot 10^{11}$	$Jm^6K^2/(kmol)^3$
d	$0.5762192995 \cdot 10^7$	$Jm^6K^2/(kmol)^3$
α	$0.16732205 \cdot 10^{-2}$	$m^9/(kmol)^3$
γ	$0.359084208 \cdot 10^{-1}$	$m^6/(kmol)^2$

Table 3

Constants of polynomial expressions used by Starling [1]
to correlate API ideal gas tables [3]

$$H^{\circ} = \sum_{i=0}^2 A_i T^i$$

$$S^{\circ} = \sum_{i=0}^4 B_i T^i$$

Temperature range 360 - 960 R

A_0	-776.11	Btu/lb
A_1	$6.872 \cdot 10^{-2}$	Btu/lb R
A_2	$3.071 \cdot 10^{-4}$	Btu/lb R ²

Temperature range 360 - 1440 R

B_0	0.86401	Btu/lb R
B_1	$9.079 \cdot 10^{-4}$	Btu/lb R ²
B_2	$-2.073 \cdot 10^{-7}$	Btu/lb R ³
B_3	$0.885 \cdot 10^{-10}$	Btu/lb R ⁴
B_4	$-0.241 \cdot 10^{-13}$	Btu/lb R ⁵

Table 4

Constants for Eubank's differential regional BWR equation [5]

$$P = \rho RT + \sum_{j=1}^7 k_{j1} \cdot \theta_j^* + U(\rho - \rho_c) \sum_{j=1}^7 k_{j2} \theta_j^*$$

In the above expression, the symbol θ_j^* stands for the following quantities

$$\begin{array}{ll} j = 1 & \theta_j^* = RT \rho^{*2} \\ 2 & \rho^{*2} \\ 3 & \rho^{*2}/T^2 \\ 4 & RT \rho^{*3} \\ 5 & \rho^{*3} \\ 6 & \rho^{*6} \\ 7 & (\rho^{*3}/T^2) (1 + k_{8r} \rho^{*2}) \exp(-k_{8r} \rho^{*2}) \end{array}$$

where $\rho^* = \rho$ for $\rho \leq \rho_c$ (region 1),

$\rho^* = (\rho - \rho_c)$ for $\rho > \rho_c$ (region 2),

and r can have the value 1 or 2 according to the region.

$U(\rho - \rho_c)$ is a unit step function defined as

$U = 0$ for $\rho \leq \rho_c$ (region 1)

$U = 1$ for $\rho > \rho_c$ (region 2)

The constants k_{j1} and k_{j2} are as follows:

Table 4 (continued)

j = 1	$k_{j1} = 0.7997415892 \cdot 10^{-1}$	$m^3/(kmol)$
2	$-0.6774754594 \cdot 10^6$	$Jm^3/(kmol)^2$
3	$-0.1154960366 \cdot 10^{12}$	$Jm^3K^2/(kmol)^2$
4	$0.4551827432 \cdot 10^{-1}$	$m^6/(kmol)^2$
5	$-0.2225707658 \cdot 10^6$	$Jm^6/(kmol)^3$
6	$0.1135044212 \cdot 10^3$	$Jm^{15}/(kmol)^6$
7	$0.332532265 \cdot 10^{11}$	$Jm^6K^2/(kmol)^3$
8	$0.2636187728 \cdot 10^{-1}$	$m^6/(kmol)^2$
j = 1	$k_{j2} = 0.3381503904$	$m^3/(kmol)$
2	$-0.1142868218 \cdot 10^7$	$Jm^3/(kmol)^2$
3	$-0.1419752222 \cdot 10^{11}$	$Jm^3K^2/(kmol)^2$
4	$-0.9072662875 \cdot 10^{-1}$	$m^6/(kmol)^2$
5	$0.6949580686 \cdot 10^6$	$Jm^6/(kmol)^3$
6	$-0.3651668712 \cdot 10^3$	$Jm^{15}/(kmol)^6$
7	$-0.4025195097 \cdot 10^{11}$	$Jm^6K^2/(kmol)^3$
8	0.1054475091	$m^6/(kmol)^2$

Table 5

Constants for the vapor-pressure and saturated-liquid density correlations
recommended by Eubank et al [5]

Vapor-pressure

$$\log_{10} P = A + B/T + C \log_{10} T + DP/T^2$$

P in mm - Hg, T in K;

$$A = 18.54662$$

$$B = -1583.23$$

$$C = -3.97829$$

$$D = 0.95173$$

Saturated-liquid density

$$\rho_{SL} = \left[\rho_L + A\theta + B\theta^2 \right] (1 + \theta + 0.25 \theta^3)$$

ρ_{SL} = saturated liquid density (gm/cc)

$$T \text{ in K, } \theta = [1 - (T/T_L)]^{1/3}$$

below 298.15K

$$\rho_L = 0.304533 \text{ g/cm}^3$$

$$A = -155.57356 \cdot 10^{-4}$$

$$B = 837.55384 \cdot 10^{-4}$$

$$T_L = 393.15K$$

above 298.15K

$$\rho_L = 0.221 \text{ g/cm}^3$$

$$A = 185.2276 \cdot 10^{-3}$$

$$B = -456.3364 \cdot 10^{-4}$$

$$T_L = 408.13 \text{ K}$$

Table 6

Constants for Milora's revised Martin-Hou equation [7]

$$P_r = \frac{1}{Z_c} \left[\frac{T_r}{(v_r - b)} + \sum_{i=1}^4 \frac{f_i(T_r)}{(v_r - b)^{i+1}} + \sum_{i=5}^6 f_i(T_r) \times \exp \left\{ - (i-4) a v_r \right\} \right]$$

where,

$$f_i(T_r) = f_i(1) + B_i(T_r - 1) + C_i \left(e^{-kT_r} - e^{-k} \right)$$

$P_r = P/P_c$ reduced pressure

$T_r = T/T_c$ reduced temperature

$v_r = v/v_c$ reduced volume

$v_c = 4.522 \cdot 10^{-3} \text{ m}^3/\text{kg}$

$T_c = 408.13 \text{ K}$

$P_c = 3.6477 \text{ MPa}$

$R = 8.313162 \text{ kJ/kmol K}$

$M = 58.134 \text{ kmol/kg.}$

The following constants are dimensionless

$a = 16.024343$

$b = 0.14926478$

$k = 3.9676634$

$i = 1$	$f_i(1) = -1.3452811$
2	$8.1331706 \cdot 10^{-1}$
3	$-1.8209186 \cdot 10^{-1}$
4	$-3.6735063 \cdot 10^{-3}$
5	$7.369856 \cdot 10^3$
6	$4.1434338 \cdot 10^6$

Table 6 (continued)

$i = 1$	$B_i = 5.6584041 \cdot 10^{-1}$
2	$1.9346061 \cdot 10^{-1}$
3	$-1.8524754 \cdot 10^{-1}$
4	$6.7988776 \cdot 10^{-2}$
5	$-1.6476544 \cdot 10^4$
6	$1.4277603 \cdot 10^7$

$i = 1$	$C_i = -1.2094862 \cdot 10^1$
2	$1.5083697 \cdot 10^1$
3	-2.0223683
4	-1.3506749
5	$2.0091059 \cdot 10^5$
6	$5.4888339 \cdot 10^8$

Table 7

Constants for the vapor-pressure and saturated-liquid density correlations
recommended by Milora [7]

$$\ln P_r = D_r + E_r/T_r + F_r \ln T_r + G_r \cdot T_r + H_r \cdot T_r^2$$

$$P_r = p^{\text{sat}}/p_c \equiv \text{reduced saturation pressure}$$

$$T_r = T/T_c \equiv \text{reduced temperature}$$

The following constants are dimensionless

$$D_r = 10.890498;$$

$$E_r = -8.7655777;$$

$$F_r = -2.6561239;$$

$$G_r = -4.7799233;$$

$$H_r = 2.6550034.$$

saturated-liquid density

$$p_l \Big|_r^{\text{sat}} = \sum_{i=0}^4 \rho_i x^i$$

$$x = (1 - T_r)^{1/3}$$

$$\rho_l \Big|_r^{\text{sat}} \equiv \text{reduced saturation-liquid density}$$

$$T_r = T/T_c \equiv \text{reduced temperature}$$

The following constants are dimensionless

$i = 0$	$\rho_i = 1$
1	1.17235
2	4.61147
3	-7.50585
4	4.7673

Table 8

Constants used by Milora [7] for the correlation of the ideal-gas properties

$$C_p^o/R = \sum_{i=0}^3 C_i^* T_r^i$$

where

$$R = 8.3132 \text{ kJ/kmol K}$$

$$T_r = T/T_c \equiv \text{reduced temperature}$$

The values of C_i^* (dimensionless) are as follows:

$i = 0$	$C_i^* = -0.95123056;$
1	20.4097
2	-4.60664;
3	0.407839.

Table 9
Conversion factors [8]

Temperature

We disregarded changes in the definition of the International Practical Temperature scale and converted uniformly °C to K by assuming

$$273.15 \text{ K}$$

for 0°C

Other units

$$1 \text{ ft} = 0.3048 \text{ m}$$

$$1 \text{ lb} = 0.435_6 \text{ kg}$$

$$1 \text{ Btu/lb}^\circ\text{F} = 1 \text{ kcal/kg}^\circ\text{C}$$

$$1 \text{ atm} = 0.101325 \text{ MPa}$$

$$1 \text{ lb/in}^2 = 6.89474 \text{ kPa}$$

Energy

Not all authors clearly indicate the exact caloric they use. We assume

$$1 \text{ cal (thermal)} = 4.184 \text{ J}$$

$$1 \text{ cal (IT)} = 4.1868 \text{ J.}$$

In the absence of a clear indication we guessed that data ref. [0170] used cal (thermal), whereas data refs. [0015, 0465, 0470] used cal (IT). In tables of specific heats in the USCS we assumed that the heat unit in the identity $1 \text{ Btu/lb}^\circ\text{F} = 1 \text{ kcal/kg}^\circ\text{C}$ is the kcal (IT).

PART II

LISTING OF EXPERIMENTAL
DATA

(A) EQUILIBRIUM

PROPERTIES

(1) No.: 01.01.1.01

(2) Properties Included : 1 2 3 0 0 0 0 0 0 0 0 0 0

1. Pressure 2.Sp.Volume 3.Temperature 4.Sp.Enthalpy
5.Isobaric Sp. Heat 6.Isochoric Sp. Heat 7.Vap.Pressure
8.Ideal gas Properties 9.Saturated Liq.Density
10.Saturated Gas Density 11.Enthalpy of Vaporization
12.Enthalpy of Melting 13.Joule Thomson coefficient
14.Other

(3) Author : Oudinoff.

(4) Date : 1909

(5) Method :

(6) Accuracy : 0.02 % for density.

(7) Reference No. : 0380

(8) Values of Properties :

Isobutane Properties (Density, gms/(litre))

Temperature (deg.C.)	Pressure (mm Hg)	Pressure (mm Hg)
	718.00000	760.00000
0.0	2.52040	2.67260

(1) No.: 01.01.2.01

(2) Properties Included : 1 2 3 0 0 0 0 0 0 0 0 0 0 0

1. Pressure	2. Sp. Volume	3. Temperature	4. Sp. Enthalpy
5. Isobaric Sp. Heat	6. Isochoric Sp. Heat	7. Vap. Pressure	
8. Ideal gas Properties		9. Saturated Liq. Density	
10. Saturated Gas Density		11. Enthalpy of Vaporization	
12. Enthalpy of Melting		13. Joule Thomson coefficient	
14. Other			

(3) Author : Oudinoff.

(4) Date : 1909

(5) Method :

(6) Accuracy : 0.02 % for density.

(7) Reference No. : 0380

(8) Values of Properties :

Isobutane Properties (Density, kg/Cubic Meter)

Temperature (deg.C.)	Pressure (Mega Pascals)	Pressure (Mega Pascals)
	0.09573	0.10132
0.0	2.52040	2.67260

(1) No.: 01.02.2.01

(2) Properties Included : 0 0 0 0 0 0 0 0 0 0 0 0 0 14

1. Pressure	2. Sp. Volume	3. Temperature	4. Sp. Enthalpy
5. Isobaric Sp. Heat	6. Isochoric Sp. Heat	7. Vap. Pressure	
8. Ideal gas Properties		9. Saturated Liq. Density	
10. Saturated Gas Density		11. Enthalpy of Vaporization	
12. Enthalpy of Melting		13. Joule Thomson coefficient	
14. Other			

(3) Author : Oudinoff.

(4) Date : 1909

(5) Method :

(6) Accuracy :

(7) Reference No. : 0380

(8) Values of Properties :

Boiling Point : -10.2 deg.C.

Critical Point : 134.5 deg.C.

(1) No.: 02.01.1.01

(2) Properties Included : 0 0 3 0 0 0 7 0 0 0 0 0 0 0

1. Pressure 2.Sp.Volume 3.Temperature 4.Sp.Enthalpy
5.Isobaric Sp. Heat 6.Isochoric Sp. Heat 7.Vap.Pressure
8.Ideal gas Properties 9.Saturated Liq.Density
10.Saturated Gas Density 11.Enthalpy of Vaporization
12.Enthalpy of Melting 13.Joule Thomson coefficient
14.Other

(3) Author : Burrel and Robertson .

(4) Date : August, 1915.

(5) Method : Vapour pressure apparatus with Pentane thermometer

(6) Accuracy : 0.04 deg.C., 0.1 mm Hg.

(7) Reference No. : 0096

(8) Values of Properties :

Vapour Pressure

Temperature (K)	Pressure (mm Hg)	Temperature (K)	Pressure (mm Hg)
259.70000	760.00000	258.20000	730.00000
256.60000	700.00000	254.00000	650.00000
251.10000	600.00000	245.40000	500.00000
239.00000	400.00000	232.00000	300.00000
211.70000	100.00000	200.40000	50.00000
192.20000	30.00000	182.40000	15.00000
174.70000	7.00000	166.90000	3.00000
158.30000	1.00000	*****	*****

(1) No.: 02.01.2.01

(2) Properties Included : 0 0 3 0 0 0 7 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Burrel and Robertson .

(4) Date : August, 1915.

(5) Method : Vapour pressure apparatus with Pentane thermometer

(6) Accuracy : 0.04 deg.C., 0.1 mm Hg.

(7) Reference No. : 0096

(8) Values of Properties :

Vapour Pressure

Temperature (deg.C.)	Pressure (k Pa)	Temperature (deg.C.)	Pressure (k Pa)
-13.45000	101.32500	-14.95000	97.32533
-16.55000	93.32566	-19.15000	86.65954
-22.05000	79.99342	-27.75000	66.66118
-34.15000	53.32895	-41.15000	39.99671
-61.45000	13.33224	-72.75000	6.66612
-80.95000	3.99967	-90.75000	1.99984
-98.45000	0.93326	-106.25000	0.39997
-114.85000	0.13332	*****	*****

(1) No.: 03.01.2.01

(2) Properties Included : 0 0 0 0 0 0 0 0 0 0 0 0 0 14

1. Pressure	2. Sp. Volume	3. Temperature	4. Sp. Enthalpy
5. Isobaric Sp. Heat	6. Isochoric Sp. Heat	7. Vap. Pressure	
8. Ideal gas Properties		9. Saturated Liq. Density	
10. Saturated Gas Density		11. Enthalpy of Vaporization	
12. Enthalpy of Melting		13. Joule Thomson coefficient	
14. Other			

(3) Author : Seibert & Burrel.

(4) Date : September, 1915.

(5) Method : Compression machine

(6) Accuracy : 0.1 deg.C., 1 mm Hg .

(7) Reference No. : 0485

(8) Values of Properties :

Critical Point

Critical Temperature : 133.7 deg.C.

Critical Pressure : 36.54 Atm.

(3.7024 MPa)

(1) No.: 03.02.1.01

(2) Properties Included : 0 0 3 0 0 0 7 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Seibert & Burrel.

(4) Date : September, 1915.

(5) Method : A compression machine .

(6) Accuracy : Temperature 0.1 %, Pressure 0.5 % .

(7) Reference No. : 0485

(8) Values of Properties :

Vapour Pressure

Temperature (deg.C.)	Pressure (mm Hg)	Temperature (deg.C.)	Pressure (mm Hg)
130.00000	*****	120.00000	21700.00000
110.00000	18600.00000	100.00000	15400.00000
90.00000	13000.00000	80.00000	10650.00000
70.00000	8700.00000	60.00000	7000.00000
50.00000	5600.00000	40.00000	4400.00000
30.00000	3400.00000	0.0	*****

(1) No.: 03.02.2.01

(2) Properties Included : 0 0 3 0 0 0 7 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Seibert & Burrell.

(4) Date : September, 1915.

(5) Method : A compression machine .

(6) Accuracy : Temperature 0.1 %, Pressure 0.5 % .

(7) Reference No. : 0485

(8) Values of Properties :

Vapour Pressure

Temperature (deg.C.)	Pressure (M Pa)	Temperature (deg.C.)	Pressure (M Pa)
130.00000	*****	120.00000	2.89309
110.00000	2.47980	100.00000	2.05316
90.00000	1.73319	80.00000	1.41988
70.00000	1.15990	60.00000	0.93326
50.00000	0.74660	40.00000	0.58662
30.00000	0.45330	0.0	*****

(1) No.: 04.01.1.01

(2) Properties Included : 0 0 3 0 0 0 7 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Dana, Jenkins, Burdick & Timm .

(4) Date : June , 1926 .

(5) Method : A combination of Platinum res. thermometer , Hg-manometer

(6) Accuracy : 0.75 % in vapour pressure.

(7) Reference No. : 0175

(8) Values of Properties :

Vapour Pressure

Temperature (deg.C.)	Pressure (mm Hg)	Temperature (deg.C.)	Pressure (mm Hg)
-24.01000	465.70000	-18.06000	598.10000
-13.34000	709.40000	-12.15000	759.10000
-9.01000	857.30000	-2.24000	1105.30000
6.66000	1499.60000	14.63000	1943.00000
22.08000	2440.00000	26.33000	2766.00000
30.98000	3161.00000	35.88000	3624.00000
39.92000	4034.00000	44.58000	4538.00000
44.58000	4535.00000	55.51000	5938.00000
62.17000	6865.00000	79.49000	9983.00000
79.49000	10047.00000	71.92000	8524.00000

(1) No.: 04.01.2.01

(2) Properties Included : 0 0 3 0 0 0 7 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Dana, Jenkins, Burdick & Timm .

(4) Date : June , 1926 .

(5) Method : A combination of Platinum res. thermometer , Hg-manomet

(6) Accuracy : 0.75 % in vapour pressure.

(7) Reference No. : 0175

(8) Values of Properties :

Vapour Pressure

Temperature (deg.C.)	Pressure (M Pa)	Temperature (deg.C.)	Pressure (M Pa)
-24.01000	0.06209	-18.06000	0.07974
-13.84000	0.09458	-12.15000	0.10120
-9.01000	0.11430	-2.24000	0.14736
6.66000	0.19993	14.63000	0.25905
22.08000	0.32531	26.33000	0.36877
30.98000	0.42143	35.88000	0.48316
39.92000	0.53782	44.58000	0.60502
44.58000	0.60462	55.51000	0.79167
62.17000	0.91526	79.49000	1.33096
79.49000	1.33949	71.92000	1.13644

(1) No.: 04.02.1.01

(2) Properties Included : 0 0 3 0 0 0 0 0 9 10 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Dana, Jenkins, Burdick & Timm .

(4) Date : June , 1926 .

(5) Method : Double picnometer method .

