Vapor Pressures, Critical Parameters, Boiling Points, and Triple Points of Halomethane Molecular Substances

Hong Wei Xiang[a)]

Center for Molecular Sciences, Institute of Chemistry, Chinese Academy of Sciences, Zhongguancun, Haidian, Beijing 100080, China

(Received 20 April 2001; accepted 23 July 2001)

A simple general corresponding-states principle for vapor pressure incorporated with a simple vapor-pressure equation is presented to describe within and extend beyond the range of available experimental data for 25 halomethane substances. Apparatus type, measurement method, and precision and uncertainties are listed for the experimental vapor-pressure data sets. The experimental data with the corresponding ranges have been reviewed to test the present method in representing the vapor-pressure behavior. Comparisons with available data show that the extended corresponding-states principle for vapor pressure has very good accuracies with different data sets. The substance-dependent characteristic parameters such as critical temperature, critical density, critical pressure, and acentric factor are given from reliable literature sources along with the general method. The values of the pressures, along with their first and second derivatives as function of temperature over the entire region from the triple point to the critical point, are tabulated and recommended for scientific and practical uses. © *2002 American Institute of Physics.*

Key words: boiling point; corresponding-states principle; critical density; critical parameters; critical pressure; critical temperature; halomethane; thermodynamic properties; triple point; vapor–liquid equilibrium; vapor pressure.

Contents

List of Tables

[a)]Electronic mail: hwxiang@infoc3.icas.ac.cn

List of Figures

1. Introduction

1.1. Background

A number of chlorofluorocarbons are used today in various applications, such as refrigerants, aerosol propellants, foam blowing agents, and solvents for degreasing and defluxing printed circuit boards. These fluids are generally inert, but when they diffuse to the stratosphere they break down into free radical fragments due to the intense ultraviolet radiation. The chlorine radicals released by this process are believed to deplete the earth's stratospheric ozone layer by a catalytic reaction with ozone molecules. A great deal of research on their properties is currently underway to identify chlorofluorocarbon substitutes. Accurate information about the properties of these substances is also necessary to understand the effect of chlorine and fluorine atoms on the molecular structure since these substances have a very large range of being spherical, weakly asymmetric, and highly polar.

The vapor pressure is of great significance in fundamental theories for vapor–liquid phase transitions and it is also important for calculating other thermodynamic properties of substances. In general, the vapor pressures of these substances have been experimentally measured over a limited range in the literature. Since the experimental determination of all the required data is an impossibly formidable proposition, it is necessary to predict these properties by use of suitable models. Of the many predictive approaches that have been proposed, the corresponding-states principle has proven to be the most powerful framework as proposed by Leland and Chappelear (1968). The corresponding-states principle was the most useful and accurate derivative of the work of van der Waals on his famous equation of state [Rowlinson, (1988)]. The general corresponding-states principle has proven to be much better than has often been thought in the past, as stated by Huber and Hanley (1996). The methods based on the principle are theoretical and predictive, rather than empirical and correlative. The corresponding-states principle has a firm basis in statistical mechanics and kinetic theory, and has a great range and high accuracy. The corresponding-states principle cannot always reproduce a set of data within its claimed experimental accuracy, as can an empirical correlation. Nevertheless, it should not only be able to represent data to a reasonable degree but, more importantly, it does what a correlation cannot do, i.e., accurately predicts the properties beyond the range of existing data as described by Huber and Hanley (1996). A simple general corresponding-states principle that accurately extends the theory of Pitzer *et al.* (1955) for normal molecules to highly nonspherical substances was recently developed [Xiang (1998), (2000), (2001a), (2001b), (2001c)]. This corresponding-states approach was verified as applicable to all substances. Thus, we apply it here to the halomethanes.

1.2. Prior Work and Present Need

For halomethanes, most of the vapor pressure measurements were obtained near the normal-boiling point. In addition, there are often either very few or no vapor pressure data up to the critical temperature or down to the triple point. Kudchadker *et al.* (1979) presented the vapor pressures of halomethanes, with adjustable parameters of a specific substance using the Antoine equation or the Wagner equation fitted from the experimental data available over a limited range. However, a general scheme is needed to interpolate between measurements and to extrapolate to extended ranges to assist in assessing the reliability of different data sets. A reliable corresponding-states method can provide vapor pressure predictions where measurements are not available for a specific substance. This work presents vapor pressures for these halomethanes over their entire ranges from the triple

point to the critical point based on the extended corresponding-states principle and available experimental data.

1.3. Organization of the Paper

In Sec. 2, the vapor pressure equation is presented to represent known physical behavior in describing the available experimental data as a proper reference equation. Furthermore, the corresponding-states principle is summarized to extend the vapor pressure values over the entire range from the triple point to the critical temperature. Section 3 gives a survey of experimental method, precision, and accuracy in temperature and pressure. In Sec. 4, the present method is compared with experimental data and smoothly calculates tables of the vapor pressure, along with their first and second derivatives. Finally, the uncertainties of these reproduced data are briefly discussed in Sec. 5.

2. Present Method

2.1. Vapor-Pressure Equation

To represent experimental data over the entire range from the triple point to the critical temperature, the vapor-pressure curve is based upon an equation with known physical behavior and has three substance-dependent parameters as described in the Xiang–Tan equation (1994)

$$\ln p_r = (a_0 + a_1\tau^{n_1} + a_2\tau^{n_2})\ln T_r, \tag{1}$$

where $\tau = 1 - T_r$, the reduced temperature $T_r = T/T_c$, with T being the temperature and T_c the critical temperature; the reduced pressure $p_r = p/p_c$ with p being the pressure and p_c the critical pressure. $n_1 = 1.89$ and $n_2 = 3n_1 = 5.67$. The substance-dependent parameter a_0 is the Riedel parameter [Riedel (1954)] and a_1 and a_2 are also substance-dependent parameters. T_c is the critical temperature and p_c is the critical pressure. Equation (1) reproduces the experimental vapor-pressure data over the entire temperature range with excellent accuracy considering the present experimental uncertainties between different data sets. This equation with only three parameters accurately represents vapor pressure behavior from the triple point to the critical point. It yields excellent predictions and extrapolations outside the range in which data are usually available both to the critical point and to the triple point.

The functional form presented in Eq. (1) is rewritten as

$$p_r = \exp[(a_0 + a_1\tau^{n_1} + a_2\tau^{n_2})\ln T_r] \tag{2}$$

and

$$p = p_c \exp[(a_0 + a_1\tau^{n_1} + a_2\tau^{n_2})\ln T_r]. \tag{3}$$

The slope of the vapor-pressure equation is given by

$$dp/dT = \frac{d\ln p_r}{dT_r} p/T_c, \tag{4}$$

where

TABLE 1. General coefficients of the extended corresponding-states principle for vapor pressure

a_{00}	5.790 206	a_{10}	6.251 894	a_{20}	11.658 59
a_{01}	4.888 195	a_{11}	15.085 91	a_{21}	46.782 73
a_{02}	33.911 96	a_{12}	−315.0248	a_{22}	−1672.179

$$\frac{d\ln p_r}{dT_r} = (a_0 + a_1\tau^{n_1} + a_2\tau^{n_2})/T_r - (n_1 a_1 \tau^{n_1-1} + n_2 a_2 \tau^{n_2-1})\ln T_r. \tag{5}$$

At the critical point, $d\ln p/d\ln T = \alpha_c$ is the Riedel parameter.

The second derivative of pressure as a function of temperature is given by

$$d^2p/dT^2 = \left[\frac{d^2\ln p_r}{dT_r^2} + \left(\frac{d\ln p_r}{dT_r}\right)^2\right] p/T_c^2, \tag{6}$$

where

$$\frac{d^2\ln p_r}{dT_r^2} = [n_1(n_1-1)a_1\tau^{n_1-2} + n_2(n_2-1)a_2\tau^{n_1-2}]\ln T_r - (a_0 + a_1\tau^{n_1} + a_2\tau^{n_2})/T_r^2 - 2(n_1 a_1\tau^{n_1-1} + n_2 a_2\tau^{n_2-1})/T_r. \tag{7}$$

Equation (1) can be used to extrapolate precise vapor-pressure measurements at modest pressures to the critical point and to the triple point, provided that the critical temperature is known. When the temperature approaches the critical point, the second derivative should weakly approach infinity, which becomes significant only for less than several thousandth of τ. For this case, it is equivalent to less than about 5° below the critical point for most substances where the amplitude of the leading-order nonanalytic term in Eq. (6) is not consistent with the correct universal constant.

2.2. The Extended Corresponding-States Principle

The two-parameter corresponding-states method applies accurately only to spherical molecules argon, krypton, and xenon. In order to extend the corresponding-states principle to molecular fluids, it is necessary to take into account the nonspherical nature of real molecules through the acentric factor of Pitzer *et al.* (1955), which works well for a wide range of nonpolar substances but its predictive capability for polar and associating molecules is generally poor. The use of four parameters for polar fluids corresponds to an intermolecular potential function in which dispersion and dipole–dipole interaction effects are accounted for. To extend the corresponding-states principle of Pitzer *et al.* to highly nonspherical substances, the recently developed extended corresponding-states parameter $\theta = (Z_c - 0.29)^2$ is introduced to describe the deviation of the critical compression factor Z_c of a real nonspherical molecule from spherical molecules [Xiang (1998), (2000), (2001a), (2001b), (2001c)]. For spherical fluids $Z_c = 0.29$. The corresponding-states parameter θ is obtained from the parameters of the behavior in the

TABLE 2. Experimental method, precision, and accuracy in temperature (ΔT) and in pressure (Δp) and substances studied