(6) Accuracy : 0.1 kg/cu. meter

(7) Reference No. : 0175

(8) Values of Properties :

Saturated Densities

Temperature (deg.C.)	liq. Density (gm/cc)	Vap. Density (gm/cc)
0.0	0.58200	0.00435
8.00000	0.57300	0.00554
16.00000	0.56300	0.00703
24.00000	0.55300	0.00898
32.00000	0.54300	0.01090
40.00000	0.53300	0.01340
48.00000	0.52200	*****
56.00000	0.51100	*****

(1) No.: 04.02.2.01

(2) Properties Included : 0 0 3 0 0 0 0 0 9 10 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Dana, Jenkins, Burdick & Timm .

(4) Date : June , 1926 .

(5) Method : Double picnometer method .

(6) Accuracy : 0.1 kg/cu. meter

(7) Reference No. : 0175

(8) Values of Properties :

Saturated Densities

Temperature (deg.C.)	liq. Density (kg/(m*m*m))	Vap. Density (kg/(m*m*m))
0.0	582.00000	4.35000
8.00000	573.00000	5.54000
16.00000	563.00000	7.03000
24.00000	553.00000	8.98000
32.00000	543.00000	10.90000
40.00000	533.00000	13.40000
48.00000	522.00000	*****
56.00000	511.00000	*****

(1) No.: 04.03.1.01

(2) Properties Included : 0 0 3 0 5 0 0 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Dana, Jenkins, Hurdick & Timm .

(4) Date : June , 1926 .

(5) Method : A copper calorimeter with multiple junction thermocouple .

(6) Accuracy : 1 %

(7) Reference No. : 0175

(8) Values of Properties :

Isobaric Specific Heat

Temperature (deg.C.)	Sp.Heat (Cal/(gm K))	Temperature (deg.C.)	Sp.Heat (Cal/(gm K))
-13.76000	0.49400	-12.53000	0.53200
-7.77000	0.51600	-2.59000	0.51900
-2.31000	0.54500	2.60000	0.56100
7.08000	0.58100	7.41000	0.58900
12.74000	0.62800	16.64000	0.63800
17.50000	0.61700	*****	*****

(1) No.: 04.03.2.01

(2) Properties Included : 0 0 3 0 5 0 0 0 0 0 0 0 0 0

1. Pressure 2.Sp.Volume 3.Temperature 4.Sp.Enthalpy
5.Isobaric Sp. Heat 6.Isochoric Sp. Heat 7.Vap.Pressure
8.Ideal gas Properties 9.Saturated Liq.Density
10.Saturated Gas Density 11.Enthalpy of Vaporization
12.Enthalpy of Melting 13.Joule Thomson coefficient
14.Other

(3) Author : Dana,Jenkins,Burdick & Timm .

(4) Date : June ,1926 .

(5) Method : A copper calorimeter with multiple junction thermocouple

(6) Accuracy : 1 %

(7) Reference No. : 0175

(8) Values of Properties :

Isobaric Specific Heat

Temperature (deg.C.)	Sp.Heat (kJ/(kg K))	Temperature (deg.C.)	Sp.Heat (kJ/(kg K))
-13.76000	2.06690	-12.53000	2.22589
-7.77000	2.15894	-2.59000	2.17150
-2.31000	2.28028	2.60000	2.34722
7.08000	2.43090	7.41000	2.46438
12.74000	2.62755	16.64000	2.66939
17.50000	2.58153	*****	*****

(1) No.: 05.01.1.01

(2) Properties Included : 0 0 3 0 0 0 0 0 9 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Coffin & Maass .

(4) Date : January , 1928 .

(5) Method : Dilatometer method

(6) Accuracy : Temperature 0.2 % , Density 0.05 % .

(7) Reference No. : 0140

(8) Values of Properties :

Saturated Liquid Density

Temperature (deg.C.)	Density (gm/cc)	Temperature (deg.C.)	Density (gm/cc)
25.30000	0.55300	20.20000	0.55910
12.50000	0.56820	11.70000	0.56910
8.50000	0.57290	4.30000	0.57870
0.70000	0.58210	-1.30000	0.58450
-2.70000	0.58570	-5.50000	0.58930
-6.20000	0.58990	-8.50000	0.59240
-11.20000	0.59570	-13.60000	0.59800
-15.80000	0.60050	-20.70000	0.60550
-27.80000	0.61310	*****	*****

(1) No.: 05.01.2.01

(2) Properties Included : 0 0 3 0 0 0 0 0 9 0 0 0 0 0

1. Pressure 2.Sp.Volume 3.Temperature 4.Sp.Enthalpy
5.Isobaric Sp. Heat 6.Isochoric Sp. Heat 7.Vap.Pressure
8.Ideal gas Properties 9.Saturated Liq.Density
10.Saturated Gas Density 11.Enthalpy of Vaporization
12.Enthalpy of Melting 13.Joule Thomson coefficient
14.Other

(3) Author : Coffin & Maass .

(4) Date : January ,1928 .

(5) Method : Dilatometer method

(6) Accuracy : Temperature 0.2 % , Density 0.05 % .

(7) Reference No. : 0140

(8) Values of Properties :

Saturated Liquid Density

Temperature (deg.C.)	Density (kg/(m*m*m))	Temperature (deg.C.)	Density (kg/(m*m*m))
25.30000	553.00000	20.20000	559.10000
12.50000	568.20000	11.70000	569.10000
8.50000	572.90000	4.30000	578.70000
0.70000	582.10000	-1.30000	584.50000
-2.70000	585.70000	-5.50000	589.30000
-6.20000	589.90000	-8.50000	592.40000
-11.20000	595.70000	-13.60000	598.00000
-15.80000	600.50000	-20.70000	605.50000
-27.80000	613.10000	*****	*****

(1) No.: 06.01.1.01

(2) Properties Included : 0 0 3 0 5 0 0 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Parks, Shomate, Kennedy & Crawford .

(4) Date : 1937 .

(5) Method : Nernst method with an aneroid calorimeter .

(6) Accuracy : 0.7 % .

(7) Reference No. : 0400

(8) Values of Properties :

Specific Heat (Isobaric)

Temperature (deg. K)	Sp. Heat (Cal/(K.gm))	Temperature (deg. K)	Sp. Heat (Cal/(K.gm))
81.30000	0.22670	86.00000	0.23790
91.20000	0.25060	97.30000	0.26490
102.50000	0.27760	104.80000	0.28720
115.40000	0.40850	122.10000	0.41220
136.50000	0.42390	142.80000	0.42700
154.60000	0.43450	160.80000	0.44020
171.50000	0.44710	177.30000	0.45280
187.80000	0.46020	193.50000	0.46640
202.70000	0.47330	208.50000	0.47790
214.30000	0.48240	225.00000	0.49170

(Continued)

No.: 06.01.1.02

Specific Heat(Isobaric)

Temperature (deg. K)	Sp.Heat (Cal/(K.gm))	Temperature (deg. K)	Sp.Heat (Cal/(K.gm))
230.60000	0.49730	240.20000	0.50650
245.40000	0.51270	253.00000	0.52310
258.30000	0.52830	*****	*****

(1) No.: 06.01.2.01

(2) Properties Included : 0 0 3 0 5 0 0 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Parks, Shomate, Kennedy & Crawford .

(4) Date : 1937 .

(5) Method : Nernst method with an aneroid calorimeter .

(6) Accuracy : 0.7 % .

(7) Reference No. : 0400

(8) Values of Properties :

Specific Heat(Isobaric)

Temperature (deg.C.)	Sp.Heat kJ/(kg deg.C.)	Temperature (deg.C.)	Sp.Heat kJ/(kg deg.C.)
-191.85000	0.94874	-187.15000	0.99561
-181.95000	1.04876	-175.85000	1.10861
-170.65000	1.16176	-168.35000	1.20193
-157.75000	1.70957	-151.05000	1.72506
-136.65000	1.77402	-130.35000	1.78700
-118.55000	1.81838	-112.35000	1.84224
-101.65000	1.87111	-95.85000	1.89497
-85.35000	1.92594	-79.65000	1.95188
-70.45000	1.98076	-64.65000	2.00001
-58.85000	2.01884	-48.15000	2.05776

(Continued)

No.: 06.01.2.02

Specific Heat(Isobaric)

Temperature (deg.C.)	Sp.Heat kJ/(kg deg.C.)	Temperature (deg.C.)	Sp.Heat kJ/(kg deg.C.)
-42.55000	2.08120	-32.95000	2.11970
-27.75000	2.14565	-20.15000	2.18917
-14.85000	2.21094	*****	*****

(1) No.: 06.02.2.01

(2) Properties Included : 0 0 3 0 0 0 0 0 0 0 11 12 0 14

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Parks, Shomate, Kennedy & Crawford .

(4) Date : 1937 .

(5) Method : Method of Kelly, Park and Huffman .

(6) Accuracy : 0.005 kJ/kg

(7) Reference No. : 0400

(8) Values of Properties :

Heat of Fusion = 18.51 Cal/gm. (4499.97 kJ/(kmole))

Temperature(K)	S(Cal/K.mole)	S(kJ/(K.kg))
<hr/>		
0 - 79	10.52	0.7581
79 - 113.2	5.43	0.3913
Fusion 113.2	9.505	0.6849
113.2 - 260.9	22.05	1.5889
Vaporization 260.9	19.53	1.4073
260.9 - 298.1	2.84	0.2046
Correction for real gas.	0.12	0.0087

(1) No.: 07.01.1.01

(2) Properties Included : 1 0 3 0 0 6 0 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Sage, Webster & Lacey.

(4) Date : November, 1937.

(5) Method : A modification of Eucken's adiabatic method .

(6) Accuracy : 0.5 %

(7) Reference No. : 0465

(8) Values of Properties :

Isobaric Specific Heats at 1 Atm. Pressure

Temperature (deg.F.)	Sp.Heat (Btu/(lb deg.F.))	Temperature (deg.F.)	Sp.Heat (Btu/(lb deg.F.))
70.00000	0.38880	100.00000	0.39880
130.00000	0.40960	160.00000	0.42120
190.00000	0.43320	220.00000	0.44580
250.00000	0.45940	280.00000	0.47340
310.00000	0.48810	340.00000	0.50300

(1) No.: 07.01.2.01

(2) Properties Included : 1 0 3 0 0 6 0 0 0 0 0 0 0 0

1. Pressure 2.Sp.Volume 3.Temperature 4.Sp.Enthalpy
5.Isobaric Sp. Heat 6.Isochoric Sp. Heat 7.Vap.Pressure
8.Ideal gas Properties 9.Saturated Liq.Density
10.Saturated Gas Density 11.Enthalpy of Vaporization
12.Enthalpy of Melting 13.Joule Thomson coefficient
14.Other

(3) Author : Sage, Webster & Lacey.

(4) Date : November, 1937.

(5) Method : A modification of Eucken's adiabatic method .

(6) Accuracy : 0.5 %

(7) Reference No. : 0465

(8) Values of Properties :

Isobaric Specific Heats at 0.101325 MPa.

Temperature (deg.C.)	Sp.Heat (kJ/(kg K))	Temperature (deg.C.)	Sp.Heat (kJ/(kg K))
21.11111	1.62783	37.77778	1.66970
54.44444	1.71491	71.11111	1.76348
87.77778	1.81372	104.44444	1.86648
121.11111	1.92342	137.77778	1.98203
154.44444	2.04358	171.11111	2.10596

(1) No.: 08.01.1.01

(2) Properties Included : 1 2 3 0 0 0 0 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Jessen and Lightfoot.

(4) Date : March, 1938

(5) Method :

(6) Accuracy : 0.02 deg.C., 0.03 mm Hg.

(7) Reference No. : 0295

(8) Values of Properties :

Compressibility $1/z = (P.v)_0 / (P.v)_p$

Temperature (deg.C.)	Pressure (mm Hg) 100.00000	Pressure (mm Hg) 300.00000	Pressure (mm Hg) 500.00000
0.0	1.00626	1.01812	1.02900
30.00000	1.00421	1.01217	1.01976

(1) No.: 08.01.2.01

(2) Properties Included : 1 2 3 0 0 0 0 0 0 0 0 0 0 0

1. Pressure 2.Sp.Volume 3.Temperature 4.Sp.Enthalpy
5.Isobaric Sp. Heat 6.Isochoric Sp. Heat 7.Vap.Pressure
8.Ideal gas Properties 9.Saturated Liq.Density
10.Saturated Gas Density 11.Enthalpy of Vaporization
12.Enthalpy of Melting 13.Joule Thomson coefficient
14.Other

(3) Author : Jessen and Lightfoot.

(4) Date : March, 1938

(5) Method :

(6) Accuracy : 0.02 deg.C., 0.03 mm Hg.

(7) Reference No. : 0295

(8) Values of Properties :

Compressibility $1/Z = (P.v)_0 / (P.v)_p$

Temperature (deg.C.)	Pressure (MPa) 0.01333	Pressure (MPa) 0.04000	Pressure (MPa) 0.06666
0.0	1.00626	1.01812	1.02900
30.00000	1.00421	1.01217	1.01976

(1) No.: 09.01.1.01

(2) Properties Included : 1 0 3 0 0 0 0 0 0 0 0 0 13 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Sage & Lacey.

(4) Date : October, 1939.

(5) Method : Personal apparatus .

(6) Accuracy : 0.2 psi in Pressure , 0.1 deg.F. in Temperature.

(7) Reference No. : 0470

(8) Values of Properties :

Joule Thomson Coefficient (deg.F/psi)

Pressure (psi)	Temperature (deg.F.) 70.00000	Temperature (deg.F.) 100.00000	Temperature (deg.F.) 130.00000
*****	0.34180	0.30510	0.27400
*****	*****	*****	*****
0.0	0.15000	0.13100	0.11190
14.70000	0.20880	0.16920	0.13840
20.00000	0.23080	0.18170	0.14780
40.00000	0.31830	0.23070	0.18020
60.00000	*****	0.27850	0.21050
80.00000	*****	*****	0.23800
100.00000	*****	*****	0.26450
125.00000	*****	*****	*****

(Continued)

No.: 09.01.1.02

 Joule Thomson Coefficient (deg.F/psi)

Pressure (psi)	Temperature (deg.F.) 70.00000	Temperature (deg.F.) 100.00000	Temperature (deg.F.) 130.00000
150.00000	*****	*****	*****
175.00000	*****	*****	*****
200.00000	*****	*****	*****
225.00000	*****	*****	*****
250.00000	*****	*****	*****
300.00000	*****	*****	*****
350.00000	*****	*****	*****
400.00000	*****	*****	*****

(Continued)

No.: 09.01.1.03

Joule Thomson Coefficient (deg.F/psi)

Pressure (psi)	Temperature (deg.F.) 160.00000	Temperature (deg.F.) 190.00000	Temperature (deg.F.) 220.00000
*****	0.24950	0.23290	0.22190
*****	*****	*****	*****
0.0	0.09280	0.07390	0.05480
14.70000	0.11410	0.09280	0.07290
20.00000	0.12170	0.09910	0.07890
40.00000	0.14780	0.12250	0.10030
60.00000	0.17240	0.14350	0.11880
80.00000	0.19300	0.16100	0.13480
100.00000	0.21130	0.17560	0.14790
125.00000	0.22880	0.19120	0.16190
150.00000	0.24320	0.20390	0.17400
175.00000	*****	0.21500	0.18420
200.00000	*****	0.22390	0.19260
225.00000	*****	0.23220	0.20030
250.00000	*****	*****	0.20760
300.00000	*****	*****	0.21890
350.00000	*****	*****	*****
400.00000	*****	*****	*****

(Continued)

No.: 09.01.1.04

Joule Thomson Coefficient (deg.F/psi)

Pressure (psi)	Temperature (deg.F.)
	250.00000
*****	0.21600
*****	*****
0.0	0.03500
14.70000	0.05400
20.00000	0.05990
40.00000	0.07970
60.00000	0.09650
80.00000	0.11120
100.00000	0.12300
125.00000	0.13550
150.00000	0.14660
175.00000	0.15680
200.00000	0.16450
225.00000	0.17320
250.00000	0.18000
300.00000	0.19220
350.00000	0.20280
400.00000	0.21200

(1) No.: 09.01.2.01

(2) Properties Included : 1 0 3 0 0 0 0 0 0 0 0 0 13 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Sage & Lacey.

(4) Date : October , 1939.

(5) Method : Personal apparatus .

(6) Accuracy : 0.2 psi in Pressure , 0.1 deg.F. in Temperature.

(7) Reference No. : 0470

(8) Values of Properties :

Joule Thomson Coefficient (deg.C/MPa)

Pressure (MPa)	Temperature (deg.C.)	Temperature (deg.C.)	Temperature (deg.C.)
	21.11111	37.77778	54.44444
*****	27.54114	24.58397	22.07803
*****	*****	*****	*****
0.0	12.08652	10.55556	9.01654
0.10135	16.82443	13.63359	11.15182
0.13789	18.59712	14.64080	11.90925
0.27579	25.64759	18.58906	14.51993
0.41368	*****	22.44063	16.96141
0.55158	*****	*****	19.17727
0.68947	*****	*****	21.31256
0.86184	*****	*****	*****

(Continued)

No.: 09.01.2.02

Joule Thomson Coefficient (deg.C/MPa)

Pressure (MPa)	Temperature (deg.C.) 21.11111	Temperature (deg.C.) 37.77778	Temperature (deg.C.) 54.44444
1.03421	*****	*****	*****
1.20658	*****	*****	*****
1.37895	*****	*****	*****
1.55132	*****	*****	*****
1.72369	*****	*****	*****
2.06842	*****	*****	*****
2.41316	*****	*****	*****
2.75790	*****	*****	*****

(Continued)

No.: 09.01.2.03

Joule Thomson Coefficient (deg.C/MPa)

Pressure (MPa)	Temperature (deg.C.) 71.11111	Temperature (deg.C.) 87.77778	Temperature (deg.C.) 104.44444
*****	20.10390	18.76633	17.87999
*****	*****	*****	*****
0.0	7.47752	5.95462	4.41561
0.10135	9.19381	7.47752	5.87405
0.13789	9.80619	7.98516	6.35751
0.27579	11.90925	9.87065	8.08185
0.41368	13.89144	11.56277	9.57252
0.55158	15.55132	12.97286	10.86175
0.68947	17.02587	14.14928	11.91730
0.86184	18.43596	15.40628	13.04538
1.03421	19.59627	16.42960	14.02036
1.20658	*****	17.32401	14.84224
1.37895	*****	18.04114	15.51909
1.55132	*****	18.70993	16.13953
1.72369	*****	*****	16.72774
2.06842	*****	*****	17.63825
2.41316	*****	*****	*****
2.75790	*****	*****	*****

(Continued)

No.: 09.01.2.04

Joule Thomson Coefficient (deg.C/MPa)

Pressure (MPa)	Temperature (deg.C.)
	121.11111
*****	17.40458
*****	*****
0.0	2.82019
0.10135	4.35115
0.13789	4.82655
0.27579	6.42197
0.41368	7.77566
0.55158	8.96014
0.68947	9.91094
0.86184	10.91815
1.03421	11.81255
1.20658	12.63444
1.37895	13.25488
1.55132	13.95590
1.72369	14.50382
2.06842	15.48686
2.41316	16.34097
2.75790	17.08228

(1) No.: 09.02.1.01

(2) Properties Included : 1 0 3 0 5 0 0 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Sage & Lacey.

(4) Date : October ,1939.

(5) Method : Personal apparatus .