Author(s)	Method[a]	ΔT/K	Δp/kPa	Substance
Adams and Stein (1971)	6	0.028	0.690	CH_2F_2
Albright and Martin (1952)	1	0.01	0.001p	$CClF_3$
Banks *et al.* (1948)				CCl_3F, CCl_2F_2
Beersmans and Jungers (1947)	15	0.02	0.0267	CH_3Cl, CH_3Br, CH_3I
Benning and McHarness (1939)	1			CCl_3F, CCl_2F_2, $CHCl_2F$, $CHClF_2$
Benning and McHarness (1940)	1	0.01	0.003p	CCl_3F, $CHCl_2F$, $CHClF_2$
Birchall and Haszeldine (1959)				CBr_3F, CBr_2F_2
Biswas *et al.* (1989)	9	0.006–0.022	3.2–5.3	CH_3F
Blanke and Weiss (1992)		0.005	0.005	CCl_2F_2, $CHClF_2$
Bominaar *et al.* (1987)	9	0.001	0.01p	CH_3F
Booth and Bixby (1932)				$CHClF_2$
Booth and Swinehart (1935)	15	0.01	1.0	$CHClF_2$
Boublik and Aim (1972)	5	0.001	0.0067	CCl_4, $CHBr_3$, $CHCl_3$, CH_2Cl_2, CH_3I
Brown and Acree (1916)				CH_3I
Campbell and Chatterjee (1968)	1	0.05	0.003p	$CHCl_3$
Campbell and Chatterjee (1969)	1	0.03	0.003p	CCl_4
Collie (1889)		0.2	200	CH_3F
Davidson (1951)	14, 15	0.2	0.067	CBr_2F_2, $CBrF_3$
Davidson and Sullivan (1949)	15		0.133	$CBrCl_3$
Defibaugh *et al.* (1994)	9, 16	0.002	0.01	CH_2F_2
Demiriz *et al.* (1993)	9	0.010	0.01p	CH_3F
De Vries (1997)	1	0.005	0.02–0.015p	CH_2F_2
Duan *et al.* (1996)	9	0.01	0.3–0.6	CF_3I
Egan and Kemp (1938)	2	0.01	0.0027	CH_3Br
Fahim and Moelwyn-Hughes (1956)	15		0.133	CCl_4, CH_3I
Fernandez-Fassnacht and del Rio (1985)	11	0.001	0.01–0.2	CCl_3F, CCl_2F_2, $CClF_3$
Findlay and Kenyon (1969)	6			$CHCl_3$
Fonseca and Lobo (1994)	1		0.005	CH_3F
Forbes and Anderson (1945)				$CHBrCl_2$, CH_2BrCl
Fu *et al.* (1995)	9	0.01	0.5	CH_2F_2
Gilkey *et al.* (1931)	1	0.3	0.005p	CCl_2F_2
Giuliani *et al.* (1995)	9	0.015–0.03	0.34–0.85	$CHClF_2$
Glew (1960)	8	0.003	0.0053	$CBrClF_2$
Goodwin *et al.* (1992)	4	0.01	0.010	$CHClF_2$
Gordon and MacWilliam (1946)	15	0.05	1	CCl_2F_2
Gregory and Style (1936)	6		0.08p	CH_2I_2
Gross and Saylor (1931)	15	0.02		CCl_4, $CHCl_3$, CH_2Br_2
Grosse *et al.* (1940)	1	0.1	0.0133	CH_3F
Handa *et al.* (1975)	1		0.015	$CHCl_3$, CH_2Cl_2
Handel *et al.* (1992)	8	0.003	0.001p	CCl_2F_2, $CHClF_2$
Haszeldine (1951)				$CBrF_3$, $CClF_3$
Haszeldine (1952)				$CHBrClF$, CH_2ClF
Henne (1937)				$CHBr_2F$, CHF_3
Holcomb *et al.* (1993)	6	0.1	3.5	CH_2F_2
Holldorff and Knapp (1988)	1	0.04	0.05	CH_3Cl
Hongo *et al.* (1990)	1	0.01	1	$CBrF_3$, $CHClF_2$
Hori *et al.* (1982)	9	0.01	2.5	CHF_3
Hou and Martin (1959)	1			CHF_3
Hsu and McKetta (1964)	1		1.0	CH_3Cl
Hudson and Winkle (1969)	6	0.02	0.0133	$CHCl_3$
Ivin and Dainton (1947)	1	0.1	0.0133	CCl_4, $CHBr_3$
Jain *et al.* (1971)	1			CCl_4
Khurma *et al.* (1983)	6	0.003	0.001p	CH_2Cl_2
Kobayashi and Nishiumi (1998)	11	0.01	0.0015p	CH_2F_2
Kohlen *et al.* (1985)	9	0.01	0.0001p	$CHClF_2$
Kubic and Stein (1981)	6	0.04	0.0002p	CF_4
Liu *et al.* (1981)	10	0.2	1	CCl_4
Magee (1996)	9	0.03	0.0005–0.0001p	CH_2F_2
Malbrunot *et al.* (1968)	1	0.005	0.0267	CH_2F_2
Mansoorian *et al.* (1981)	9	0.01	0.0001p	CH_3Cl

TABLE 2. Experimental method, precision, and accuracy in temperature (ΔT) and in pressure (Δp) and substances studied—Continued

Author(s)	Method[a]	ΔT/K	Δp/kPa	Substance
McDonald *et al.* (1959)	6			CBr_2F_2, $CBrF_3$, CH_2BrCl
McGlashan *et al.* (1954)	11	0.02	0.0067	CCl_4, $CHCl_3$
McGlashan and Rastogi (1958)	11	0.01	0.0067	$CHCl_3$
Menzel and Mohry (1933)				CF_4
Messerly and Aston (1940)	2	0.05		CH_3Cl
Michels *et al.* (1966)		0.05	5	CCl_2F_2, $CClF_3$
Michels and Wassenaar (1948)	15	0.0004	0.1	CH_3F
Miller and Smyth (1957)				CBr_3F, CBr_2F_2, $CBrCl_3$, $CBrClF_2$, $CBrF_3$, CCl_3F, CCl_2F_2, $CClF_3$
Moelwyn-Hughes and Missen (1957)	11	0.02	0.0133	CCl_4, $CHCl_3$, CH_2Cl_2, CH_3I
Mollerup and Fredenslund (1976)	6	0.01	0.003*p*	CCl_2F_2, $CClF_3$
Morgan and Yager (1940)				$CHBr_3$, $CHCl_3$, CH_2Br_2, CH_2Cl_2, CH_2I_2, CH_3I
Mueller and Ignatowski (1960)	11	0.004	0.0027	CCl_4, CH_2Cl_2
Neilson and White (1957)				$CHClF_2$
Nodiff *et al.* (1953)				CF_3I
Oi *et al.* (1983)	15	0.001	0.001	CH_3F
Okano *et al.* (1987)	9	0.01	0.001*p*	$CBrF_3$
Osborne *et al.* (1941)	2	0.05	0.013	CCl_3F
Perez *et al.* (1994)	1	0.05	0.0013	CCl_4
Philippe *et al.* (1971)	11			$CHCl_3$
Philippe *et al.* (1973)	1	0.05	0.0001	$CHBr_3$, $CHCl_3$, CH_2Br_2, CH_2Cl_2
Phillips and Murphy (1970)		0.01		$CHCl_3$, $CHCl_2F$, $CHClF_2$, CHF_3, CH_2Cl_2, CH_2ClF, CH_2F_2
Popowicz *et al.* (1982)	15	0.001	0.001	CHF_3
Rastogi *et al.* (1967)	11	0.01	0.0013	CCl_4
Sato *et al.* (1994)	9	0.007	2	CH_2F_2
Scatchard and Raymond (1938)	11	0.02	0.0027	$CHCl_3$
Scatchard *et al.* (1939)	11	0.02	0.0013	CCl_4
Simon *et al.* (1967)	15	0.001	0.0026	CF_4
Smith and Pace (1969)	2	0.01	0.001 33	CF_4
Smyth and McAlpine (1934)				CH_3I
Stein and Proust (1971)	6	0.02	0.069–0.69	$CClF_3$, CHF_3
Thornton *et al.* (1933)	17			CCl_2F_2, $CClF_3$
Thorpe and Rodger (1897)				CCl_4, $CHCl_3$, CH_3I
Valentine *et al.* (1962)	2	0.001	0.0133	CHF_3
Varshni and Mohan (1954)				$CBrCl_3$, CCl_4, CCl_3F, CCl_2F_2, $CClF_3$, CF_4, $CHBr_3$, $CHCl_3$, CHF_3, CH_2Br_2, CH_2Cl_2, CH_2F_2, CH_3Br, CH_3Cl, CH_3F
Wang *et al.* (1970)	6	0.03	0.0067	CCl_4
Weber (1989)	6	0.025	3	$CClF_3$
Weber and Goodwin (1993)	4	0.004	0.01	CH_2F_2
Weber and Silva (1994)	4	0.005	0.0003*p*	CH_2F_2
Widiatmo *et al.* (1994)	15,16	0.015	2	CH_2F_2
Williams and Meeker (1948)	6	0.05		CH_3Br
Willock and van Winkle (1970)	11	0.1	0.0133	$CHCl_3$
Wolff *et al.* (1976)				CH_3I
Wong and Eckert (1969)	1	0.001	0.0067	CCl_4, CH_2Cl_2
Wren and Vikis (1982)	8	0.3	0.0001	CH_3I
Yurttas *et al.* (1990)	9	0.003	0.05	CCl_3F
Zellhoefer *et al.* (1938)				CH_2ClF

[a](1) static, (2) calorimetry static, (3) ebulliometry, (4) comparative ebulliometry, (5) comparative Swietoslawski ebulliometer, (6) recirculating still, (7) Stage-Muller recirculating still, (8) gas saturation, (9) isochoric method, (10) gas–liquid partition chromatography, (11) equilibrium still, (12) gas expansion, (13) open-tube technique, (14) ultraviolet adsorption, (15) manometer, (16) densimeter.

TABLE 3. Experimental vapor pressure data for total uncertainty and calculated deviation of the vapor pressure p at the minimum (T_{min}) and maximum (T_{max}) temperature

Author(s)	Data points	Temp. range (K)	Pressure range (kPa)	T_{min}/T_{max} Uncertainty $100\Delta p/p$	T_{min}/T_{max} Calculated $100(1-p_{calc}/p_{expt})$
CBr_2F_2					
Birchall and Haszeldine (1959)	1	296.636	101.325		−2.4
Davidson (1951)	6	221–284	2.7–64.5	2.77/0.64	1.3/−2
McDonald *et al.* (1959)	7	247–297	12.2–104		0.99/2
Miller and Smyth (1957)	1	297.036	101.325		−3.8
$CBrCl_3$					
Davidson and Sullivan (1949)	4	273–377	1.46–99.3		4.9/−2.7
Miller and Smyth (1957)	1	376.125	101.325		2.6
Varshni and Mohan (1954)	1	377.075	101.325		−0.04
$CBrClF_2$					
Glew (1960)	22	177–283	0.33–168	0.35/0.01	0.38/0.02
Miller and Smyth (1957)	1	269.851	101.325		−2.7
$CBrF_3$					
Davidson (1951)	4	164–194	4–32	2.2/1.0	6.4/0.89
Haszeldine (1951)	1	215.16	101.325		1.4
Hongo *et al.* (1990)	11	298–338	1625–3762	0.065/0.32	0.54/−1.3
McDonald *et al.* (1959)	3	214–216	97–104		0.93/−2.4
Miller and Smyth (1957)	1	215.961	101.325		−2.4
Okano *et al.* (1987)	31	245–339	345–3889	0.1	−0.2/−0.1
CCl_4					
Boublik and Aim (1972)	16	262–348	7–98	0.27/0.01	−3.4/0.36
Campbell and Chatterjee (1969)	40	382–554	249–4464	0.058/0.031	−0.18/−0.1
Gross and Saylor (1931)	1	349.89	101.325		0.16
Ivin and Dainton (1947)	1	349.836	101.325		0.32
Jain *et al.* (1971)	3	308–328	15–50		−0.93/1.1
Liu *et al.* (1981)		328–373	49.8–196	−0.01/0.45	2.0/0.66
McGlashan *et al.* (1954)	3	298–328	15–50	0.57/0.031	−0.83/0.11
Moelwyn-Hughes and Missen (1957)	1	349.903	101.325		0.115
Mueller and Ignatowski (1960)	5	303–343	19–82	0.017/0.010	−0.60/0.35
Perez *et al.* (1994)	9	283–323	7–42	0.20/0.15	−1.1/0.27
Rastogi *et al.* (1967)	4	264–273	2–4.5	0.093/0.055	−4.2/2.0
Scatchard *et al.* (1939)	5	303–343	19–82	0.070/0.050	−0.66/0.35
Thorpe and Rodger (1897)	1	349.743	101.325		
Varshni and Mohan (1954)	1	348.973	101.325		2.9
Wang *et al.* (1970)	5	303–338	19–70	0.070/0.078	−0.66/−0.21
CCl_3F					
Banks *et al.* (1948)	1	296.836	101.325		−0.25
Benning and McHarness (1939)	1	296.836	101.325		−0.25
Benning and McHarness (1940)	7	243–468	9–4274	0.3/0.3	0.14/0.30
Fernandez-Fassnacht and del Rio (1985)	17	233–291	5–83	0.19/0.012	1.0/−0.08
Osborne *et al.* (1941)	7	236–293	6–88	0.33/0.15	0.77/0.08
Yurttas *et al.* (1990)	6	353–378	523–913	0.01	−0.43/−0.25
Varshni and Mohan (1954)	1	297.086	101.325		−1.1
CCl_2F_2					
Banks *et al.* (1948)	1	245.156	101.325		−7.6
Blanke and Weiss (1992)	20	116–243	0–102	0.55/0.018	4.9/0.10
Fernandez-Fassnacht and del Rio (1985)	48	213–293	23–566	0.88/0.035	0.21/−0.15
Gilkey *et al.* (1931)	20	203–384	12–4008	1.6/0.68	0.73/−1.7
Gordon and McWilliam (1946)	2	283–293	422–566	0.27/0.21	−0.078/−0.030
Handel *et al.* (1992)	53	180–330	2–1420	0.1/0.1	2.8/0.13
Michels *et al.* (1966)	9	298–384	656–4062	0.77/0.14	−0.1/0.63
Mollerup and Fredenslund (1976)	2	255–290	162–519	0.30/0.30	0.25/0.29
Varshni and Mohan (1954)	1	245.006	101.325		−6.9
$CClF_3$					
Albright and Martin (1952)	7	145–300	3–3709	0.90/0.10	−7.0/−0.5
Fernandez-Fassnacht and del Rio (1985)	41	188–273	84–1967	0.013/0.01	0.67/−0.48
Haszeldine (1951)	1	191.163	101.325		3.4
Mollerup and Fredenslund (1976)	2	255–290	1208–2998	0.3	0.2/0.9
Stein and Proust (1971)	4	200–273	154–1966	0.089/0.044	1.2/−0.89
Thornton *et al.* (1933)	9	161–192	13–101		0.33/−1.7
Varshni and Mohan (1954)	1	193.013	101.325		−6.5