(6) Accuracy : 1 % for $C_p(T < 93.3 \text{ deg.C.})$, 0.2 psi (P), 0.1 Deg.F. (T)

(7) Reference No. : 0470

(8) Values of Properties :

Isobaric Specific Heat (btu/lb.deg.F)

Pressure (psi)	Temperature (deg.F.) 70.00000	Temperature (deg.F.) 100.00000	Temperature (deg.F.) 130.00000
*****	0.42900	0.45400	0.48040
*****	0.56310	0.59720	0.63530
0.0	0.38480	0.39460	0.40580
14.70000	0.38960	0.39950	0.40960
20.00000	0.39410	0.40110	0.41130
40.00000	0.41920	0.41430	0.41960
60.00000	*****	0.43630	0.43130
80.00000	*****	*****	0.44700
100.00000	*****	*****	0.46920
125.00000	*****	*****	*****

(Continued)

No.: 09.02.1.02
-----Isobaric Specific Heat (btu/lb.deg.F)

Pressure (psi)	Temperature (deg.F.) 70.00000	Temperature (deg.F.) 100.00000	Temperature (deg.F.) 130.00000
150.00000	*****	*****	*****
175.00000	*****	*****	*****
200.00000	*****	*****	*****
225.00000	*****	*****	*****
250.00000	*****	*****	*****
300.00000	*****	*****	*****
350.00000	*****	*****	*****
400.00000	*****	*****	*****

(Continued)

No.: 09.02.1.03

 Isobaric Specific Heat (btu/lb.deg.F)

Pressure (psi)	Temperature (deg.F.) 160.00000	Temperature (deg.F.) 190.00000	Temperature (deg.F.) 220.00000
*****	0.51120	0.54750	0.60000
*****	0.68200	0.74130	0.81930
0.0	0.41700	0.42930	0.44190
14.70000	0.42120	0.43320	0.44580
20.00000	0.42270	0.43470	0.44730
40.00000	0.42920	0.44060	0.45290
60.00000	0.43710	0.44710	0.45900
80.00000	0.44680	0.45420	0.46540
100.00000	0.45850	0.46220	0.47220
125.00000	0.47670	0.47350	0.48130
150.00000	0.49970	0.48690	0.49120
175.00000	*****	0.50190	0.50200
200.00000	*****	0.52000	0.51400
225.00000	*****	0.54310	0.52750
250.00000	*****	*****	0.54280
300.00000	*****	*****	0.58400
350.00000	*****	*****	*****
400.00000	*****	*****	*****

(Continued)

No.: 08.02.1.04

Isobaric Specific Heat (btu/lb.deg.F)

Pressure (psi)	Temperature (deg.F.)
	250.00000
*****	*****
*****	*****
0.0	0.45550
14.70000	0.45940
20.00000	0.46090
40.00000	0.46650
60.00000	0.47250
80.00000	0.47870
100.00000	0.48530
125.00000	0.49380
150.00000	0.50280
175.00000	0.51230
200.00000	0.52220
225.00000	0.53260
250.00000	0.54370
300.00000	0.56900
350.00000	0.60200
400.00000	*****

(1) No.: 09.02.2.01

(2) Properties Included : 1 0 3 0 5 0 0 0 0 0 0 0 0 0

1. Pressure 2.Sp.Volume 3.Temperature 4.Sp.Enthalpy
5.Isobaric Sp. Heat 6.Isochoric Sp. Heat 7.Vap.Pressure
8.Ideal gas Properties 9.Saturated Liq.Density
10.Saturated Gas Density 11.Enthalpy of Vaporization
12.Enthalpy of Melting 13.Joule Thomson coefficient
14.Other

(3) Author : Sage & Lacey.

(4) Date : October ,1939.

(5) Method : Personal apparatus .

(6) Accuracy : 1 % for Cp(T< 93.3 deg.C.),0.2 psi (P), 0.1 Deg.F. (T)

(7) Reference No. : 0470

(8) Values of Properties :

Isobaric Specific Heat (kJ/kg.K)

Pressure (MPa)	Temperature (deg.C.)	Temperature (deg.C.)	Temperature (deg.C.)
	21.11111	37.77778	54.44444
*****	1.79614	1.90081	2.01134
*****	2.35759	2.50036	2.65987
0.0	1.61108	1.65211	1.69900
0.10135	1.63118	1.67263	1.71491
0.13789	1.65002	1.67933	1.72203
0.27579	1.75511	1.73459	1.75678
0.41368	*****	1.82670	1.80577
0.55158	*****	*****	1.87150
0.68947	*****	*****	1.96445
0.86184	*****	*****	*****

(Continued)

No.: 09.02.2.02

 Isobaric Specific Heat (kJ/kg.K)

Pressure (MPa)	Temperature (deg.C.) 21.11111	Temperature (deg.C.) 37.77778	Temperature (deg.C.) 54.44444
1.03421	*****	*****	*****
1.20658	*****	*****	*****
1.37895	*****	*****	*****
1.55132	*****	*****	*****
1.72369	*****	*****	*****
2.06842	*****	*****	*****
2.41316	*****	*****	*****
2.75790	*****	*****	*****

(Continued)

No.: 09.02.2.03

Isoharic Specific Heat (kJ/kg.K)

Pressure (MPa)	Temperature (deg.C.) 71.11111	Temperature (deg.C.) 87.77778	Temperature (deg.C.) 104.44444
*****	2.14029	2.29227	2.51208
*****	2.85540	3.10367	3.43025
0.0	1.74590	1.79739	1.85015
0.10135	1.76348	1.81372	1.86648
0.13789	1.76976	1.82000	1.87276
0.27579	1.79697	1.84470	1.89620
0.41368	1.83005	1.87192	1.92174
0.55158	1.87066	1.90164	1.94854
0.68947	1.91965	1.93514	1.97701
0.86184	1.99585	1.98245	2.01511
1.03421	2.09214	2.03855	2.05656
1.20658	*****	2.10135	2.10177
1.37895	*****	2.17714	2.15202
1.55132	*****	2.27385	2.20854
1.72369	*****	*****	2.27260
2.06842	*****	*****	2.44509
2.41316	*****	*****	*****
2.75790	*****	*****	*****

(Continued)

No.: 09.02.2.04

 Isobaric Specific Heat (kJ/kg.K)

Pressure (MPa)	Temperature (deg.C.)
	121.11111
*****	*****
*****	*****
0.0	1.90709
0.10135	1.92342
0.13789	1.92970
0.27579	1.95314
0.41368	1.97826
0.55158	2.00422
0.68947	2.03185
0.86184	2.06744
1.03421	2.10512
1.20658	2.14490
1.37895	2.18635
1.55132	2.22989
1.72369	2.27636
2.06842	2.38229
2.41316	2.52045
2.75790	*****

(1) No.: 09.03.1.01

(2) Properties Included : 1 2 3 0 0 0 0 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Sage & Lacey.

(4) Date : October, 1939.

(5) Method : Personal apparatus .

(6) Accuracy : 0.1 % for v, 0.1 deg.F. for (T), 0.2 psi for (P).

(7) Reference No. : 0470

(8) Values of Properties :

Specific Volume (cu .ft./lb)

Pressure (psi)	Temperature (deg.F.) 70.00000	Temperature (deg.F.) 100.00000	Temperature (deg.F.) 130.00000
*****	1.97500	1.24630	0.81230
*****	0.02863	0.02981	0.03118
10.00000	9.60700	10.17500	10.73300
14.69600	6.48200	6.87200	7.25700
20.00000	4.71500	5.00800	5.29400
30.00000	3.07500	3.27900	3.47600
40.00000	2.24900	2.41100	2.56500
50.00000	*****	1.88800	2.01700
60.00000	*****	1.53790	1.65080
80.00000	*****	*****	1.19050

(Continued)

No.: 09.03.1.02

Specific Volume (cu .ft./lb)

Pressure (psi)	Temperature (deg.F.) 70.00000	Temperature (deg.F.) 100.00000	Temperature (deg.F.) 130.00000
100.00000	*****	*****	0.91210
125.00000	*****	*****	*****
150.00000	*****	*****	*****
175.00000	*****	*****	*****
200.00000	*****	*****	*****
225.00000	*****	*****	*****
250.00000	0.02848	0.02966	0.03100
275.00000	*****	*****	*****
300.00000	*****	*****	*****
350.00000	*****	*****	*****
400.00000	*****	*****	*****
500.00000	0.02831	0.02942	0.03066
750.00000	0.02814	0.02920	0.03036
1000.00000	0.02799	0.02900	0.03009
1250.00000	0.02785	0.02881	0.02986
1500.00000	0.02770	0.02864	0.02966
1750.00000	0.02756	0.02847	0.02945
2000.00000	0.02742	0.02831	0.02926
2250.00000	0.02730	0.02816	0.02908
2500.00000	0.02719	0.02802	0.02891

(Continued)

No.: 09.03.1.03

Specific Volume (cu .ft./lb)

Pressure (psi)	Temperature (deg.F.) 70.00000	Temperature (deg.F.) 100.00000	Temperature (deg.F.) 130.00000
2750.00000	0.02709	0.02790	0.02876
3000.00000	0.02699	0.02776	0.02860

(Continued)

No.: 09.03.1.04

Specific Volume (cu .ft./lb)			
Pressure (psi)	Temperature (deg.F.) 160.00000	Temperature (deg.F.) 190.00000	Temperature (deg.F.) 220.00000
*****	0.54370	0.36870	0.24760
*****	0.03285	0.03506	0.03799
10.00000	11.29100	11.85400	12.41000
14.69600	7.64100	8.02300	8.40300
20.00000	5.57800	5.86000	6.14100
30.00000	3.66900	3.86100	4.05100
40.00000	2.71500	2.86100	3.00600
50.00000	2.14000	2.26000	2.37900
60.00000	1.75750	1.86000	1.96190
80.00000	1.27810	1.36040	1.44040
100.00000	0.98880	1.00000	1.12780
125.00000	0.75580	0.81830	0.87710
150.00000	0.59830	0.65570	0.70910
175.00000	*****	0.53910	0.58880
200.00000	*****	0.45050	0.49770
225.00000	*****	0.37940	0.42520
250.00000	0.03265	0.03499	0.36490
275.00000	*****	*****	0.31390
300.00000	*****	*****	0.26960
350.00000	*****	*****	*****

(Continued)

No.: 09.03.1.05

Specific Volume (cu .ft./lb)

Pressure (psi)	Temperature (deg.F.) 160.00000	Temperature (deg.F.) 190.00000	Temperature (deg.F.) 220.00000
400.00000	*****	*****	*****
500.00000	0.03215	0.03421	0.03678
750.00000	0.03174	0.03352	0.03566
1000.00000	0.03139	0.03300	0.03484
1250.00000	0.03107	0.03251	0.03424
1500.00000	0.03079	0.03212	0.03370
1750.00000	0.03051	0.03177	0.03317
2000.00000	0.03027	0.03145	0.03278
2250.00000	0.03006	0.03118	0.03241
2500.00000	0.02986	0.03091	0.03208
2750.00000	0.02966	0.03067	0.03176
3000.00000	0.02944	0.03044	0.03152

(Continued)

No.: 09.03.1.06

Specific Volume (cu .ft./lb)	

Pressure	Temperature
(psi)	(deg.F.)

250.00000	

*****	0.15400
*****	0.04228
10.00000	12.96500
14.69600	8.78300
20.00000	6.42200
30.00000	4.24000
40.00000	3.15000
50.00000	2.49700
60.00000	2.06100
80.00000	1.51780
100.00000	1.19250
125.00000	0.93220
150.00000	0.75850
175.00000	0.63550
200.00000	0.53920
225.00000	0.46520
250.00000	0.40480
275.00000	0.35410
300.00000	0.31110
350.00000	0.24160

(Continued)

No.: 09.03.1.07

Specific Volume (cu .ft./lb)

Pressure (psi)	Temperature (deg.F.)
	250.00000
400.00000	0.18700
500.00000	0.04112
750.00000	0.03875
1000.00000	0.03730
1250.00000	0.03628
1500.00000	0.03549
1750.00000	0.03487
2000.00000	0.03431
2250.00000	0.03383
2500.00000	0.03345
2750.00000	0.03307
3000.00000	0.03273

(1) No.: 09.03.2.01

(2) Properties Included : 1 2 3 0 0 0 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Sage & Lacey.

(4) Date : October , 1939.

(5) Method : Personal apparatus .

(6) Accuracy : 0.1 % for v, 0.1 deg. F. for (T), 0.2 psi for (P).

(7) Reference No. : 0470

(8) Values of Properties :

Specific Volume ((m*m*m)/kg)

Pressure (M Pa)	Temperature (deg. C.)	Temperature (deg. C.)	Temperature (deg. C.)
	21.11111	37.77778	54.44444
*****	0.12330	0.07780	0.05071
*****	0.00179	0.00186	0.00195
0.06895	0.59975	0.63520	0.67004
0.10133	0.40466	0.42901	0.45304
0.13789	0.29435	0.31264	0.33049
0.20684	0.19197	0.20470	0.21700
0.27579	0.14040	0.15051	0.16013
0.34474	*****	0.11786	0.12592
0.41368	*****	0.09601	0.10306
0.55158	*****	*****	0.07432

(Continued)

No.: 09.03.2.02

Specific Volume ((m*m*m)/kg)

Pressure (M Pa)	Temperature (deg.C.) 21.11111	Temperature (deg.C.) 37.77778	Temperature (deg.C.) 54.44444
0.68947	*****	*****	0.05694
0.86184	*****	*****	*****
1.03421	*****	*****	*****
1.20658	*****	*****	*****
1.37895	*****	*****	*****
1.55132	*****	*****	*****
1.72369	0.00178	0.00185	0.00194
1.89605	*****	*****	*****
2.06842	*****	*****	*****
2.41316	*****	*****	*****
2.75790	*****	*****	*****
3.44737	0.00177	0.00184	0.00191
5.17106	0.00176	0.00182	0.00190
6.89474	0.00175	0.00181	0.00188
8.61843	0.00174	0.00180	0.00186
10.34212	0.00173	0.00179	0.00185
12.06580	0.00172	0.00178	0.00184
13.78949	0.00171	0.00177	0.00183
15.51318	0.00170	0.00176	0.00182
17.23686	0.00170	0.00175	0.00180

(Continued)

No.: 09.03.2.03

Specific Volume ((m*m*m)/kg)

Pressure (M Pa)	Temperature (deg.C.) 21.11111	Temperature (deg.C.) 37.77778	Temperature (deg.C.) 54.44444
18.96055	0.00169	0.00174	0.00180
20.68423	0.00168	0.00173	0.00179

(Continued)

No.: 09.03.2.04

Specific Volume ((m**m**m)/kg)

Pressure (M Pa)	Temperature (deg.C.) 71.11111	Temperature (deg.C.) 87.77778	Temperature (deg.C.) 104.44444
*****	0.03394	0.02302	0.01546
*****	0.00205	0.00219	0.00237
0.06895	0.70487	0.74002	0.77473
0.10133	0.47701	0.50086	0.52458
0.13789	0.34822	0.36583	0.38337
0.20684	0.22905	0.24103	0.25290
0.27579	0.16949	0.17861	0.18766
0.34474	0.13360	0.14109	0.14852
0.41368	0.10972	0.11612	0.12248
0.55158	0.07979	0.08493	0.08992
0.68947	0.06173	0.06243	0.07041
0.86184	0.04718	0.05108	0.05476
1.03421	0.03735	0.04093	0.04427
1.20658	*****	0.03365	0.03676
1.37895	*****	0.02812	0.03107
1.55132	*****	0.02369	0.02654
1.72369	0.00204	0.00218	0.02278
1.89605	*****	*****	0.01960
2.06842	*****	*****	0.01683
2.41316	*****	*****	*****

(Continued)

No.: 09.03.2.05

Specific Volume ((m*m*m)/kg)

Pressure (M Pa)	Temperature (deg.C.) 71.11111	Temperature (deg.C.) 87.77778	Temperature (deg.C.) 104.44444
2.75790	*****	*****	*****
3.44737	0.00201	0.00214	0.00230
5.17106	0.00198	0.00209	0.00223
6.89474	0.00196	0.00206	0.00217
8.61843	0.00194	0.00203	0.00214
10.34212	0.00192	0.00201	0.00210
12.06580	0.00190	0.00198	0.00207
13.78949	0.00189	0.00196	0.00205
15.51318	0.00188	0.00195	0.00202
17.23686	0.00186	0.00193	0.00200
18.96055	0.00185	0.00191	0.00198
20.68423	0.00184	0.00190	0.00197

(Continued)

No.: 09.03.2.06

Specific Volume ((m*m*m)/kg)

Pressure (M Pa)	Temperature (deg.C.)
	121.11111

*****	0.00961
*****	0.00264
0.06895	0.80938
0.10133	0.54831
0.13789	0.40091
0.20684	0.26469
0.27579	0.19665
0.34474	0.15588
0.41368	0.12866
0.55158	0.09475
0.68947	0.07445
0.86184	0.05820
1.03421	0.04735
1.20658	0.03967
1.37895	0.03366
1.55132	0.02904
1.72369	0.02527
1.89605	0.02211
2.06842	0.01942
2.41316	0.01508

(Continued)

No.: 09.03.2.07

Specific Volume ((m*m*m)/kg)	

Pressure	Temperature
(M Pa)	(deg.C.)

	121.11111

2.75790	0.01167
3.44737	0.00257
5.17106	0.00242
6.89474	0.00233
8.61843	0.00226
10.34212	0.00222
12.06580	0.00218
13.78949	0.00214
15.51318	0.00211
17.23686	0.00209
18.96055	0.00206
20.68423	0.00204

(1) No.: 09.04.1.01

(2) Properties Included : 0 0 3 0 0 0 7 0 9 10 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Sage & Lacey.

(4) Date : October , 1939.

(5) Method : Personal apparatus .

(6) Accuracy : 0.1 % in vapour pressure , 0.1 deg.F. in temperature

(7) Reference No. : 0470

(8) Values of Properties :

Saturated Properties

Pressure (psi)	Temperature (deg.F.)	Sat. Vap. Sp. Vol. (cu.ft./lb)	Sat. liq. Sp. Vol. (cu.ft./lb)
40.00000	63.00000	2.21000	0.02838
50.00000	76.50000	1.78130	0.02888
60.00000	88.10000	1.49040	0.02932
70.00000	98.20000	1.27960	0.02973
80.00000	107.30000	1.11980	0.03013
90.00000	115.50000	0.99470	0.03049
100.00000	123.80000	0.89490	0.03088
125.00000	139.80000	0.71030	0.03167
150.00000	154.20000	0.58640	0.03245
175.00000	167.00000	0.49790	0.03331

(Continued)

No.: 09.04.1.02

Saturated Properties

Pressure (psi)	Temperature (deg.F.)	Sat.Vap.Sp.Vol. (cu.ft./lb)	Sat.liq.Sp.Vol. (cu.ft./lb)
200.00000	178.30000	0.43050	0.03412
225.00000	188.70000	0.37690	0.03496
250.00000	198.30000	0.33270	0.03578
275.00000	207.30000	0.29540	0.03663
300.00000	215.60000	0.26330	0.03748
325.00000	223.50000	0.23250	0.03838
350.00000	231.00000	0.21100	0.03935
375.00000	238.10000	0.18880	0.04036
400.00000	244.90000	0.16860	0.04143

(1) No.: 09.04.2.01

(2) Properties Included : 0 0 3 0 0 0 7 0 9 10 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Sage & Lacey.

(4) Date : October , 1939.

(5) Method : Personal apparatus .