TABLE 3. Experimental vapor pressure data for total uncertainty and calculated deviation of the vapor pressure p at the minimum (T_{min}) and maximum (T_{max}) temperatures—Continued

Author(s)	Data points	Temp. range (K)	Pressure range (kPa)	T_{min}/T_{max} Uncertainty $100\Delta p/p$	T_{min}/T_{max} Calculated $100(1-p_{calc}/p_{expt})$
Weber (1989)	3	298–302	3567–3885	0.097	0.071/0.20
CF_4					
Menzel and Mohry (1933)	19	93–146	0.2–106		4.0/−0.3
Kubic and Stein (1981)	3	199–222	1544–3192		0.31/0.61
Simon *et al.* (1967)	48	90–146	0.112–105	2.3/0.01	2.6/−0.16
Smith and Pace (1969)	11	115–146	7–106	0.077/0.056	7.3/0.09
Varshni and Mohan (1954)	1	145.013	101.325		0.74
CF_3I					
Duan *et al.* (1996)	64	243–393	72–3736	0.42/0.02	0.18/0.10
Nodiff *et al.* (1953)	1	250.655	101.325		2.7
$CHBr_3$					
Boublik and Aim (1972)	15	320–412	2–77	0.15/0.01	−0.13/0.12
Ivin and Dainton (1947)	1	422.985	101.325		−1.7
Morgan and Yager (1940)	1	423.535	101.325		−3.2
Philippe *et al.* (1973)	1	298.144	0.779		5.0
Varshni and Mohan (1954)	1	422.485	101.325		−0.45
$CHCl_3$					
Boublik and Aim (1972)	15	262–333	4.5–98	0.15/0.01	0.42/−0.40
Campbell and Chatterjee (1968)	23	374–533	328–5187	0.3/0.3	1.1/5.8
Findlay and Kenyon (1969)	2	323–336	69–109		−0.22/−0.59
Gross and Saylor (1931)	1	334.20	101.325		0.027
Handa *et al.* (1975)	1	283.138	13.26		0.38
Hudson and van Winkle (1969)	1	334.325	101.325	0.052	−0.38
McGlashan and Rastogi (1958)	1	323.127	69.358	0.056	−0.058
Morgan and Yager (1940)	1	334.325	101.325		−0.38
Philippe *et al.* (1971)	5	293–328	21–82		0.23/−0.21
Phillips and Murphy (1970)	1	334.334	101.325	0.007	−0.41
Scatchard and Raymond (1938)	6	308–333	39–97	0.063/0.051	−0.45/−0.44
Thorpe and Rodger (1897)	1	334.6	102.725		
Varshni and Mohan (1954)	1	332.98	101.325		4.0
Willock and van Winkle (1970)	1	334.365	101.325	0.029	−0.52
$CHCl_2F$					
Benning and McHarness (1940)	7	243–448	17–4894	0.3/0.3	−0.69/0.17
Benning and McHarness (1939)	1	282.044	101.325		−0.098
Phillips and Murphy (1970)	1	282.044	101.325		−0.098
$CHClF_2$					
Benning and McHarness (1939)	1	232.358	101.325		−0.059
Benning and McHarness (1940)	6	212–366	3.5–4652	0.3/0.3	0.7/−0.7
Blanke and Weiss (1992)	18	140–248	0.042–202	11.9/0.016	−0.77/0.03
Booth and Bixby (1932)	1	233.358	101.325		
Booth and Swinehart (1935)	19	296–369	951–4881	0.10/0.03	−2.8/−2.2
Giuliani *et al.* (1995)	24	245–328	180–2195	0.20/0.05	0.099/0.2
Goodwin *et al.* (1992)	26	217–248	47–204	0.048/0.030	−0.13/0.003
Handel *et al.* (1992)	68	180–340	4–2807	0.1/0.1	0.22/0.077
Hongo *et al.* (1990)	21	298–369	1044–4970	0.098/0.026	0.01/0.072
Kohlen *et al.* (1985)	39	313–368	1516–4923	0.022/0.019	0.17/0.028
Neilson and White (1957)	1	232.50	101.325		−0.73
Phillips and Murphy (1970)	1	232.358	101.325		−0.059
CHF_3					
Henne (1937)	1	190.963	101.325		0.39
Hori *et al.* (1981)	35	244–298	1055–4714	0.238/0.056	0.15/−0.01
Hou and Martin (1959)	47	141–298	2–4739		0.80/0.45
Phillips and Murphy (1970)	1	191.063	101.325		−0.19
Popowicz *et al.* (1982)	294	126–212	0.21–298		3.1/−0.73
Stein and Proust (1971)	4	200–273	164–2498	0.088/0.044	−0.064/0.19
Valentine *et al.* (1962)	13	145–191	3–102	0.49/0.014	2.9/0.24
Varshni and Mohan (1954)	1	190.813	101.325		1.25
CH_2Br_2					
Gross and Saylor (1931)	1	370.3	101.325		−0.71
Morgan and Yager (1940)	1	370.924	101.325		−2.6
Philippe *et al.* (1973)	10	293–343	5–42	0.22/0.14	0.95/0.27