(6) Accuracy : 0.1 % in vapour pressure , 0.1 deg.F. in temperature

(7) Reference No. : 0470

(8) Values of Properties :

Saturated Properties

Pressure (Mega Pascals)	Temperature (deg.C.)	Sat. Vap. Sp. Vol. (cu. meter/kg)	Sat. liq. Sp. Vol. (cu. meter/lb)
0.27579	17.22222	0.13797	0.00177
0.34474	24.72222	0.11120	0.00180
0.41368	31.16667	0.09304	0.00183
0.48263	36.77778	0.07988	0.00186
0.55158	41.83333	0.06991	0.00188
0.62053	46.38889	0.06210	0.00190
0.68947	51.00000	0.05587	0.00193
0.86184	59.88889	0.04434	0.00198
1.03421	67.88889	0.03661	0.00203
1.20658	75.00000	0.03108	0.00208

(Continued)

No.: 09.04.2.02

Saturated Properties

Pressure Mega Pascals)	Temperature (deg.C.)	Sat.Vap.Sp.Vol. (cu.meter/kg)	Sat.liq.Sp.Vol. (cu.meter/lb)
1.37895	81.27778	0.02688	0.00213
1.55132	87.05556	0.02353	0.00218
1.72369	92.38889	0.02077	0.00223
1.89605	97.38889	0.01844	0.00229
2.06842	102.00000	0.01644	0.00234
2.24079	106.38889	0.01451	0.00240
2.41316	110.55556	0.01317	0.00246
2.58553	114.50000	0.01179	0.00252
2.75790	118.27778	0.01053	0.00259

(1) No.: 10.01.1.01

(2) Properties Included : 1 2 3 0 0 0 0 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Morris, Sage & Lacey Data.

(4) Date : October , 1939 .

(5) Method : Personal apparatus .

(6) Accuracy : 0.05 % in pressures above 500 psi , 0.03 % in Sp. Volu

(7) Reference No. : 0365

(8) Values of Properties :

Sp. Vol. of Isobutane (cu. ft./lb)

Pressure (psi)	Temperature (deg. F.) 100.00000	Temperature (deg. F.) 160.00000	Temperature (deg. F.) 220.00000
*****	0.02981	0.03284	0.03799
100.00000	0.02978	*****	*****
200.00000	0.02969	0.03277	*****
400.00000	0.02950	0.03236	0.03746
500.00000	*****	*****	*****
600.00000	0.02932	0.03202	0.03640
700.00000	*****	*****	*****
800.00000	0.02916	0.03170	0.03559
900.00000	*****	*****	*****
1000.00000	0.02900	0.03141	0.03495

(Continued)

No.: 10.01.1.02

 Sp.Vol.of Isobutane (cu.ft./lb)

Pressure (psi)	Temperature (deg.F.) 100.00000	Temperature (deg.F.) 160.00000	Temperature (deg.F.) 220.00000
1250.00000	0.02881	0.03108	0.03429
1500.00000	0.02864	0.03079	0.03374
1750.00000	0.02848	0.03053	0.03327
2000.00000	0.02833	0.03028	0.03286
2250.00000	0.02819	0.03006	0.03249
2500.00000	0.02807	0.02986	0.03216
2750.00000	0.02794	0.02966	0.03186
3000.00000	0.02782	0.02948	0.03159
3250.00000	0.02771	0.02932	0.03133
3500.00000	0.02760	0.02917	0.03109
3750.00000	0.02749	0.02903	0.03087
4000.00000	0.02739	0.02889	0.03066
4250.00000	0.02729	0.02876	0.03045
4500.00000	0.02720	0.02863	0.03026
4750.00000	0.02711	0.02852	0.03008
5000.00000	0.02703	0.02841	0.02991

(Continued)

No.: 10.01.1.03

Sp.Vol.of Isobutane (cu.ft./lb)

Pressure (psi)	Temperature (deg.F.) 280.00000	Temperature (deg.F.) 340.00000	Temperature (deg.F.) 400.00000
*****	*****	*****	*****
100.00000	1.27200	1.40300	1.52200
200.00000	0.58570	0.66340	0.72990
400.00000	0.23060	0.28740	0.33220
500.00000	0.14370	0.20910	0.25140
600.00000	0.04900	0.15470	0.19710
700.00000	0.04460	0.11360	0.15840
800.00000	0.04245	0.08350	0.12900
900.00000	*****	0.06494	0.10670
1000.00000	0.04079	0.05645	0.08994
1250.00000	0.03384	0.04780	0.06574
1500.00000	0.03779	0.04411	0.05551
1750.00000	0.03688	0.04197	0.05019
2000.00000	0.03613	0.04041	0.04698
2250.00000	0.03550	0.03920	0.04471
2500.00000	0.03496	0.03824	0.04301
2750.00000	0.03449	0.03744	0.04167
3000.00000	0.03406	0.03682	0.04060
3250.00000	0.03368	0.03628	0.03979
3500.00000	0.03332	0.03577	0.03904

(Continued)

No.: 10.01.1.04
-----Sp.Vol.of Isobutane (cu.ft./lb)

Pressure (psi)	Temperature (deg.F.) 280.00000	Temperature (deg.F.) 340.00000	Temperature (deg.F.) 400.00000
3750.00000	0.03299	0.03533	0.03842
4000.00000	0.03269	0.03490	0.03780
4250.00000	0.03240	0.03450	0.03723
4500.00000	0.03213	0.03416	0.03671
4750.00000	0.03188	0.03384	0.03627
5000.00000	0.03164	0.03353	0.03590

(Continued)

No.: 10.01.1.05

Sp.Vol.of Isobutane (cu.ft./lb)

Pressure (psi)	Temperature (deg.F.)
	460.00000
*****	*****
100.00000	1.64200
200.00000	0.79520
400.00000	0.37180
500.00000	0.28660
600.00000	0.22970
700.00000	0.18900
800.00000	0.15890
900.00000	0.13570
1000.00000	0.11760
1250.00000	0.08731
1500.00000	0.07045
1750.00000	0.06084
2000.00000	0.05510
2250.00000	0.05134
2500.00000	0.04856
2750.00000	0.04649
3000.00000	0.04481
3250.00000	0.04343
3500.00000	0.04227

(Continued)

No.: 10.01.1.06

Sp.Vol.of Isobutane (cu.ft./lb)	

Pressure (psi)	Temperature (deg.F.)

	460.00000

3750.00000	0.04131
4000.00000	0.04047
4250.00000	0.03972
4500.00000	0.03904
4750.00000	0.03846
5000.00000	0.03795

(1) No.: 10.01.2.01

(2) Properties Included : 1 2 3 0 0 0 0 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Morris, Sage & Lacey Data.

(4) Date : October , 1939 .

(5) Method : Personal apparatus .

(6) Accuracy : 0.05 % in pressures above 500 psi , 0.03 % in Sp. Volume

(7) Reference No. : 0365

(8) Values of Properties :

Sp. Vol. of Isobutane (cu. meter/kg)

Pressure (MPa)	Temperature (deg. C.) 37.77778	Temperature (deg. C.) 71.11111	Temperature (deg. C.) 104.44444
*****	0.00186	0.00205	0.00237
0.68947	0.00186	*****	*****
1.37895	0.00185	0.00205	*****
2.75790	0.00184	0.00202	0.00234
3.44737	*****	*****	*****
4.13685	0.00183	0.00200	0.00227
4.82632	*****	*****	*****
5.51580	0.00182	0.00198	0.00222
6.20527	*****	*****	*****
6.89474	0.00181	0.00196	0.00218

(Continued)

No.: 10.01.2.02

Sp.Vol.of Isobutane (cu.meter/kg)

Pressure (MPa)	Temperature (deg.C.) 37.77778	Temperature (deg.C.) 71.11111	Temperature (deg.C.) 104.44444
8.61843	0.00180	0.00194	0.00214
10.34212	0.00179	0.00192	0.00211
12.06580	0.00178	0.00191	0.00208
13.78949	0.00177	0.00189	0.00205
15.51318	0.00176	0.00188	0.00203
17.23686	0.00175	0.00186	0.00201
18.96055	0.00174	0.00185	0.00199
20.68423	0.00174	0.00184	0.00197
22.40792	0.00173	0.00183	0.00196
24.13161	0.00172	0.00182	0.00194
25.85529	0.00172	0.00181	0.00193
27.57898	0.00171	0.00180	0.00191
29.30267	0.00170	0.00180	0.00190
31.02635	0.00170	0.00179	0.00189
32.75004	0.00169	0.00178	0.00188
34.47372	0.00169	0.00177	0.00187

(Continued)

No.: 10.01.2.03

Sp.Vol.of Isobutane (cu.meter/kg)

Pressure (MPa)	Temperature (deg.C.) 137.77778	Temperature (deg.C.) 171.11111	Temperature (deg.C.) 204.44444
*****	*****	*****	*****
0.68947	0.07941	0.08759	0.09502
1.37895	0.03656	0.04141	0.04557
2.75790	0.01440	0.01794	0.02074
3.44737	0.00897	0.01305	0.01569
4.13685	0.00306	0.00966	0.01230
4.82632	0.00278	0.00709	0.00989
5.51580	0.00265	0.00521	0.00805
6.20527	*****	0.00405	0.00666
6.89474	0.00255	0.00352	0.00561
8.61843	0.00242	0.00298	0.00410
10.34212	0.00236	0.00275	0.00347
12.06580	0.00230	0.00262	0.00313
13.78949	0.00226	0.00252	0.00293
15.51318	0.00222	0.00245	0.00279
17.23686	0.00218	0.00239	0.00269
18.96055	0.00215	0.00234	0.00260
20.68423	0.00213	0.00230	0.00253
22.40792	0.00210	0.00226	0.00248
24.13161	0.00208	0.00223	0.00244

(Continued)

No.: 10.01.2.04

Sp.Vol.of Isobutane (cu.meter/kg)

Pressure (MPa)	Temperature (deg.C.) 137.77778	Temperature (deg.C.) 171.11111	Temperature (deg.C.) 204.44444
25.85529	0.00206	0.00221	0.00240
27.57838	0.00204	0.00218	0.00236
29.30267	0.00202	0.00215	0.00232
31.02635	0.00201	0.00213	0.00229
32.75004	0.00199	0.00211	0.00226
34.47372	0.00198	0.00209	0.00224

(Continued)

No.: 10.01.2.05

Sp.Vol.of Isobutane (cu.meter/kg)

Pressure (MPa)	Temperature (deg.C.)
	237.77778
*****	*****
0.68947	0.10251
1.37895	0.04964
2.75790	0.02321
3.44737	0.01789
4.13685	0.01434
4.82632	0.01180
5.51580	0.00992
6.20527	0.00847
6.89474	0.00734
8.61843	0.00545
10.34212	0.00440
12.06580	0.00380
13.78949	0.00344
15.51318	0.00321
17.23686	0.00303
18.96055	0.00290
20.68423	0.00280
22.40792	0.00271
24.13161	0.00264

(Continued)

No.: 10.01.2.06
-----Sp.Vol.of Isobutane (cu.meter/kg)

Pressure (MPa)	Temperature (deg.C.)
	237.77778
25.85529	0.00258
27.57898	0.00253
29.30267	0.00248
31.02635	0.00244
32.75004	0.00240
34.47372	0.00237

(1) No.: 10.02.1.01

(2) Properties Included : 1 2 3 0 0 0 0 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Morris, Sage & Lacey Data.

(4) Date : October , 1939 .

(5) Method : Personal apparatus.

(6) Accuracy : 0.05 % in pressures above 500 psi , 0.03 % in Sp. Volume

(7) Reference No. : 0365

(8) Values of Properties :

Specific Volumes of Isobutane at 280 deg.F.

Pressure (psi)	Sp. Volume (cu.ft./lb)	Pressure (psi)	Sp. Volume (cu.ft./lb)
460.00000	0.17700	480.00000	0.16020
500.00000	0.14370	520.00000	0.12550
530.00000	0.11520	540.00000	0.10230
550.00000	0.08360	560.00000	0.05950
570.00000	0.05510	580.00000	0.05180
600.00000	0.04900	700.00000	0.04460

(1) No.: 10.02.2.01

(2) Properties Included : 1 2 3 0 0 0 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Morris, Sage & Lacey Data.

(4) Date : October , 1939 .

(5) Method : Personal apparatus.

(6) Accuracy : 0.05 % in pressures above 500 psi , 0.03 % in Sp. Volume .

(7) Reference No. : 0365

(8) Values of Properties :

Specific Volumes of Isobutane at 137.78 deg.C.

Pressure (M Pa)	Sp. Volume (cu. metre / kg)	Pressure (M Pa)	Sp. Volume (cu. metre / kg)
3.17158	0.01105	3.30948	0.01000
3.44737	0.00897	3.58527	0.00783
3.65421	0.00719	3.72316	0.00639
3.79211	0.00522	3.86106	0.00371
3.93000	0.00344	3.99895	0.00323
4.13685	0.00306	4.82632	0.00278

(1) No.: 11.01.1.01

(2) Properties Included : 0 0 3 0 0 0 7 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Gilland & Scheeline .

(4) Date : 1940

(5) Method : Transparent equilibrium still with inert gas thermometer

(6) Accuracy : Temperature 0.1 deg.F., Pressure 2 psia .

(7) Reference No. : 0245

(8) Values of Properties :

Vapour Pressure

Pressure (psi)	Temperature (deg.F.)	Pressure (psi)	Temperature (deg.F.)
198.00000	174.00000	290.00000	211.00000
395.00000	241.00000	493.00000	266.00000
535.00000	274.00000	*****	*****

(1) No.: 11.01.2.01

(2) Properties Included : 0 0 3 0 0 0 7 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Gilland & Scheeline .

(4) Date : 1940

(5) Method : Transparent equilibrium still with inert gas thermometer.

(6) Accuracy : Temperature 0.1 deg.F., Pressure 2 psia .

(7) Reference No. : 0245

(8) Values of Properties :

Vapour Pressure

Pressure (M Pa)	Temperature (deg. C.)	Pressure (M Pa)	Temperature (deg. C.)
1.36516	78.88889	1.99948	99.44444
2.72342	116.11111	3.39911	130.00000
3.68869	134.44444	*****	*****

(1) No.: 12.01.1.01

(2) Properties Included : 0 0 3 0 5 0 0 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Aston, Kennedy & Schumann .

(4) Date : August , 1940

(5) Method : Glaque & Webb calorimeter

(6) Accuracy : Worse than 1% below 25 K, 1% over 25:40 K; |.1% above tha

(7) Reference No. : 0020

(8) Values of Properties :

Isobaric Specific Heat (1 Cal.=4.1833 I.T.Joule)

Temperature (K)	Sp.Heat (Cal/mole.K)	Temperature (K)	Sp.Heat (Cal/mole.K)
62.79000	10.75600	68.42000	11.44300
74.57000	12.34100	82.22000	13.30800
86.47000	13.76100	92.69000	14.52200
97.51000	15.28000	103.16000	16.10000
107.50000	16.48000	110.57000	16.75000
112.58000	17.50000	116.94000	23.88000
123.11000	24.13000	129.43000	24.23000
135.80000	24.51000	142.84000	24.76000
150.13000	25.07000	158.46000	25.48000
165.22000	25.87000	168.70000	25.94000

(Continued)

No.: 12.01.1.02

 Isobaric Specific Heat (1 Cal.=4.1833 I.T.Joule)

Temperature (K)	Sp.Heat (Cal/mole.K)	Temperature (K)	Sp.Heat (Cal/mole.K)
174.45000	26.19000	180.31000	26.56000
185.87000	26.80000	190.99000	27.03000
196.10000	27.22000	201.52000	27.48000
206.56000	27.61000	211.63000	27.86000
216.78000	28.33000	222.27000	28.47000
227.31000	28.86000	232.89000	29.21000
238.57000	29.67000	245.04000	30.07000
251.94000	30.50000	257.02000	30.66000
60.12000	10.37800	65.73000	11.11500
84.31000	13.55600	91.20000	14.38000
12.53000	0.66400	14.57000	1.14600
17.16000	1.82300	20.54000	2.64800
24.20000	3.57600	28.45000	4.66000
35.74000	6.19500	40.51000	7.23400
46.45000	8.29800	50.90000	9.04500
55.68000	9.78200	*****	*****

(1) No.: 12.01.2.01

(2) Properties Included : 0 0 3 0 5 0 0 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Aston, Kennedy & Schumann .

(4) Date : August , 1940

(5) Method : Giaque & Webb calorimeter

(6) Accuracy : Worse than 1% below 25 K, 1% over 25:40 K; |.1% above tha

(7) Reference No. : 0020

(8) Values of Properties :

Isobaric Specific Heat

Temperature (deg.C.)	Sp.Heat (kJ/kg.K)	Temperature (deg.C.)	Sp.Heat (kJ/kg.K)
-210.36000	0.77417	-204.73000	0.82362
-198.58000	0.88825	-190.93000	0.95785
-186.68000	0.99046	-180.46000	1.04523
-175.64000	1.09979	-169.99000	1.15881
-165.65000	1.18616	-162.58000	1.20559
-160.57000	1.25957	-156.21000	1.71878
-150.04000	1.73677	-143.72000	1.74397
-137.35000	1.76412	-130.31000	1.78212
-123.02000	1.80443	-114.69000	1.83394
-107.93000	1.86201	-104.45000	1.86705

(Continued)

No.: 12.01.2.02

Isobaric Specific Heat

Temperature (deg.C.)	Sp.Heat (kJ/kg.K)	Temperature (deg.C.)	Sp.Heat (kJ/kg.K)
-98.70000	1.88504	-92.84000	1.91167
-87.28000	1.92895	-82.16000	1.94550
-77.05000	1.95918	-71.63000	1.97789
-66.59000	1.98725	-61.52000	2.00524
-56.37000	2.03907	-50.88000	2.04915
-45.84000	2.07722	-40.26000	2.10241
-34.58000	2.13552	-28.11000	2.16431
-21.21000	2.19526	-16.13000	2.20678
-213.03000	0.74696	-207.42000	0.80001
-188.84000	0.97570	-181.95000	1.03501
-260.62000	0.04779	-258.58000	0.08248
-255.99000	0.13121	-252.61000	0.19059
-248.95000	0.25739	-244.70000	0.33541
-237.41000	0.44589	-232.64000	0.52067
-226.70000	0.59725	-222.25000	0.65102
-217.47000	0.70407	*****	*****

(1) No.: 12.02.1.01

(2) Properties Included : 0 0 3 0 0 0 7 0 0 0 0 0 0 0

1. Pressure 2.Sp.Volume 3.Temperature 4.Sp.Enthalpy
5.Isobaric Sp. Heat 6.Isochoric Sp. Heat 7.Vap.Pressure
8.Ideal gas Properties 9.Saturated Liq.Density
10.Saturated Gas Density 11.Enthalpy of Vaporization
12.Enthalpy of Melting 13.Joule Thomson coefficient
14.Other

(3) Author : Aston, Kennedy & Schumann .

(4) Date : August , 1940

(5) Method :

(6) Accuracy : 0.01 mm Hg , 0.02 deg.C.

(7) Reference No. : 0020

(8) Values of Properties :

Vapour Pressure

Pressure (mm Hg)	Temperature (K)	Pressure (mm Hg)	Temperature (K)
11.37000	188.07000	31.96000	201.45600
86.85000	216.72900	174.26000	229.05300
391.02000	245.58400	498.08000	251.08900
572.67000	254.39900	716.13000	259.92200
763.44000	261.55100	*****	*****

(1) No.: 12.02.2.01

(2) Properties Included : 0 0 3 0 0 0 7 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Aston, Kennedy & Schumann .