TABLE 3. Experimental vapor pressure data for total uncertainty and calculated deviation of the vapor pressure p at the minimum (T_{min}) and maximum (T_{max}) temperatures—Continued

Author(s)	Data points	Temp. range (K)	Pressure range (kPa)	T_{min}/T_{max} Uncertainty $100\Delta p/p$	T_{min}/T_{max} Calculated $100(1-p_{calc}/p_{expt})$
Varshni and Mohan (1954)	1	371.174	101.325		−0.33
CH_2BrCl					
Forbes and Anderson (1945)	1	341.12±0.5	101.325		−0.095
McDonald *et al.* (1959)	6	289–341	12–101.325		−0.04/−0.11
CH_2Cl_2					
Boublik and Aim (1972)	12	264–312	12–96	0.056/0.01	0.21/0.20
Handa *et al.* (1975)	1	283.148	30.596		0.09
Khurma *et al.* (1983)	30	298–398	58–1030	0.1/0.1	0.7/−0.1
Moelwyn-Hughes and Missen (1957)	1	312.949	101.325		0.067
Morgan and Yager (1940)	1	313.229	101.325		−0.94
Mueller and Ignatowski (1960)	4	303–313	70–102	0.011	0.29/0.22
Philippe *et al.* (1973)	8	293–308	47–85	0.16/0.14	0.24/0.01
Phillips and Murphy (1970)	1	313.240	101.325		−0.98
Varshni and Mohan (1954)	1	313.079	101.325		−0.40
Wong and Eckert (1969)	1	298.135	57.755	0.012	−0.09
CH_2ClF					
Phillips and Murphy (1970)	1	264.05	101.325		−0.083
Zellhoefer *et al.* (1938)	2	277–305	175–441		1.9/2.8
CH_2F_2					
Adams and Stein (1971)	4	222–283	105–1110	0.67/0.089	0.38/0.27
Defibaugh *et al.* (1994)	18	268–348	690–5409	0.005/0.003	−0.056/−0.059
de Vries (1997)	139	223–351	110–5769	0.037/0.014	−0.01/0.02
Fu *et al.* (1995)	60	233–351	177–5768	0.28/0.019	0.24/0.017
Holcomb *et al.* (1993)	25	295–348	1573–5463	0.31/0.18	0.57/−0.19
Kobayashi and Nishiumi (1998)	14	268–304	695–1980	0.15/0.15	0.49/0.39
Magee (1996)	7	270–330	733–3665	0.089/0.054	−0.089/−0.09
Malbrunot *et al.* (1968)	30	191–351	16–5828	0.17/0.01	−0.18/0.01
Phillips and Murphy (1970)	1	221.460	101.325		0.13
Sato *et al.* (1994)	21	320–351	2919–5783	0.07/0.04	0.01/−0.05
Varshni and Mohan (1954)	1	221.410	101.325		0.38
Weber and Goodwin (1993)	27	208–237	49–214	0.027/0.014	−0.16/0.01
Weber and Silva (1994)	17	236–266	200–650	0.034	−0.01/0.02
Widiatmo *et al.* (1994)	26	220–351	95–5784	2.1/0.067	1.1/0.061
CH_2I_2					
Gregory and Style (1936)	19	288–328	0.089–1		0.6/−4.0
CH_3Br					
Beersmans and Jungers (1947)	10	203–276	1.73–101	0.78/0.067	0.53/−0.37
Egan and Kemp (1938)	13	203–278	1.73–105	0.16/0.01	0.10/0.04
Varshni and Mohan (1954)	1	276.60	101.325		0.29
Williams and Meeker (1948)	1	276.77	101.325		−0.37
CH_3Cl					
Beersmans and Jungers (1947)	10	183–249	1.7–101.5	0.80/0.07	−3.7/−1.5
Holldorff and Knapp (1988)	29	253–322	124–1098	0.17/0.10	0.051/−0.25
Hsu and McKetta (1964)	24	303–416	662–6679	0.15/0.015	−0.75/−0.38
Mansoorian *et al.* (1981)	13	313–408	870–5905	0.023/0.017	−0.017/0.16
Messerly and Aston (1940)	15	175–248	0.8–101.325	0.47/0.18	0.04/0.05
Varshni and Mohan (1954)	1	248.805	101.325		0.71
CH_3F					
Biswas *et al.* (1989)	35	283–317	2656–5880	0.10/0.10	−0.75/0.01
Bominaar *et al.* (1987)	22	298–316	3844–5757	0.01/0.01	−0.02/0.08
Collie (1889)	11	268–313	1515–5399	10/3.7	−4/1.3
Demiriz *et al.* (1993)	28	253–314	1159–5492	0.027/0.021	0.05/−0.18
Fonseca and Lobo (1994)	3	161–195	10–105	0.048/0.01	1.8/−0.056
Grosse *et al.* (1940)	6	140–195	1–101.325	1.4/0.44	6.5/0.71
Michels and Wassenaar (1948)	34	163–288	10–3030	0.76/0.01	0.134/0.71
Oi *et al.* (1983)	118	132–213	0.49–251	0.2/0.01	1.3/−0.81
CH_3I					
Beersmans and Jungers (1947)	8	273–315	18–101.5	0.11/0.06	1.3/−1.3
Boublik and Aim (1972)	14	259–314	9–98	0.07/0.01	0.25/−0.32
Brown and Acree (1916)	1	315.479	101.325		0.010
Fahim and Moelwyn-Hughes (1956)	5	283–333	29–173	0.45/0.077	0.22/−3.7