(4) Date : August , 1940

(5) Method :

(6) Accuracy : 0.01 mm Hg , 0.02 deg.C.

(7) Reference No. : 0020

(8) Values of Properties :

Vapour Pressure

Pressure (M Pa)	Temperature (deg.C.)	Pressure (M Pa)	Temperature (deg.C.)
0.00152	-85.08000	0.00426	-71.69400
0.01158	-56.42100	0.02323	-44.09700
0.05213	-27.56600	0.06641	-22.06100
0.07635	-18.75100	0.09548	-13.22800
0.10178	-11.59900	*****	*****

(1) No.: 12.03.2.01

(2) Properties Included : 0 0 3 0 0 0 0 8 0 0 11 12 0 14

1. Pressure	2. Sp. Volume	3. Temperature	4. Sp. Enthalpy
5. Isobaric Sp. Heat	6. Isochoric Sp. Heat	7. Vap. Pressure	
8. Ideal gas Properties		9. Saturated Liq. Density	
10. Saturated Gas Density		11. Enthalpy of Vaporization	
12. Enthalpy of Melting		13. Joule Thomson coefficient	
14. Other			

(3) Author : Aston, Kennedy & Schumann .

(4) Date : August , 1940

(5) Method :

(6) Accuracy :

(7) Reference No. : 0020

(8) Values of Properties :

Melting Point : 113.74 +/- 0.05 K

Heat of Vaporization : 5089.6 +/- 8 Cal/mole
(366.6 +/- 0.6 kJ/kg)

Heat of Fusion : 1085.4 +/- 0.5 Cal/mole
(78.2 +/- 0.1 kJ/kg)

Entropy of Ideal Gas at 298.16 K : 1 Atmosphere Pressure ;
70.43 +/- 0.15 Cal/K.mole (5.073 +/- 0.011 kJ/kg.K)

(1) No.: 13.01.1.01

(2) Properties Included : 0 0 3 0 0 0 0 0 9 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Technical Committee, NGAA.

(4) Date : October , 1942

(5) Method : A metal pycometer (T > -18 deg. C.), a glass pipet

(6) Accuracy : T: 0.1 deg. F., density: 0.015% (T > -18 Deg. C), 0.03%

(7) Reference No. : 0520

(8) Values of Properties :

Saturated Liquid Densities

Temperature (deg. F.)	Density (gm/cc)	Temperature (deg. F.)	Density (gm/cc)
140.00000	0.50350	120.00000	0.51990
100.00000	0.53450	80.00000	0.54860
60.00000	0.56260	40.00000	*****
39.20000	0.57620	20.00000	0.58860
0.0	0.60080	0.20000	0.60070
-10.00000	0.60670	-16.60000	0.61050
-29.50000	0.61820	-41.60000	0.62520
-48.50000	0.62930	*****	*****

(1) No.: 13.01.2.01

(2) Properties Included : 0 0 3 0 0 0 0 0 9 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Technical Committee, NGAA.

(4) Date : October , 1942

(5) Method : A metal pycometer (T > -18 deg. C.), a glass pipet

(6) Accuracy : T: 0.1 deg. F., density: 0.015% (T > -18 Deg. C), 0.03%

(7) Reference No. : 0520

(8) Values of Properties :

Saturated Liquid Densities

Temperature (deg. C.)	Density (kg/(m*m*m))	Temperature (deg. C.)	Density (kg/(m*m*m))
60.00000	503.50000	48.88889	519.90000
37.77778	534.50000	26.66667	548.60000
15.55556	562.60000	4.44444	*****
4.00000	576.20000	-6.66667	588.60000
-17.77778	600.80000	-17.66667	600.70000
-23.33333	606.70000	-27.00000	610.50000
-34.16667	618.20000	-40.88889	625.20000
-44.72222	629.30000	*****	*****

(1) No.: 14.01.1.01

(2) Properties Included : 0 0 3 0 5 0 0 8 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Dailey and Felsing.

(4) Date : January, 1943.

(5) Method : Modified Bennewitz and Schulze type ad. flow calorimeter.

(6) Accuracy : 1 %

(7) Reference No. : 0170

(8) Values of Properties :

Isobaric Specific Heats

Temperature (K)	Sp. Heat (Cal/deg. mole)	Id. Sp. Heat (Cal/deg. mole)
347.60000	26.41000	26.21000
359.40000	27.09000	26.90000
387.50000	28.73000	28.59000
452.50000	32.86000	32.75000
520.90000	36.64000	36.55000
561.70000	38.60000	38.55000
605.30000	40.60000	40.56000
692.70000	44.29000	44.26000

(1) No.: 14.01.2.01

(2) Properties Included : 0 0 3 0 5 0 0 8 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Dailey and Felsing.

(4) Date : January, 1943.

(5) Method : Modified Bennewitz and Schulze type ad. flow calorimeter.

(6) Accuracy : 1 %

(7) Reference No. : 0170

(8) Values of Properties :

Isoharic Specific Heats

Temperature (deg.C.)	Sp. Heat (kJ/kg.K)	Id. Sp. Heat (kJ/kg.K)
74.45000	1.90120	1.88680
86.25000	1.95015	1.93647
114.35000	2.06821	2.05813
179.35000	2.36552	2.35760
247.75000	2.63763	2.63115
288.55000	2.77873	2.77513
332.15000	2.92270	2.91982
419.55000	3.18834	3.18618

(1) No.: 15.01.1.01

(2) Properties Included : 0 0 3 0 0 0 0 8 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isoharic Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : A.P.I. Research Project No. 44

(4) Date : August, 1944

(5) Method : Theoritically calculated .

(6) Accuracy :

(7) Reference No. : 0015

(8) Values of Properties :

Ideal Gas Properties

Temperature (deg.C.)	Sp. Enthalpy (Cal/gm)	Temperature (deg.C.)	Sp. Enthalpy (Cal/gm)
-273.15000	*****	-50.00000	46.70000
0.0	63.91000	25.00000	73.57000
50.00000	83.85000	100.00000	106.52000
150.00000	132.00000	200.00000	160.21000
300.00000	223.62000	400.00000	295.13000
500.00000	373.73000	600.00000	458.45000

(1) No.: 15.01.2.01

(2) Properties Included : 0 0 3 0 0 0 0 8 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : A.P.I. Research Project No. 44

(4) Date : August, 1944

(5) Method : Theoritically calculated .

(6) Accuracy :

(7) Reference No. : 0015

(8) Values of Properties :

Ideal Gas Properties

Temperature (deg.C.)	Sp. Enthalpy (kJ/kg)	Temperature (deg.C.)	Sp. Enthalpy (kJ/kg)
-273.15000	*****	-50.00000	195.52356
0.0	267.57839	25.00000	308.02288
50.00000	351.06318	100.00000	445.97794
150.00000	552.65760	200.00000	670.76723
300.00000	936.25222	400.00000	1235.65028
500.00000	1564.73276	600.00000	1919.43846

(1) No.: 15.02.1.01

(2) Properties Included : 0 0 3 0 0 0 0 8 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : A.P.I. Research Project No. 44

(4) Date : August, 1944

(5) Method : Theoretically calculated

(6) Accuracy :

(7) Reference No. : 0015

(8) Values of Properties :

Ideal Gas Properties

Temperature (K)	Enthalpy of Form ation(KCal/mole)	Temperature (K)	Enthalpy of Form ation(KCal/mole)
0.0	-25.30000	200.00000	-30.17000
250.00000	-31.19000	298.16000	-32.15000
300.00000	-32.19000	350.00000	-33.12000
400.00000	-34.00000	450.00000	-34.78000
500.00000	-35.48000	600.00000	-36.67000
700.00000	-37.61000	800.00000	-38.30000
900.00000	-38.80000	*****	*****

(1) No.: 15.02.2.01

(2) Properties Included : 0 0 3 0 0 0 0 8 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : A.P.I. Research Project No. 44

(4) Date : August, 1944

(5) Method : Theoretically calculated

(6) Accuracy :

(7) Reference No. : 0015

(8) Values of Properties :

Ideal Gas Properties

Temperature (deg.C.)	Enthalpy of Formation(kJ/kg)	Temperature (deg.C.)	Enthalpy of Formation(kJ/kg)
-273.15000	-1822.50890	-73.15000	-2173.32386
-23.15000	-2246.80050	25.01000	-2315.95499
26.85000	-2318.83643	76.85000	-2385.82984
126.85000	-2449.22145	176.85000	-2505.40947
226.85000	-2555.83462	326.85000	-2641.55737
426.85000	-2709.27114	526.85000	-2758.97593
626.85000	-2794.99389	*****	*****

(1) No.: 16.01.1.01

(2) Properties Included : 0 0 3 0 0 0 0 0 9 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Wacker , Linn & Grosse

(4) Date : May , 1945

(5) Method : A dilatometer

(6) Accuracy : T : 0.1 deg.C. below -30 Deg.C. , 0.05 Deg.C. above it.

(7) Reference No. : 0340

(8) Values of Properties :

Saturated Liquid Densities

Temperature (deg.C.)	Density (gm/cc)	Temperature (deg.C.)	Density (gm/cc)
0.0	0.58096	-9.50000	0.59199
-19.50000	0.60344	-29.50000	0.61415
-39.50000	0.62471	-49.50000	0.63486

(1) No.: 16.01.2.01

(2) Properties Included : 0 0 3 0 0 0 0 0 9 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Wacker , Linn & Grosse

(4) Date : May , 1945

(5) Method : A dilatometer

(6) Accuracy : T : 0.1 deg.C. below -30 Deg.C. , 0.05 Deg.C. above it

(7) Reference No. : 0340

(8) Values of Properties :

Saturated Liquid Densities

Temperature (deg.C.)	Density (kg/(m*m*m))	Temperature (deg.C.)	Density (kg/(m*m*m))
0.0	580.96000	-9.50000	591.99000
-19.50000	603.44000	-29.50000	614.15000
-39.50000	624.71000	-49.50000	634.86000

(1) No.: 16.02.1.01

(2) Properties Included : 0 0 3 0 0 0 7 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Wacker , Linn & Grosse

(4) Date : May , 1945

(5) Method : Static method

(6) Accuracy : T : 0.1 deg.C. below -30 deg.C. , 0.05 deg.C. above it.

(7) Reference No. : 0340

(8) Values of Properties :

Vapour Pressure

Temperature (deg.C.)	Pressure (mm Hg)	Temperature (deg.C.)	Pressure (mm Hg)
-10.40000	799.10000	-11.90000	758.00000
-15.00000	666.70000	-22.70000	491.20000
-31.00000	342.00000	-35.80000	271.30000
-44.40000	178.90000	-58.00000	83.30000
-66.70000	48.30000	*****	*****

(1) No.: 16.02.2.01

(2) Properties Included : 0 0 3 0 0 0 7 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Wacker , Linn & Grosse

(4) Date : May , 1945

(5) Method : Static method

(6) Accuracy : T : 0.1 deg.C. below -30 deg.C. , 0.05 deg.C. above it

(7) Reference No. : 0340

(8) Values of Properties :

Vapour Pressure

Temperature (deg.C.)	Pressure (M Pa)	Temperature (deg.C.)	Pressure (M Pa)
-10.40000	0.10654	-11.90000	0.10106
-15.00000	0.08889	-22.70000	0.06549
-31.00000	0.04560	-35.80000	0.03617
-44.40000	0.02385	-58.00000	0.01111
-66.70000	0.00644	*****	*****

(1) No.: 16.03.2.01

(2) Properties Included : 0 0 3 0 0 0 0 0 0 0 0 0 0 14

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Wacker , Linn & Grosse

(4) Date : May , 1945

(5) Method : A stock v.p. thermometer and a calibrated Hg thermometer.

(6) Accuracy : 0.1 deg.C.

(7) Reference No. : 0340

(8) Values of Properties :

Melting Point : -159.42 deg.C at 760 mm Hg
(.101325 MPa)

Boiling Point : -11.7 deg.C. at 760 mm Hg
(.101325 MPa)

(1) No.: 17.01.1.01

(2) Properties Included : 1 0 3 0 5 0 0 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Wacker, Cheney and Scott.

(4) Date : June, 1947

(5) Method : Adiabatic constant flow calorimeter

(6) Accuracy : 0.07 %

(7) Reference No. : 0535

(8) Values of Properties :

Isobaric Specific Heats

Temperature (deg.C.)	Pressure (mm Hg)	Sp. Heat (Cal/deg.mole)
-29.96000	90.00000	19.77000
-29.97000	94.00000	19.77900
-30.05000	91.00000	19.78000
-29.95000	180.00000	19.80100
-29.99000	178.00000	19.90500
-30.00000	179.00000	19.89700
-30.06000	180.00000	19.86200
-30.03000	176.00000	19.87600
-29.96000	178.00000	19.90100
-29.99000	180.00000	19.88800

(Continued)

No.: 17.01.1.02

Isobaric Specific Heats

Temperature (deg.C.)	Pressure (mm Hg)	Sp.Heat (Cal/deg.mole)
-30.07000	176.00000	19.85800
-29.99000	233.00000	19.94100
-29.91000	228.00000	19.96200
-29.91000	227.00000	19.93500
0.11000	189.00000	21.64900
0.09000	189.00000	21.66200
-0.06000	378.00000	21.81200
-0.02000	390.00000	21.81400
-0.06000	378.00000	21.79600
-0.13000	390.00000	21.79000
0.06000	380.00000	21.78600
-0.08000	390.00000	21.79600
39.78000	184.00000	24.14800
39.83000	189.00000	24.15500
40.23000	389.00000	24.24900
40.22000	390.00000	24.25800
40.04000	387.00000	24.24700
40.04000	390.00000	24.23500
40.33000	387.00000	24.27200
40.01000	390.00000	24.24100

(Continued)

No.: 17.01.1.03
-----Isobaric Specific Heats

Temperature (deg.C.)	Pressure (mm Hg)	Sp.Heat (Cal/deg.mole)
79.72000	185.00000	26.71800
79.65000	190.00000	26.74000
79.64000	391.00000	26.76300
79.65000	391.00000	26.77200
80.30000	387.00000	26.82400
79.73000	392.00000	26.79200
79.72000	391.00000	26.77700

(1) No.: 17.01.2.01

(2) Properties Included : 1 0 3 0 5 0 0 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Wacker, Cheney and Scott.

(4) Date : June, 1947

(5) Method : Adiabatic constant flow calorimeter

(6) Accuracy : 0.07 %

(7) Reference No. : 0535

(8) Values of Properties :

Isobaric Specific Heats

Temperature (deg.C.)	Pressure (M Pa)	Sp. Heat (kJ/kg.K)
-29.96000	0.01200	1.42298
-29.97000	0.01253	1.42363
-30.05000	0.01213	1.42370
-29.95000	0.02400	1.43241
-29.99000	0.02373	1.43270
-30.00000	0.02386	1.43213
-30.06000	0.02400	1.42961
-30.03000	0.02346	1.43061
-29.96000	0.02373	1.43241
-29.99000	0.02400	1.43148

(Continued)

No.: 17.01.2.02

Isobaric Specific Heats

Temperature (deg.C.)	Pressure (M Pa)	Sp.Heat (kJ/kg.K)
-30.07000	0.02346	1.42932
-29.99000	0.03106	1.43529
-29.91000	0.03040	1.43680
-29.91000	0.03026	1.43486
0.11000	0.02520	1.55823
0.09000	0.02520	1.55916
-0.06000	0.05040	1.56996
-0.02000	0.05200	1.57010
-0.06000	0.05040	1.56881
-0.13000	0.05200	1.56838
0.06000	0.05066	1.56809
-0.08000	0.05200	1.56881
39.78000	0.02453	1.73810
39.83000	0.02520	1.73860
40.23000	0.05186	1.74537
40.22000	0.05200	1.74602
40.04000	0.05160	1.74522
40.04000	0.05200	1.74436
40.33000	0.05160	1.74702
40.01000	0.05200	1.74479

(Continued)

No.: 17.01.2.03
-----Isobaric Specific Heats

Temperature (deg.C.)	Pressure (M Pa)	Sp.Heat (kJ/kg.K)
79.72000	0.02466	1.92308
79.65000	0.02533	1.92466
79.64000	0.05213	1.92632
79.65000	0.05213	1.92697
80.30000	0.05160	1.93071
79.73000	0.05226	1.92841
79.72000	0.05213	1.92733

(1) No.: 18.01.1.01

(2) Properties Included : 0 0 3 0 0 0 7 0 9 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Beattie et al.

(4) Date : June, 1949

(5) Method :

(6) Accuracy : Density : 1 kg/(m*m*m) , Temperature : 0.01 deg.C.

(7) Reference No. : 0060

(8) Values of Properties :

Vapour Pressure

Temperature (deg.C.)	Pressure (Normal Atm.)	Density (gm/ml)
30.00000	3.94100	0.54900
50.00000	6.70100	0.51800
75.00000	11.93200	0.48000
100.00000	19.57300	0.42800
125.00000	30.44000	0.35300

(1) No.: 18.01.2.01

(2) Properties Included : 0 0 3 0 0 0 7 0 9 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Beattie et al.

(4) Date : June, 1949

(5) Method :

(6) Accuracy : Density : 1 kg/(m*m*m) , Temperature : 0.01 deg.C.

(7) Reference No. : 0060

(8) Values of Properties :

Vapour Pressure

Temperature (deg.C.)	Pressure (M Pa)	Density (kg/(m*m*m))
30.00000	0.39932	549.00000
50.00000	0.67898	518.00000
75.00000	1.20901	480.00000
100.00000	1.98323	428.00000
125.00000	3.08433	353.00000

(1) No.: 18.02.1.01

(2) Properties Included : 1 2 3 0 0 0 0 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Beattie et al.

(4) Date : June, 1949

(5) Method :

(6) Accuracy : Density : 1 kg/(m*m*m) , Temperature : 0.01 deg.C.

(7) Reference No. : 0060

(8) Values of Properties :

Pressure (Normal Atmosphere)

Density (moles/litre)	Temperature (deg.C.) 134.60000	Temperature (deg.C.) 134.70000	Temperature (deg.C.) 134.80000
3.10800	35.70500	35.76900	35.82300
3.22700	35.73300	35.80100	35.85200
3.29100	35.75300	35.80900	35.86800
3.35600	35.77300	35.81600	35.87400
3.42300	35.77000	35.82300	35.88200
3.49500	35.77100	35.82800	35.88600
3.56900	35.76900	35.82900	35.88900
3.64700	*****	35.82800	35.88700
3.68600	*****	*****	*****
3.72700	35.77300	35.83100	35.89000

(Continued)

No.: 18.02.1.02

 Pressure (Normal Atmosphere)

Density (moles/litre)	Temperature (deg.C.) 134.60000	Temperature (deg.C.) 134.70000	Temperature (deg.C.) 134.80000
3.76800	*****	*****	*****
3.81100	*****	35.82500	35.88900
3.85500	*****	*****	*****
3.89900	35.77000	35.83200	35.89200
3.99200	35.76900	35.82600	35.89400
4.08800	35.76900	35.83300	35.89300
4.18900	35.77000	35.83200	35.89500
4.29700	*****	35.83800	*****
4.40900	35.77600	*****	35.90700
4.65300	35.79900	35.89000	35.96700

(Continued)

No.: 18.02.1.03

 Pressure (Normal Atmosphere)

Density (moles/litre)	Temperature (deg.C.) 134.85000	Temperature (deg.C.) 134.88000	Temperature (deg.C.) 134.90000
3.10800	35.84700	35.86100	35.87000
3.22700	35.88200	35.89900	35.90800
3.29100	*****	*****	*****
3.35600	35.90400	35.91900	35.92800
3.42300	35.91000	35.92600	35.93400
3.49500	35.91500	35.93200	35.94000
3.56900	35.92200	35.93900	35.94600
3.64700	35.92200	*****	35.95200
3.68600	*****	*****	*****
3.72700	35.92100	35.94600	35.95300
3.76800	*****	*****	*****
3.81100	35.92200	35.94400	35.95300
3.85500	*****	*****	*****
3.89900	*****	35.94400	35.95400
3.99200	35.92500	35.94500	35.95600
4.08800	*****	35.94500	*****
4.18900	35.92700	35.94700	35.96000
4.29700	*****	*****	*****
4.40900	35.94300	35.96500	35.97800
4.65300	36.01000	36.02800	36.04500

(Continued)

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No.: 18.02.1.04

Pressure (Normal Atmosphere)

Density (moles/litre)	Temperature (deg.C.) 134.95000	Temperature (deg.C.) 134.97000	Temperature (deg.C.) 134.98000
3.10800	35.89500	35.90700	*****
3.22700	35.93100	35.93900	*****
3.29100	*****	*****	*****
3.35600	35.95500	35.96600	35.97000
3.42300	*****	*****	*****
3.49500	35.97300	35.97800	35.98800
3.56900	35.97400	35.98300	35.99300
3.64700	35.97900	35.99000	35.99400
3.68600	35.98200	35.99000	*****
3.72700	35.98300	35.99200	36.00000
3.76800	35.98300	35.99400	35.99700
3.81100	35.98300	35.99400	35.99900
3.85500	35.98300	35.99600	*****
3.89900	35.98400	35.99600	36.00200
3.99200	35.98800	36.00000	36.00300
4.08800	35.99000	36.00200	*****
4.18900	35.99500	36.00500	36.01800
4.29700	*****	*****	*****
4.40900	36.01500	36.02400	*****
4.65300	36.08400	36.09200	*****

(Continued)

No.: 18.02.1.05

Pressure (Normal Atmosphere)

Density (moles/litre)	Temperature (deg.C.) 134.99000	Temperature (deg.C.) 135.00000	Temperature (deg.C.) 135.05000
3.10800	*****	35.92300	35.94500
3.22700	*****	35.96100	35.98600
3.29100	*****	*****	*****
3.35600	35.97700	35.98100	36.01000
3.42300	*****	*****	*****
3.49500	35.99300	35.99800	36.02400
3.56900	35.99800	36.00400	*****
3.64700	36.00400	36.00700	36.03400
3.68600	*****	*****	*****
3.72700	36.00500	36.00900	*****
3.76800	*****	*****	*****
3.81100	36.00800	36.01200	36.04200
3.85500	*****	*****	*****
3.89900	36.00800	36.01300	*****
3.99200	36.01100	36.01800	36.04800
4.08800	*****	36.02000	*****
4.18900	36.01900	36.02600	36.05400
4.29700	*****	*****	*****
4.40900	*****	36.04600	36.08000
4.65300	*****	36.11900	36.15300

(Continued)

No.: 18.02.1.06

 Pressure (Normal Atmosphere)

Density (moles/litre)	Temperature (deg.C.) 135.15000

3.10800	35.99700
3.22700	36.03800
3.29100	*****
3.35600	36.06500
3.42300	*****
3.49500	36.08400
3.56900	*****
3.64700	36.09200
3.68600	*****
3.72700	*****
3.76800	*****
3.81100	36.10000
3.85500	*****
3.89900	*****
3.99200	36.11000
4.08800	*****
4.18900	36.11700
4.29700	*****
4.40900	36.14400
4.65300	36.22600

(1) No.: 18.02.2.01

(2) Properties Included : 1 2 3 0 0 0 0 0 0 0 0 0 0 0

1. Pressure 2.Sp.Volume 3.Temperature 4.Sp.Enthalpy
5.Isobaric Sp. Heat 6.Isochoric Sp. Heat 7.Vap.Pressure
8.Ideal gas Properties 9.Saturated Liq.Density
10.Saturated Gas Density 11.Enthalpy of Vaporization
12.Enthalpy of Melting 13.Joule Thomson coefficient
14.Other

(3) Author : Beattie et al.

(4) Date : June, 1949

(5) Method :

(6) Accuracy : Density : 1 kg/(m*m*m) , Temperature : 0.01 deg.C.

(7) Reference No. : 0060

(8) Values of Properties :

Pressure (Mega Pascals)

Density (kg/(m*m*m))	Temperature (deg.C.) 134.60000	Temperature (deg.C.) 134.70000	Temperature (deg.C.) 134.80000
180.50332	3.61781	3.62429	3.62977
187.41448	3.62065	3.62754	3.63270
191.13141	3.62267	3.62835	3.63433
194.90641	3.62470	3.62906	3.63493
198.79757	3.62440	3.62977	3.63574
202.97912	3.62450	3.63027	3.63615
207.27681	3.62429	3.63037	3.63645
211.80682	*****	3.63027	3.63625
214.07182	*****	*****	*****
216.45298	3.62470	3.63058	3.63655

(Continued)

No.: 18.02.2.02

 Pressure (Mega Pascals)

Density (kg/(m*m*m))	Temperature (deg.C.) 134.60000	Temperature (deg.C.) 134.70000	Temperature (deg.C.) 134.80000
218.83414	*****	*****	*****
221.33145	*****	3.62997	3.63645
223.88684	*****	*****	*****
226.44222	3.62440	3.63068	3.63676
231.84338	3.62429	3.63007	3.63696
237.41878	3.62429	3.63078	3.63686
243.28455	3.62440	3.63068	3.63706
249.55687	*****	3.63129	*****
256.06149	3.62500	*****	3.63828
270.23228	3.62733	3.63655	3.64436

(Continued)

No.: 18.02.2.03

 Pressure (Mega Pascals)

Density (kg/(m*m*m))	Temperature (deg.C.) 134.85000	Temperature (deg.C.) 134.88000	Temperature (deg.C.) 134.90000
180.50332	3.63220	3.63362	3.63453
187.41448	3.63574	3.63747	3.63838
191.13141	*****	*****	*****
194.90641	3.63797	3.63949	3.64040
198.79757	3.63858	3.64020	3.64101
202.97912	3.63909	3.64081	3.64162
207.27681	3.63980	3.64152	3.64223
211.80682	3.63980	*****	3.64284
214.07182	*****	*****	*****
216.45298	3.63970	3.64223	3.64294
218.83414	*****	*****	*****
221.33145	3.63980	3.64203	3.64294
223.88684	*****	*****	*****
226.44222	*****	3.64203	3.64304
231.84338	3.64010	3.64213	3.64324
237.41878	*****	3.64213	*****
243.28455	3.64030	3.64233	3.64365
249.55687	*****	*****	*****
256.06149	3.64192	3.64415	3.64547
270.23228	3.64871	3.65054	3.65226

(Continued)

No.: 18.02.2.04

Pressure (Mega Pascals)

Density (kg/(m*m*m))	Temperature (deg.C.) 134.95000	Temperature (deg.C.) 134.97000	Temperature (deg.C.) 134.98000
180.50332	3.63706	3.63828	*****
187.41448	3.64071	3.64152	*****
191.13141	*****	*****	*****
194.90641	3.64314	3.64425	3.64466
198.79757	*****	*****	*****
202.97912	3.64496	3.64547	3.64648
207.27681	3.64507	3.64598	3.64699
211.80682	3.64557	3.64669	3.64709
214.07182	3.64588	3.64669	*****
216.45298	3.64598	3.64689	3.64770
218.83414	3.64598	3.64709	3.64740
221.33145	3.64598	3.64709	3.64760
223.88684	3.64598	3.64729	*****
226.44222	3.64608	3.64729	3.64790
231.84338	3.64648	3.64770	3.64800
237.41878	3.64669	3.64790	*****
243.28455	3.64719	3.64821	3.64952
249.55687	*****	*****	*****
256.06149	3.64922	3.65013	*****
270.20228	3.65621	3.65702	*****

(Continued)

No.: 18.02.2.05

Pressure (Mega Pascals)

Density (kg/(m*m*m))	Temperature (deg.C.) 134.99000	Temperature (deg.C.) 135.00000	Temperature (deg.C.) 135.05000
180.50332	*****	3.63990	3.64213
187.41448	*****	3.64375	3.64628
191.13141	*****	*****	*****
194.90641	3.64537	3.64577	3.64871
198.79757	*****	*****	*****
202.97912	3.64699	3.64750	3.65013
207.27681	3.64750	3.64811	*****
211.80682	3.64811	3.64841	3.65115
214.07182	*****	*****	*****
216.45298	3.64821	3.64861	*****
218.83414	*****	*****	*****
221.33145	3.64851	3.64892	3.65196
223.88684	*****	*****	*****
226.44222	3.64851	3.64902	*****
231.84338	3.64881	3.64952	3.65256
237.41878	*****	3.64973	*****
243.28455	3.64963	3.65033	3.65317
249.55687	*****	*****	*****
256.06149	*****	3.65236	3.65581
270.23228	*****	3.65976	3.66320

(Continued)

No.: 18.02.2.06

Pressure (Mega Pascals)	
Density (kg/(m*m*m))	Temperature (deg.C.)
	135.15000
180.50332	3.64740
187.41448	3.65155
191.13141	*****
194.90641	3.65429
198.79757	*****
202.97912	3.65621
207.27681	*****
211.80682	3.65702
214.07132	*****
216.45288	*****
218.83414	*****
221.33145	3.65783
223.88684	*****
226.44222	*****
231.84338	3.65885
237.41878	*****
243.28455	3.65956
249.55687	*****
256.06149	3.66229
270.23228	3.67060

(1) No.: 18.03.2.01

(2) Properties Included : 0 0 0 0 0 0 0 0 0 0 0 0 0 14

1. Pressure	2. Sp. Volume	3. Temperature	4. Sp. Enthalpy
5. Isobaric Sp. Heat	6. Isochoric Sp. Heat	7. Vap. Pressure	
8. Ideal gas Properties		9. Saturated Liq. Density	
10. Saturated Gas Density		11. Enthalpy of Vaporization	
12. Enthalpy of Melting		13. Joule Thomson coefficient	
14. Other			

(3) Author : Beattie et al.

(4) Date : June, 1949

(5) Method : By plotting P-v-T data

(6) Accuracy :

(7) Reference No. : 0060

(8) Values of Properties :

Critical Temperature : 134.98 +/- 0.05 deg.C.

Critical Pressure : 36.00 +/- 0.05 Normal Atmosphere
(4.077 +/- .005 MPa)

Critical Volume : 0.263 litres/mole (0.263 cu.m./kmole)
(2 % uncertainty.)

Critical Density : 3.80 moles/litre (3.80 kmole/cu.metre)
(2 % uncertainty.)

(1) No.: 19.01.1.01

(2) Properties Included : 1 2 3 0 0 0 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Beattie, Marple & Edwards .

(4) Date : January , 1950

(5) Method :

(6) Accuracy : Density: 0.57%, (upto 5 moles/l); 0.94% (5 to 8 moles/l)

(7) Reference No. : 0065

(8) Values of Properties :

Pressure(Normal Atmospheres)

Temperature (deg.C.)	Density (moles/litre) 1.00000	Density (moles/litre) 1.50000	Density (moles/litre) 2.00000
150.00000	25.70000	33.05000	37.84000
175.00000	28.45000	37.63000	44.49000
200.00000	31.13000	42.06000	50.93000
225.00000	33.78000	46.44000	57.27000
250.00000	36.39000	50.75000	63.48000
275.00000	38.99000	55.02000	69.66000
300.00000	41.51000	59.24000	75.77000

(Continued)

No.: 19.01.1.02

Pressure(Normal Atmospheres)

Temperature (deg.C.)	Density	Density	Density
	(moles/litre) 2.50000	(moles/litre) 3.00000	(moles/litre) 3.50000
150.00000	40.89000	42.85000	44.29000
175.00000	49.75000	54.04000	57.92000
200.00000	58.36000	65.02000	71.51000
225.00000	66.86000	75.93000	85.12000
250.00000	75.23000	86.73000	98.66000
275.00000	83.58000	97.52000	112.27000
300.00000	91.86000	108.25000	125.80000

(Continued)

No.: 19.01.1.03

Pressure(Normal Atmospheres)

Temperature (deg.C.)	Density (moles/litre)	Density (moles/litre)	Density (moles/litre)
	4.00000	4.50000	5.00000
150.00000	45.60000	47.20000	49.70000
175.00000	61.95000	66.77000	73.34000
200.00000	78.52000	86.85000	97.67000
225.00000	95.22000	107.20000	122.42000
250.00000	111.94000	127.65000	147.36000
275.00000	128.78000	148.35000	172.59000
300.00000	145.61000	169.00000	197.85000

(Continued)

No.: 19.01.1.04

 Pressure(Normal Atmospheres)

Temperature (deg.C.)	Density (moles/litre) 6.00000	Density (moles/litre) 7.00000	Density (moles/litre) 8.00000
150.00000	63.08000	106.66000	224.71000
175.00000	98.41000	160.44000	303.79000
200.00000	134.54000	214.22000	*****
225.00000	171.25000	269.05000	*****
250.00000	208.05000	*****	*****
275.00000	245.51000	*****	*****
300.00000	*****	*****	*****

(1) No.: 19.01.2.01

(2) Properties Included : 1 2 3 0 0 0 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Beattie, Marple & Edwards .

(4) Date : January , 1950

(5) Method :

(6) Accuracy : Density: 0.57%, (upto 5 moles/l); 0.94% (5 to 8 moles/l)

(7) Reference No. : 0065

(8) Values of Properties :

Pressure (Mega Pascals)

Temperature (deg. C.)	Density (kg/(m*m*m)) 58.07700	Density (kg/(m*m*m)) 87.11550	Density (kg/(m*m*m)) 116.15400
150.00000	2.60405	3.34879	3.83414
175.00000	2.88270	3.81286	4.50795
200.00000	3.15425	4.26173	5.16048
225.00000	3.42276	4.70553	5.80288
250.00000	3.68722	5.14224	6.43211
275.00000	3.95066	5.57490	7.05830
300.00000	4.20600	6.00249	7.67740

(Continued)

No.: 19.01.2.02

Pressure (Mega Pascals)

Temperature (deg.C.)	Density (kg/(m*m*m)) 145.19250	Density (kg/(m*m*m)) 174.23100	Density (kg/(m*m*m)) 203.26950
150.00000	4.14318	4.34178	4.48768
175.00000	5.04092	5.47560	5.86874
200.00000	5.91333	6.58815	7.24575
225.00000	6.77459	7.69361	8.62478
250.00000	7.62268	8.78792	9.99672
275.00000	8.46874	9.88121	11.37576
300.00000	9.30771	10.96843	12.74669

(Continued)

No.: 19.01.2.03
-----Pressure (Mega Pascals)

Temperature (deg.C.)	Density (kg/(m*m*m)) 232.30800	Density (kg/(m*m*m)) 261.34650	Density (kg/(m*m*m)) 290.38500
150.00000	4.62042	4.78254	5.03585
175.00000	6.27708	6.76547	7.43118
200.00000	7.95604	8.80008	9.89641
225.00000	9.64817	10.86204	12.40421
250.00000	11.34232	12.93414	14.93125
275.00000	13.04863	15.03156	17.48768
300.00000	14.75393	17.12393	20.04715

(Continued)

No.: 19.01.2.04
-----Pressure (Mega Pascals)

Temperature (deg.C.)	Density (kg/(m*m*m)) 348.46200	Density (kg/(m*m*m)) 406.53900	Density (kg/(m*m*m)) 464.61600
150.00000	6.39158	10.80732	22.76874
175.00000	9.97139	16.25658	30.78152
200.00000	13.63227	21.70584	*****
225.00000	17.35191	27.26149	*****
250.00000	21.08067	*****	*****
275.00000	24.87630	*****	*****
300.00000	*****	*****	*****

(1) No.: 20.01.2.01

(2) Properties Included : 0 0 0 0 0 0 0 0 0 0 0 0 0 14

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Mason & Eakin

(4) Date : October , 1961

(5) Method : Burnett method

(6) Accuracy :

(7) Reference No. : 0360

(8) Values of Properties :

(Original Units)

$$P.v = (P.v)_0.z = (P.v)_0.(1 + \text{Beta}.P)$$

Beta (Atm.inverse)

b =(1-z)

-0.03022

0.02982

-0.02993

0.02953

-0.03013

0.02973

-0.02973

0.0297

-0.03022

0.02982

-0.02942

0.02947

(1) No.: 20.02.2.01

(2) Properties Included : 0 0 0 0 0 0 0 0 0 0 0 0 0 14

1. Pressure 2.Sp.Volume 3.Temperature 4.Sp.Enthalpy
5.Isobaric Sp. Heat 6.Isochoric Sp. Heat 7.Vap.Pressure
8.Ideal gas Properties 9.Saturated Liq.Density
10.Saturated Gas Density 11.Enthalpy of Vaporization
12.Enthalpy of Melting 13.Joule Thomson coefficient
14.Other

(3) Author : Mason & Eakin

(4) Date : October ,1961

(5) Method : Burnett method

(6) Accuracy :

(7) Reference No. : 0360

(8) Values of Properties :

(S.I. Units)

$$P.v = (P.v)_0.z = (P.v)_0.(1 + \text{Beta}.P)$$

Beta (MPa.inverse)	b =(1-z)
-0.298248	0.02982
-0.295386	0.02953
-0.297360	0.02973
-0.293412	0.02970
-0.298248	0.02982
-0.290353	0.02947

(1) No.: 21.01.1.01

(2) Properties Included : 0 0 3 0 0 0 7 0 0 0 0 0 0 0

1. Pressure 2.Sp.Volume 3.Temperature 4.Sp.Enthalpy
5.Isobaric Sp. Heat 6.Isochoric Sp. Heat 7.Vap.Pressure
8.Ideal gas Properties 9.Saturated Liq.Density
10.Saturated Gas Density 11.Enthalpy of Vaporization
12.Enthalpy of Melting 13.Joule Thomson coefficient
14.Other

(3) Author : Connoly

(4) Date : June, 1962

(5) Method : Calibrated glass capillary method

(6) Accuracy : 1 % from Sage & Lacey data.

(7) Reference No. : 0145

(8) Values of Properties :

Vapour Pressure

Temperature (deg.C.)	Pressure (Normal Atm.)	Temperature (deg.C.)	Pressure (Normal Atm.)
71.11000	11.00000	87.78000	15.52000
104.44000	21.29000	121.11000	28.56000
133.72000	35.32000	134.62000	35.85000

(1) No.: 21.01.2.01

(2) Properties Included : 0 0 3 0 0 0 7 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Connolly

(4) Date : June, 1962

(5) Method : Calibrated glass capillary method

(6) Accuracy : 1 % from Sage & Lacey data.