TABLE 3. Experimental vapor pressure data for total uncertainty and calculated deviation of the vapor pressure p at the minimum (T_{min}) and maximum (T_{max}) temperatures—Continued

Author(s)	Data points	Temp. range (K)	Pressure range (kPa)	T_{min}/T_{max} Uncertainty $100\Delta p/p$	T_{min}/T_{max} Calculated $100(1-p_{calc}/p_{expt})$
Moelwyn-Hughes and Missen (1957)	1	315.629	101.325		−0.50
Smyth and McAlpine (1934)	1	315.729	101.325		−0.84
Thorpe and Rodger (1897)	1	315.6	101.325		−0.40
Wolff *et al.* (1976)	20	218–343	0.636–236		−1.8/−7.7
Wren and Vikis (1982)	88	206–226	0.252–1.25	2.8/2.1	−2.7/0.17

TABLE 4. Molar mass, critical parameters, acentric factor ω, aspherical factor θ, normal-boiling-point and triple-point temperatures of each halomethane

Formula	M (kg/kmol)	T_c (K)	p_c(kPa)	ρ_c (kg/ m^3)	ω	$10^3\ \theta$	T_f (K)	T_b (K)
CBr_2F_2	209.816	471.3	4450	850	0.180	0.0938	163.06	295.91
$CBrCl_3$	198.273	606	4980	690	0.190	0.0359	252.15	377.73
$CBrClF_2$	165.365	426.9	4220	700	0.177	0.0835	113.66	269.14
$CBrF_3$	148.910	340.2	3970	750	0.173	0.128	105.16	215.46
CCl_4	153.822	556.4	4550	558	0.193	0.338	250.33	350.00
CCl_3F	137.368	471.2	4408	560	0.187	0.196	162.05	296.76
CCl_2F_2	120.913	384.95	4100	560	0.178	0.180	115.16	243.42
$CClF_3$	104.459	301.9	3890	610	0.178	0.606	92.16	191.81
CF_4	88.005	227.5	3740	630	0.177	0.194	89.57	145.10
CF_3I	195.911	395.0	3860	860	0.180	0.495		251.34
$CHBr_3$	252.731	696.0	6200	950	0.190	0.0111	281.20	422.54
$CHCl_3$	119.377	536.4	5400	520	0.212	0.145	209.64	334.21
$CHCl_2F$	102.923	451.6	5183	525	0.208	0.382	138.16	282.01
$CHClF_2$	86.470	369.28	4988	525	0.221	0.501	115.74	232.35
CHF_3	70.014	298.9	4800	530	0.263	1.21	117.98	191.03
CH_2Br_2	173.835	610	6950	850	0.200	0.0952	220.61	370.07
CH_2BrCl	129.384	557	6670	690	0.218	0.397	185.21	341.09
CH_2Cl_2	84.932	510	6420	475	0.214	0.372	178.02	312.97
CH_2ClF	68.478	427	5700	450	0.210	2.09	138.01	264.03
CH_2F_2	52.024	351.26	5780	430	0.277	2.56	137.01	221.49
CH_2I_2	267.836	740	6800	1080	0.220	0.253	279.25	452.76
CH_3Br	94.939	464	6850	630	0.150	0.503	179.48	276.67
CH_3Cl	50.488	416.25	6710	365	0.153	0.476	175.44	248.97
CH_3F	34.033	317.42	5880	310	0.197	2.06	131.36	194.85
CH_3I	141.939	528	6700	810	0.150	0.509	206.71	315.48

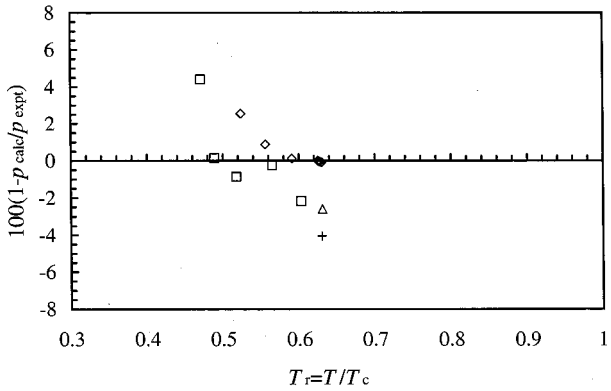

FIG. 1. Comparison of vapor-pressure data for CBr_2F_2 with values calculated from the extended corresponding-states principle: (△) Birchall and Haszeldine (1959); (□) Davidson (1951); (◇) McDonald *et al.* (1959); (+) Miller and Smyth (1957).