(7) Reference No. : 0145

(8) Values of Properties :

Vapour Pressure

Temperature (deg.C.)	Pressure (M Pa)	Temperature (deg.C.)	Pressure (M Pa)
71.11000	1.11458	87.78000	1.57256
104.44000	2.15721	121.11000	2.89384
133.72000	3.57880	134.62000	3.63250

(1) No.: 22.01.1.01

(2) Properties Included : 1 0 3 0 0 0 0 0 9 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Gonzalez & Lee

(4) Date : 1966

(5) Method : Steel Pycometer

(6) Accuracy : 5 % for density

(7) Reference No. : 0250

(8) Values of Properties :

Density of isobutane at 8000 psi

Temperature (Deg.F.)	Density (g/cc)	Temperature (Deg.F.)	Density (g/cc)
100.00000	0.61260	160.00000	0.58820
220.00000	0.56950	280.00000	0.54510
340.00000	0.51920	*****	*****

(1) No.: 22.01.2.01

(2) Properties Included : 1 0 3 0 0 0 0 0 9 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Gonzalez & Lee

(4) Date : 1966

(5) Method : Steel Pycometer

(6) Accuracy : 5 % for density

(7) Reference No. : 0250

(8) Values of Properties :

Density of isobutane at 55.14 MPa

Temperature (Deg.C.)	Density (kg/cu.m.)	Temperature (Deg.C.)	Density (kg/cu.m.)
37.77778	612.60000	71.11111	588.20000
104.44444	569.50000	137.77778	545.10000
171.11111	519.20000	*****	*****

(1) No.: 23.01.1.01

(2) Properties Included : 0 0 3 0 0 0 0 0 9 10 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Sliwinsky

(4) Date : 1969

(5) Method :

(6) Accuracy : 0.05 kg/cu.m. in density

(7) Reference No. : 0490

(8) Values of Properties :

Saturated Densities

Temperature (deg.C.)	Sat. liq. Density (kg/(m*m*m))	Sat. Vap. Density (kg/(m*m*m))
10.05000	568.55000	5.85000
20.04000	556.72000	7.95000
30.00000	544.23000	10.50000
39.97000	531.13000	13.65000
49.97000	517.25000	17.60000
59.96000	502.69000	22.36000
69.93000	487.08000	28.25000
79.94000	470.02000	35.58000
89.96000	451.10000	44.85000
94.95000	440.71000	50.33000

(1) No.: 24.01.1.01

(2) Properties Included : 1 0 3 0 5 0 0 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Ernst & Busser

(4) Date : March ,1970

(5) Method : Continuous flow method

(6) Accuracy : 0.1 %

(7) Reference No. : 0225

(8) Values of Properties :

Isobaric Specific Heats (J/mole.K)

Pressure (kgf/sq.cm)	Temperature (deg.C.) 20.00000	Temperature (deg.C.) 40.00000	Temperature (deg.C.) 60.00000
0.0	95.21000	100.67000	106.37000
0.50000	96.09000	101.36000	106.83000
1.00000	97.06000	102.11000	107.32000
2.00000	99.18000	103.68000	108.34000
3.50000	*****	106.58000	110.58000
5.00000	*****	110.57000	113.17000
6.50000	*****	*****	116.51000
8.00000	*****	*****	*****

(Continued)

No.: 24.01.1.02

Isobaric Specific Heats (J/mole.K)

Pressure (kgf/sq.cm)	Temperature (deg.C.) 80.00000
0.0	111.74000
0.50000	112.10000
1.00000	112.48000
2.00000	113.42000
3.50000	115.06000
5.00000	116.88000
6.50000	119.20000
8.00000	121.83000

(1) No.: 24.01.2.01

(2) Properties Included : 1 0 3 0 5 0 0 0 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Ernst & Busser

(4) Date : March ,1970

(5) Method : Continuous flow method

(6) Accuracy : 0.1 %

(7) Reference No. : 0225

(8) Values of Properties :

Isobaric Specific Heats (kJ/kg.K)

Pressure (M Pa)	Temperature (deg.C.) 20.00000	Temperature (deg.C.) 40.00000	Temperature (deg.C.) 60.00000
0.0	1.63805	1.73199	1.83005
0.04903	1.65319	1.74386	1.83797
0.09807	1.66988	1.75676	1.84640
0.19613	1.70635	1.78377	1.86395
0.34323	*****	1.83367	1.90248
0.49033	*****	1.90231	1.94704
0.63743	*****	*****	2.00451
0.78453	*****	*****	*****

(Continued)

No.: 24.01.2.02

Isobaric Specific Heats (kJ/kg.K)

Pressure (M Pa)	Temperature (deg.C.) 80.00000
0.0	1.92244
0.04903	1.92864
0.09807	1.93517
0.19613	1.95135
0.34323	1.97956
0.49033	2.01087
0.63743	2.05079
0.78453	2.09604

(1) No.: 25.01.1.01

(2) Properties Included : 0 0 3 0 0 0 0 8 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Chen, Wilhoit & Zwolinsky

(4) Date : 1975

(5) Method : Theoretically calculated

(6) Accuracy :

(7) Reference No. : 0135

(8) Values of Properties :

Ideal Gas Properties

Temperature (K)	$(h^0 - h_0^0)$ (Cal/mole)	s^0 (Cal/mole.K)	C_p^0 (Cal/mole.K)
0.0	0.0	0.0	0.0
50.00000	400.00000	46.37000	8.32000
100.00000	884.00000	52.96000	11.30000
150.00000	1529.00000	58.14000	14.41000
200.00000	2319.00000	62.67000	17.17000
273.15000	3729.00000	68.64000	21.49000
298.15000	4286.00000	70.60000	23.10000
300.00000	4329.00000	70.74000	23.22000
400.00000	6979.00000	78.32000	29.74000
500.00000	10257.00000	85.61000	35.67000

(Continued)

No.: 25.01.1.02

Ideal Gas Properties

Temperature (K)	$(h^0 - h_0^0)$ (Cal/mole)	s^0 (Cal/mole.K)	C_p^0 (Cal/mole.K)
600.00000	14083.00000	92.57000	40.72000
700.00000	18375.00000	99.17000	45.00000
800.00000	23063.00000	105.43000	48.67000
900.00000	28093.00000	111.35000	51.85000
1000.00000	33419.00000	116.96000	54.60000
1100.00000	39002.00000	122.28000	57.00000
1200.00000	44808.00000	127.33000	59.07000
1300.00000	50807.00000	132.13000	60.88000
1400.00000	56976.00000	136.70000	62.45000
1500.00000	63291.00000	141.06000	63.82000

(1) No.: 25.01.2.01

(2) Properties Included : 0 0 3 0 0 0 0 8 0 0 0 0 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Sp. Enthalpy
5. Isobaric Sp. Heat 6. Isochoric Sp. Heat 7. Vap. Pressure
8. Ideal gas Properties 9. Saturated Liq. Density
10. Saturated Gas Density 11. Enthalpy of Vaporization
12. Enthalpy of Melting 13. Joule Thomson coefficient
14. Other

(3) Author : Chen, Wilhoit & Zwolinsky

(4) Date : 1975

(5) Method : Theoretically calculated

(6) Accuracy :

(7) Reference No. : 0135

(8) Values of Properties :

Ideal Gas Properties

Temperature (deg.C.)	($h^0 - h_0^0$) (kJ/kg)	s^0 (kJ/kg.K)	C_p^0 (kJ/kg.K)
-273.15000	0.0	0.0	0.0
-223.15000	28.81288	3.34013	0.59931
-173.15000	63.67647	3.81483	0.81396
-123.15000	110.13724	4.18795	1.03798
-73.15000	167.04269	4.51426	1.23679
0.0	268.60810	4.94429	1.54797
25.00000	308.73004	5.08547	1.66394
26.85000	311.82742	5.09556	1.67259
126.35000	502.71277	5.64156	2.14224
226.85000	738.83435	6.16668	2.56939

(Continued)

No.: 25.01.2.02

Ideal Gas Properties

Temperature (deg.C.)	$(h^0 - h_0^0)$ (kJ/kg)	s^0 (kJ/kg.K)	C_p^0 (kJ/kg.K)
326.85000	1014.42957	6.66802	2.93315
426.85000	1323.59180	7.14343	3.24145
526.85000	1661.27879	7.59436	3.50581
626.85000	2023.60079	8.02079	3.73487
726.85000	2407.24433	8.42489	3.93296
826.85000	2809.40014	8.80810	4.10584
926.85000	3227.61913	9.17186	4.25494
1026.85000	3659.74034	9.51762	4.38532
1126.85000	4104.10703	9.84680	4.49841
1226.85000	4558.99041	10.16086	4.59710

(B) TRANSPORT

PROPERTIES

(1) No.: 01.01.3.01

(2) Properties Included : 1 0 2 4 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Viscosity
5. Thermal Conductivity 6. Other

(3) Author : Ishida

(4) Date : 1922

(5) Method : oil-drop method

(6) Accuracy : 0.3 %

(7) Reference No. : 0035

(8) Values of Properties :

Temperature = 23 Deg.C.

viscosity = 75.5 micro-poise

= 7.55 micro Pa.s

(1) No.: 02.01.0.01

(2) Properties Included : 1 0 3 4 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Viscosity
5. Thermal Conductivity 6. Other

(3) Author : Titani

(4) Date : 1930

(5) Method : Transpiration method

(6) Accuracy :

(7) Reference No. : 0090

(8) Values of Properties :

viscosity of isobutane gas

Temperature (Deg.C.)	viscosity (micro poise)	Temperature (Deg.C.)	viscosity (micro poise)
20.00000	74.40000	40.00000	79.20000
60.00000	84.50000	80.00000	88.80000
100.00000	94.70000	120.00000	99.50000

(1) No.: 02.01.4.01

(2) Properties Included : 1 0 3 4 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Viscosity
5. Thermal Conductivity 6. Other

(3) Author : Titani

(4) Date : 1930

(5) Method : Transpiration method

(6) Accuracy :

(7) Reference No. : 0030

(8) Values of Properties :

viscosity of isobutane gas

Temperature (Deg.C.)	viscosity (micro Pa.s)	Temperature (Deg.C.)	viscosity (micro Pa.s)
20.00000	7.44000	40.00000	7.92000
60.00000	8.45000	80.00000	8.88000
100.00000	9.47000	120.00000	9.95000

(1) No.: 03.01.3.01

(2) Properties Included : 0 0 3 0 5 6

1. Pressure 2. Sp. Volume 3. Temperature 4. Viscosity
5. Thermal Conductivity 6. Other

(3) Author : Dickins and Mann

(4) Date : 1931

(5) Method : Pt-wire in pyrex cylinder glass and a compensating tube

(6) Accuracy : 0.2 %

(7) Reference No. : 0060

(8) Values of Properties :

$$K_t = K_0(1 + \alpha \cdot t)$$

Thermal conductivity at 0 Deg.C.

$$\begin{aligned} &= K_0 = 33.2 \text{ micro cal.}/(\text{cm. sec. Deg. C.}) \\ &= .0139 \text{ J}/(\text{m. sec. Deg. C.}) \end{aligned}$$

Temperature coefficient

$$\begin{aligned} &= \alpha = 0.0076 / \text{Deg. C.} \\ &\quad \quad \quad (t \text{ in Deg. C.}) \end{aligned}$$

(1) No.: 04.01.3.01

(2) Properties Included : 1 0 3 4 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Viscosity
5. Thermal Conductivity 6. Other

(3) Author : Sage , Yale and Lacey

(4) Date : 1939

(5) Method : a closely-fitting steel ball in an inclined tube

(6) Accuracy : 5 % in gaseous region, 2.5 % in liquid region

(7) Reference No. : 0080

(8) Values of Properties :

viscosity of isobutane in micro-poise

Pressure (psi)	Temperature (Deg. F.) 100.00000	Temperature (Deg. F.) 130.00000	Temperature (Deg. F.) 160.00000
*****	84.10000	91.30000	103.30000
*****	1320.00000	1058.00000	890.00000
14.70000	76.50000	79.50000	82.60000
20.00000	77.50000	80.20000	83.10000
40.00000	79.20000	81.80000	85.20000
60.00000	82.10000	84.20000	87.30000
100.00000	*****	89.80000	92.50000
150.00000	*****	*****	101.00000
200.00000	1344.00000	1071.00000	896.00000
250.00000	*****	*****	*****

(Continued)

No.: 04.01.3.02

viscosity of isobutane in micro-poise

Pressure (psi)	Temperature (Deg.F.) 100.00000	Temperature (Deg.F.) 130.00000	Temperature (Deg.F.) 160.00000
400.00000	1376.00000	1102.00000	928.00000
600.00000	1404.00000	1132.00000	956.00000
1000.00000	1456.00000	1186.00000	1011.00000
1500.00000	1506.00000	1252.00000	1065.00000
2000.00000	1554.00000	1297.00000	1106.00000

(Continued)

No.: 04.01.3.03

viscosity of isobutane in micro-poise

Pressure (psi)	Temperature (Deg.F.) 190.00000	Temperature (Deg.F.) 220.00000
*****	134.40000	*****
*****	753.00000	*****
14.70000	85.70000	88.70000
20.00000	86.60000	89.80000
40.00000	83.70000	92.10000
60.00000	91.10000	94.20000
100.00000	95.70000	99.40000
150.00000	103.00000	106.00000
200.00000	117.00000	114.00000
250.00000	*****	131.00000
400.00000	780.00000	*****
600.00000	811.00000	*****
1000.00000	862.00000	*****
1500.00000	913.00000	*****
2000.00000	954.00000	*****

(1) No.: 04.01.4.01

(2) Properties Included : 1 0 3 4 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Viscosity
5. Thermal Conductivity 6. Other

(3) Author : Sage , Yale and Lacey

(4) Date : 1939

(5) Method : a closely-fitting steel ball in an inclined tube

(6) Accuracy : 5 % in gaseous region, 2.5 % in liquid region

(7) Reference No. : 0080

(8) Values of Properties :

viscosity of isobutane in micro Pa.s

Pressure (MPa)	Temperature (Deg.C.) 37.77778	Temperature (Deg.C.) 54.44444	Temperature (Deg.C.) 71.11111
*****	8.41000	9.13000	10.38000
*****	132.00000	105.80000	89.00000
0.10135	7.65000	7.95000	8.26000
0.13789	7.75000	8.02000	8.31000
0.27579	7.92000	8.18000	8.52000
0.41368	8.21000	8.42000	8.73000
0.68947	*****	8.98000	9.25000
1.03421	*****	*****	10.10000
1.37895	134.40000	107.10000	89.60000
1.72368	*****	*****	*****

(Continued)

No.: 04.01.4.02

viscosity of isobutane in micro Pa.s

Pressure (MPa)	Temperature (Deg.C.) 37.77778	Temperature (Deg.C.) 54.44444	Temperature (Deg.C.) 71.11111
2.75789	137.60000	110.20000	92.80000
4.13684	140.40000	113.20000	95.60000
6.89473	145.60000	118.60000	101.10000
10.34210	150.60000	125.20000	106.50000
13.78947	155.40000	129.70000	110.60000

(Continued)

No.: 04.01.4.03

viscosity of isobutane in micro Pa.s

Pressure (MPa)	Temperature (Deg.C.) 87.77778	Temperature (Deg.C.) 104.44444
*****	13.44000	*****
*****	75.30000	*****
0.10135	8.57000	8.87000
0.13789	8.66000	8.98000
0.27579	8.87000	9.21000
0.41368	9.11000	9.42000
0.68947	9.57000	9.94000
1.03421	10.30000	10.60000
1.37895	11.70000	11.40000
1.72368	*****	13.10000
2.75789	78.00000	*****
4.13684	81.10000	*****
6.89473	86.20000	*****
10.34210	91.30000	*****
13.78947	95.40000	*****

(1) No.: 05.01.3.01

(2) Properties Included : 1 0 3 4 0 6

1. Pressure 2.Sp.Volume 3.Temperature 4.Viscosity
5.Thermal Conductivity 6.Other

(3) Author : Lipkin, Davison and Kurtz

(4) Date : 1942

(5) Method : High Pressure and low Pressure capillary flow viscometer

(6) Accuracy : 2 %

(7) Reference No. : 0050

(8) Values of Properties :

viscosity of liquid isobutane

Temperature (Deg.F.)	kinematic visco- sity(centi stokes)	viscosity (centi poises)
-100.00000	0.85000	0.56200
-80.00000	0.72500	0.47100
-60.00000	0.62500	0.39900
-40.00000	0.55000	0.34400
-20.00000	0.48500	0.29800
0.0	0.43300	0.26100
20.00000	0.39200	0.23100
40.00000	0.35600	0.20500
60.00000	0.32700	0.18400
80.00000	0.30000	0.16500

(Continued)

No.: 05.01.3.02

viscosity of liquid isobutane

Temperature (Deg.F.)	kinematic visco- sity(centi stokes)	viscosity (centi poises)
100.00000	0.27800	0.14900

(1) No.: 05.01.4.01

(2) Properties Included : 1 0 3 4 0 6

1. Pressure 2. Sp. Volume 3. Temperature 4. Viscosity
5. Thermal Conductivity 6. Other

(3) Author : Lipkin, Davison and Kurtz

(4) Date : 1942

(5) Method : High Pressure and low Pressure capillary flow viscometer

(6) Accuracy : 2 %

(7) Reference No. : 0050

(8) Values of Properties :

viscosity of isobutane in liquid state

Temperature (Deg.C.)	kinematic visco- sity(10^{-6} m*m/sec)	viscosity (micro Pa.s)
-73.33333	0.85000	0.56200
-62.22222	0.72500	0.47100
-51.11111	0.62500	0.39900
-40.00000	0.55000	0.34400
-28.88889	0.48500	0.29800
-17.77778	0.43300	0.26100
-6.66667	0.39200	0.23100
4.44444	0.35600	0.20500
15.55556	0.32700	0.18400
26.66667	0.30000	0.16500

(Continued)

No.: 05.01.4.02

viscosity of isobutane in liquid state

Temperature (Deg.C.)	kinematic visco- sity(10^{-6} m ² /sec)	viscosity (micro Pa.s)
37.77778	0.27800	0.14900

(1) No.: 06.01.3.01

(2) Properties Included : 0 0 3 4 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Viscosity
5. Thermal Conductivity 6. Other

(3) Author : Bromley and Wilke

(4) Date : 1951

(5) Method : Theoretically predicted

(6) Accuracy :

(7) Reference No. : 0020

(8) Values of Properties :

viscosity of isobutane gas

Temperature (K)	viscosity (centi-poise)	Temperature (K)	viscosity (centi-poise)
100.00000	0.00277	150.00000	0.00391
200.00000	0.00540	250.00000	0.00660
300.00000	0.00790	350.00000	0.00925
400.00000	0.01060	450.00000	0.01180
500.00000	0.01300	600.00000	0.01520
700.00000	0.01720	800.00000	0.01900
1000.00000	0.02330	1200.00000	0.02600
1400.00000	0.02870	1500.00000	0.03120

(1) No.: 06.01.4.01

(2) Properties Included : 0 0 3 4 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Viscosity
5. Thermal Conductivity 6. Other

(3) Author : Bromley and Wilke

(4) Date : 1951

(5) Method : Theoretically predicted

(6) Accuracy :

(7) Reference No. : 0020

(8) Values of Properties :

viscosity of isobutane gas

Temperature (Deg.C.)	viscosity (mili Pa.s)	Temperature (Deg.C.)	viscosity (mili Pa.s)
-173.15000	0.00277	-123.15000	0.00391
-73.15000	0.00540	-23.15000	0.00660
26.85000	0.00790	76.85000	0.00925
126.85000	0.01060	176.85000	0.01180
226.85000	0.01300	326.85000	0.01520
426.85000	0.01720	526.85000	0.01900
726.85000	0.02330	926.85000	0.02600
1126.85000	0.02870	1226.85000	0.03120

(1) No.: 07.01.3.01

(2) Properties Included : 0 0 3 4 5 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Viscosity
5. Thermal Conductivity 6. Other

(3) Author : Lambert et al

(4) Date : 1955

(5) Method : capill. flow viscom., pendulum viscom. and hot wire method

(6) Accuracy : 1 % for viscosity, 0.5 % for thermal conductivity

(7) Reference No. : 0040

(8) Values of Properties :

Temperature = 66 Deg.C.

viscosity = 87.5 micro-poise
 = 8.75 micro Pa.s

K=50.1 micro cal./(cm.sec Deg.C.)

(1) No.: 07.02.3.01

(2) Properties Included : 1 0 3 4 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Viscosity
5. Thermal Conductivity 6. Other

(3) Author : Lambert et al

(4) Date : 1955

(5) Method : capillary flow viscometer, pendulum viscometer

(6) Accuracy : 1 % for viscosity

(7) Reference No. : 0040

(8) Values of Properties :

viscosity of isobutane gas

Temperature (Deg.C.)	viscosity (micro poise)	Temperature (Deg.C.)	viscosity (micro poise)
35.00000	80.90000	50.00000	84.70000
65.00000	87.80000	77.00000	91.10000
62.20000	86.30000	70.00000	88.20000
79.60000	90.70000	90.20000	93.60000

(1) No.: 07.02.4.01

(2) Properties Included : 1 0 3 4 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Viscosity
5. Thermal Conductivity 6. Other

(3) Author : Lambert et al

(4) Date : 1955

(5) Method : capillary flow viscometer, pendulum viscometer

(6) Accuracy : 1 % for viscosity

(7) Reference No. : 0040

(8) Values of Properties :

viscosity of isobutane gas

Temperature (Deg.C.)	viscosity (micro Pa.s)	Temperature (Deg.C.)	viscosity (micro Pa.s)
35.00000	8.09000	50.00000	8.47000
65.00000	8.78000	77.00000	9.11000
62.20000	8.63000	70.00000	8.82000
79.60000	9.07000	90.20000	9.36000

(1) No.: 08.01.3.01

(2) Properties Included : 1 0 3 4 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Viscosity
5. Thermal Conductivity 6. Other

(3) Author : Gonzalez and Lee

(4) Date : 1966

(5) Method :

(6) Accuracy : 1 %

(7) Reference No. : 0030

(8) Values of Properties :

viscosity of isobutane(micropoises)

Pressure (psi)	Temperature (Deg.F.) 100.00000	Temperature (Deg.F.) 160.00000	Temperature (Deg.F.) 220.00000
100.00000	1358.40000	*****	*****
165.00000	*****	959.90000	*****
200.00000	1368.30000	967.00000	*****
310.00000	*****	*****	680.60000
400.00000	1401.70000	1002.20000	681.40000
600.00000	1449.30000	*****	731.90000
800.00000	1478.40000	1069.50000	781.60000
1000.00000	1514.10000	1106.30000	817.60000
1500.00000	1629.40000	*****	901.70000
2000.00000	1670.60000	1259.00000	973.00000

(Continued)

No.: 08.01.3.02

viscosity of isobutane(micropoises)

Pressure (psi)	Temperature (Deg.F.) 100.00000	Temperature (Deg.F.) 160.00000	Temperature (Deg.F.) 220.00000
3000.00000	1860.50000	*****	1107.00000
4000.00000	1983.10000	1518.40000	*****
5000.00000	2125.80000	*****	1344.80000
6000.00000	2282.50000	1774.40000	*****
8000.00000	2550.40000	2021.50000	*****

(Continued)

No.: 08.01.3.03

viscosity of isobutane(micropoises)

Pressure (psi)	Temperature (Deg.F.) 280.00000	Temperature (Deg.F.) 340.00000
100.00000	106.10000	115.30000
165.00000	*****	*****
200.00000	106.70000	118.40000
310.00000	*****	*****
400.00000	119.60000	124.70000
600.00000	397.40000	145.20000
800.00000	508.70000	210.60000
1000.00000	562.30000	329.00000
1500.00000	*****	489.20000
2000.00000	755.00000	586.00000
3000.00000	*****	721.60000
4000.00000	1008.00000	*****
5000.00000	1117.00000	936.90000
6000.00000	*****	*****
8000.00000	*****	*****

(1) No.: 08.01.4.01

(2) Properties Included : 1 0 3 4 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Viscosity
5. Thermal Conductivity 6. Other

(3) Author : Gonzalez and Lee

(4) Date : 1966

(5) Method :

(6) Accuracy : 1 %

(7) Reference No. : 0030

(8) Values of Properties :

viscosity of isobutane(micro Pa.sec)

Pressure ()	Temperature (Deg.C.)	Temperature (Deg.C.)	Temperature (Deg.C.)
	37.77778	71.11111	104.44444
0.68947	135.84000	*****	*****
1.13763	*****	95.89000	*****
1.37895	136.83000	96.70000	*****
2.13737	*****	*****	68.06000
2.75789	140.17000	100.22000	68.14000
4.13684	144.93000	*****	73.19000
5.51579	147.84000	106.95000	78.16000
6.89473	151.41000	110.63000	81.76000
10.34210	162.94000	*****	90.17000
13.78947	167.06000	125.90000	97.30000

(Continued)

No.: 08.01.4.02

viscosity of Isobutane(micro Pa.sec)

Pressure ()	Temperature (Deg.C.) 37.77778	Temperature (Deg.C.) 71.11111	Temperature (Deg.C.) 104.44444
20.68420	186.05000	*****	110.70000
27.57893	198.31000	151.84000	*****
34.47367	212.58000	*****	134.48000
41.36840	228.25000	177.44000	*****
55.15787	255.04000	202.15000	*****

(Continued)

No.: 08.01.4.03

viscosity of isobutane(micro Pa.sec)

Pressure ()	Temperature (Deg.C.) 137.77778	Temperature (Deg.C.) 171.11111
0.68947	10.61000	11.53000
1.13763	*****	*****
1.37895	10.67000	11.84000
2.13737	*****	*****
2.75789	11.96000	12.47000
4.13684	39.74000	14.52000
5.51579	50.87000	21.06000
6.89473	56.23000	32.90000
10.34210	*****	48.92000
13.78947	75.50000	58.60000
20.68420	*****	72.16000
27.57893	100.80000	*****
34.47367	111.70000	93.69000
41.36840	*****	*****
55.15787	*****	*****

(1) No.: 09.01.3.01

(2) Properties Included : 1 0 3 0 5 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Viscosity
5. Thermal Conductivity 6. Other

(3) Author : Parkinson and Gray

(4) Date : 1972

(5) Method : Two double-wire cells

(6) Accuracy : t : 0.01 % , K : 2 %

(7) Reference No. : 0075

(8) Values of Properties :

Thermal conductivity of isobutane gas at 50 Deg.C.

50 Deg.C.	:	4.62 cal/(km.s.K)
		19.33 J/(km.s.K)
100 Deg.C.	:	6.05 cal/(km.s.K)
		25.31 J/(km.s.K)

(1) No.: 10.01.3.01

(2) Properties Included : 1 0 3 4 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Viscosity
5. Thermal Conductivity 6. Other

(3) Author : Abe, Kestin, Khalifa and Wakeham

(4) Date : 1978

(5) Method : Oscillating disk viscometer

(6) Accuracy : 0.2 %

(7) Reference No. : 0010

(8) Values of Properties :

viscosity of isobutane gas at 1 atm.

Temperature (Deg.C.)	Viscosity (micro Pa.s)	Temperature (Deg.C.)	Viscosity (micro Pa.s)
25.00000	7.48400	45.00000	8.00400
60.00000	8.36700	80.00000	8.84100
100.00000	9.31500	145.00000	10.34900
195.00000	11.50000	*****	*****

(1) No.: 10.01.4.01

(2) Properties Included : 1 0 3 4 0 0

1. Pressure 2. Sp. Volume 3. Temperature 4. Viscosity
5. Thermal Conductivity 6. Other

(3) Author : Abe, Kestin, Khalifa and Wakeham

(4) Date : 1978

(5) Method : Oscillating disk viscometer

(6) Accuracy : 0.2 %

(7) Reference No. : 0010

(8) Values of Properties :

viscosity of isobutane gas at .101 MPa

Temperature (Deg.C.)	Viscosity (micro Pa.s)	Temperature (Deg.C.)	Viscosity (micro Pa.s)
25.00000	7.48400	45.00000	8.00400
60.00000	8.36700	80.00000	8.84100
100.00000	9.31500	145.00000	10.34900
195.00000	11.50000	*****	*****

PART III

LIST OF REFERENCES IN
CHRONOLOGICAL ORDER

Part III

List of references in chronological order

(a) Equilibrium properties

No.	Ref. No.	Details
1	0380	Oudinoff, M., Bulletin. Societe Chimique de Belgique. V. 23 (1909) 226.
2	0096	Burrell, G. A. and Robertson, I. W., "The Vapour Pressures of Acetylene, Ammonia and Isobutane Below Their Normal B.P.". J. Amer. Chem. Soc. V. 37 (1915) 2482-2486.
3	0485	Seibert, F. M. and Burrell, G. A.; "The Critical Constants of Normal Butane, Isobutane and Propylene and Their Vapor Pressures at Temperatures Between 0°C and 120°C". J. Amer. Chem. Soc. V. 37 (1915) 2683-2691.
4	0175	Dana, L. I., Jenkins, A. C., Burdick, J. N. and Timm, R. C., "Thermodynamic Properties of Butane, Isobutane and Propane (Saturation Tables)". Refrign. Eng. V. 12 (12) (1926) 387-405.
5	0140	Coffin, C. C. and Maass, O., "The Preparation and Physical Properties of Alpha-, Beta- and Gamma-Butylene and n- and Isobutane (Density)". J. Amer. Chem. Soc. V. 50 (1928) 1427-1437.
6	0400	Parks, G. C., Shomate, C. H., Kennedy, W. D. and Crawford, B. L. J., "The Entropies of n-Butane and Isobutane with some Heat Capacity Data for Isobutane". J. Chem. Phys. V. 5 (1937) 359-363.
7	0465	Sage, B. H., Webster, D. C. and Lacey, W. N., "Phase Equilibria in Hydrocarbon Systems". Indl. Eng. Chem. 29 (11) (1937) 1309-1314.
8	0295	Jessen, F. W. and Lightfoot, J. H., "Compressibility of Butane-Pentane Mixtures Below 1 Atmosphere". Indl. Eng. Chem. V. 30 (3) (1938) 312-314.
9	0470	Sage, B. H. and Lacey, W. N., "Phase Equilibrium in Hydrocarbon Systems (Liq., Vap. and Sat. Properties)". Indl. Eng. Chem. V. 30 (6) (1938) 673-681.
10	0365	Morris, W. M., Sage, B. H. and Lacey, W. N., "Volumetric Behavior of Isobutane". Amer. Inst. Mining & Met. E. Tech. Publ. No. 1128 (1939) 158-164.

No.	Ref. No.	Details
11	0245	Gilland, E. R. and Scheeline, H. W., "High Pressure Vapour-Liquid Equilibrium". Indl. Eng. Chem. V. 32 (1940) 48.
12	0020	Aston, J. G., Kennedy, R. M. and Schumann, S. C., "The Heat Capacity & Entropy, Heats of Fusion and Vaporization and Vapor Pressure of Isobutane". J. Amer. Chem. Soc. V. 62 (1940) 2059-2063.
13	0520	Technical Committee, Natural Gasoline Association of America, "Densities of Liquified Petroleum Gases (-50° to 140°F)". Indl. Eng. Chem. V. 34 (10) (1942) 1240-1243.
14	0170	Dailey, B. P. and Felsing, W. A., "Heat Capacities of and Hindered Rotation in n-Butane and Isobutane". J. Amer. Chem. Soc. 65 (1943) 44-46.
15	0015	A.P.I. Research Project No. 44, "Selected Values of Physical and Thermodynamic Properties of H/C and Related Compounds". Pittsburgh, PA (1953) 560, 582-3, 596, 705.
16	0340	Linn, C. B., Wackher, R. C. and Grosse, A. V., "Physical Properties of Butanes and Butenes". Indl. Eng. Chem. V. 37 (5) (1945) 464-468.
17	0535	Wacker, P. F., Cheney, R. K. and Scott, R. B., "Heat Capacities of Gaseous Oxygen, Isobutane and 1-Butene from -30°C to 90°C". J. Res. Nat. Bur. Std. V. 38 (1947) 651-659.
18	0060	Beattie, J. A., Edwards, D. G. and Marple, S. J., "The Vapor Pressure, Orthobaric Liquid Density and Critical Constants of Isobutane". J. Chem. Phys. 17 (6) (1949) 576-577.
19	0065	Beattie, J. A., Marple, S. J. and Edwards, D. G., "The Compressibility of and an Equation of State for Gaseous Isobutane". J. Chem. Phys. 18 (1) (1950) 127-128.
20	0360	Mason, D. M. and Eakin, B. E., "Compressibility Factor of Fuel Gases at 60°F and 1 Atm". J. Chem. Eng. Data 6 (4) (1961) 499-504.
21	0145	Connoly, J. F., "Ideality of n-Butane: Isobutane Solutions". J. Phys. Chem. 66 (1962) 1082-1086.
22	0250	Gonzalez, M. H. and Lee, A. L., "Viscosity of Isobutane". J. Chem. Eng. Data 11 (1966) 357-359.
23	0490	Sliwinsky, P., "Die Lorentz Funktion Von Dampfformigem und Flussigem Athan, Propan Und Butan". Z. Phys. Chem. (Frankfurt Am Main) 43 (1969) 263-279.

No.	Ref. No.	Details
24	0225	Ernst, G. and Busser, J., "Ideal and Real Gas State Near Capacities of C_3H_8 , $I-C_4H_{10}$, C_2F_5Cl , CH_2ClCF_3 , $CF_2ClCFCl_2FCl_2$ and CHF_2Cl ". Chem. Therm. 2 (1970) 781-791.
25	0135	Chen, S. S., Wilhoit, R. C. and Zwolinsky, B. J., "Ideal Gas Thermodynamic Properties and Isomerization of n-Butane and Isobutane". J. Phys. Chem. Ref. Data. V. 4 (1975) 859-869.

(b) Transport properties

No.	Ref. No.	Details
1	0035	Ishida, Y., "Determination of Viscosity and of the Stokes-Millikan Law Constant by the Oil-Drop Method". Phys. Rev. 21 (1923) 550-563.
2	0090	Titani, T., "The Viscosity of Vapours of Organic Compounds - Part II". Bulletin of Chem. Soc. of Japan 5 (1930) 98-108.
3	0060	Mann, W. B. and Dickins, B. G., "Thermal Conductivities of Saturated Hydrocarbons in the Gaseous State". Proc. Roy. Soc. London 134 A (1931) 77-96.
4	0080	Sage, B. H., Yale, W. D. and Lacey, W. N., "Effect of Pressure on Viscosity of n-Butane and Iso-Butane". Ind. Eng. Chem. 31 (1939) 223-226.
5	0050	Lipkin, M. R., Davison, J. A. and Kurtz, S. S. J., "Viscosity of Propane, Butane and Iso-Butane". Ind. Eng. Chem. 34 (1942) 976-979.
6	0020	Bromley, L. A. and Wilke, C. R., "Viscosity Behaviour of Gases". Ind. Eng. Chem. 43 (1951) 1641-1648.
7	0040	Lambert, J. D., Cotton, K. J., Pailthorpe, M. W., Robinson, A. M., Scrivins, J., Vale, W. R. F. and Young, R. M., "Transport Properties of Gaseous Hydrocarbons". Proc. Royal Soc. London 231A (1955) 280-290.
8	0030	Gonzalez, M. H. and Lee, A. L., "Viscosity of Iso-Butane". J. Chem. Eng. Data 11 (1966) 357-359.
9	0075	Parkinson, C. and Gray, P., "Thermal Conductivity of Gaseous Mixtures Containing Hydrocarbons 1. Butane, iso-Butane, iso-Pentane and neo-Pentane and their Binary Mixtures with Argon". J. Chem. Soc. Farad. Trans. I 68 (1972) 1065-1076.

No.	Ref. No.	Details
10	0010	Abe, Y., Kestin, J., Khalifa, H. E. and Wakeham, W. A., Unpublished paper (communicated privately) (1978).

PART IV

LIST OF REFERENCES IN
ALPHABETICAL ORDER

Part IV

List of references in alphabetical order

(a) Equilibrium properties

No.	Ref. No.	Details
15	0015	A.P.I. Research Project No. 44. "Selected Values of Physical and Thermodynamic Properties of H/C and Related Compounds". Pittsburgh, PA (1953) 560, 582-3, 596, 705.
12	0020	Aston, J. G., Kennedy, R. M. and Schumann, S. C., "The Heat Capacity & Entropy, Heats of Fusion and Vaporization and Vapor Pressure of Isobutane". J. Amer. Chem. Soc. V. 62 (1940) 2059-2063.
18	0060	Beattie, J. A., Edwards, D. G. and Marple, S. J., "The Vapor Pressure, Orthobaric Liquid Density and Critical Constants of Isobutane". J. Chem. Phys. 17 (6) (1949) 576-577.
19	0065	Beattie, J. A., Marple, S. J. and Edwards, D. G., "The Compressibility of and an Equation of State for Gaseous Isobutane". J. Chem. Phys. 18 (1) (1950) 127-128.
2	0096	Burrell, G. A. and Robertson, I. W., "The Vapour Pressures of Acetylene, Ammonia and Isobutane Below their Normal B.P.". J. Amer. Chem. Soc. V. 37 (1915) 2482-2486.
25	0135	Chen, S. S., Wilhoit, R. C. and Zwolinsky, B. J., "Ideal Gas Thermodynamic Properties and Isomerization of n-Butane and Isobutane". J. Phys. Chem. Ref. Data V. 4 (1975) 859-869.
5	0140	Coffin, C. C. and Maass, C., "The Preparation and Physical Properties of Alpha-, Beta- and Gamma-Butylene and n- and Isobutane (Density)". J. Amer. Chem. Soc. V. 50 (1928) 1427-1437.
21	0145	Connolly, J. F., "Ideality of n-Butane: Isobutane Solutions". J. Phys. Chem. 66 (1962) 1082-1086.
14	0170	Dailey, B. P. and Felsing, W. A., "Heat Capacities of and Hindered Rotation in n-Butane and Isobutane". J. Amer. Chem. Soc. 65 (1943) 44-46.
4	0175	Dana, L. I., Jenkins, A. C., Burdick, J. N. and Timm, R. C., "Thermodynamic Properties of Butane, Isobutane and Propane (Saturation Tables)". Refrign. Eng. V. 12 (12) (1926) 378-405.

No.	Ref. No.	Details
24	0225	Ernst, G. and Busser, J., "Ideal and Real Gas State Heat Capacities of C_3H_8 , $I-C_4H_{10}$, C_2F_5Cl , CH_2ClCF_3 , $CF_2ClCFCl_2FCI_2$ and CHF_2Cl ". Chem. Therm. 2 (1970) 781-791.
11	0245	Gilland, E. R. and Scheeline, H. W., "High Pressure Vapour-Liquid Equilibrium". Indl. Eng. Chem. V. 32 (1940) 48.
22	0250	Gonzalez, M. H. and Lee, A. L., "Viscosity of Isobutane". J. Chem. Eng. Data 11 (1966) 357-359.
8	0295	Jessen, F. W. and Lightfoot, J. H., "Compressibility of Butane-Pentane Mixtures Below 1 Atmosphere". Indl. Eng. Chem. V. 30 (3) (1938) 312-314.
16	0340	Linn, C. B., Wackher, R. C. and Grosse, A. V., "Physical Properties of Butanes and Butenes". Indl. Eng. Chem. V. 37 (5) (1945) 464-468.
20	0360	Mason, D. M. and Eakin, E. E., "Compressibility Factor of Fuel Gases at 60°F and 1 Atm.". J. Chem. Eng. Data 6 (4) (1961) 499-504.
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