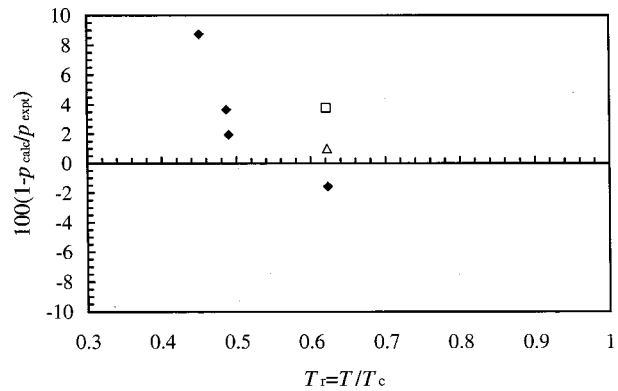

FIG. 2. Comparison of vapor-pressure data for $CBrCl_3$ with values calculated from the extended corresponding-states principle: (◆) Davison and Sullivan (1949); (□) Miller and Smyth (1957); (△) Varshni and Mohan (1954).

TABLE 5. The smoothed pressures, along with their first and second derivatives, as function of temperature for CBr_2F_2

T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)	T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)
163.06	7.9250E-03	1.090E-03	1.359E-04	318.15	209.60	6.312	0.1455
168.15	1.5609E-02	2.012E-03	2.337E-04	323.15	243.02	7.067	0.1565
173.15	2.9146E-02	3.527E-03	3.826E-04	328.15	280.36	7.877	0.1678
178.15	5.2400E-02	5.959E-03	6.045E-04	333.15	321.89	8.745	0.1793
183.15	9.0969E-02	9.734E-03	9.240E-04	338.15	367.90	9.670	0.1910
188.15	1.5290E-01	1.541E-02	1.370E-03	343.15	418.69	10.65	0.2029
193.15	2.4942E-01	2.370E-02	1.976E-03	348.15	474.55	11.70	0.2149
198.15	3.9576E-01	3.550E-02	2.778E-03	353.15	535.79	12.80	0.2271
203.15	6.1203E-01	5.187E-02	3.814E-03	358.15	602.70	13.97	0.2395
208.15	9.2423E-01	7.409E-02	5.123E-03	363.15	675.60	15.20	0.2521
213.15	1.3652	0.1036	6.746E-03	368.15	754.80	16.49	0.2649
218.15	1.9755	0.1421	8.720E-03	373.15	840.63	17.85	0.2780
223.15	2.8046	0.1915	1.108E-02	378.15	933.41	19.27	0.2913
228.15	3.9116	0.2537	1.386E-02	383.15	1033.5	20.76	0.3050
233.15	5.3662	0.3309	1.710E-02	388.15	1141.2	22.32	0.3191
238.15	7.2492	0.4254	2.080E-02	393.15	1256.8	23.96	0.3337
243.15	9.6532	0.5397	2.500E-02	398.15	1380.8	25.66	0.3489
248.15	12.683	0.6762	2.970E-02	403.15	1513.6	27.45	0.3648
253.15	16.457	0.8376	3.492E-02	408.15	1655.4	29.31	0.3814
258.15	21.105	1.026	4.066E-02	413.15	1806.8	31.26	0.3991
263.15	26.770	1.245	4.692E-02	418.15	1968.2	33.30	0.4179
268.15	33.610	1.496	5.368E-02	423.15	2140.0	35.44	0.4379
273.15	41.793	1.783	6.095E-02	428.15	2322.8	37.69	0.4595
278.15	51.500	2.107	6.870E-02	433.15	2517.1	40.04	0.4829
283.15	62.926	2.471	7.692E-02	438.15	2723.4	42.52	0.5083
288.15	76.276	2.877	8.558E-02	443.15	2942.5	45.13	0.5360
293.15	91.766	3.327	9.466E-02	448.15	3174.9	47.88	0.5663
295.91	101.325	3.596	9.985E-02	453.15	3421.5	50.80	0.5998
298.15	109.62	3.824	0.1041	458.15	3683.2	53.89	0.6368
303.15	130.09	4.369	0.1140	463.15	3960.7	57.17	0.6780
308.15	153.40	4.964	0.1242	468.15	4255.2	60.67	0.7247
313.15	179.82	5.611	0.1347	471.30	4450.0	63.01	0.7585

TABLE 6. The smoothed pressures, along with their first and second derivatives, as function of temperature for $CBrCl_3$

T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)	T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)
252.15	0.32679	2.373E-02	1.509E-03	428.15	350.69	7.494	0.1211
253.15	0.35129	2.528E-02	1.592E-03	433.15	389.70	8.115	0.1273
258.15	0.49945	3.438E-02	2.062E-03	438.15	431.89	8.767	0.1336
263.15	0.69937	4.607E-02	2.632E-03	443.15	477.42	9.451	0.1400
268.15	0.96533	6.089E-02	3.317E-03	448.15	526.45	10.17	0.1465
273.15	1.3145	7.945E-02	4.128E-03	453.15	579.15	10.92	0.1530
278.15	1.7671	1.024E-01	5.080E-03	458.15	635.67	11.70	0.1596
283.15	2.3471	1.305E-01	6.182E-03	463.15	696.18	12.51	0.1663
288.15	3.0819	1.645E-01	7.449E-03	468.15	760.85	13.36	0.1731
293.15	4.0034	2.053E-01	8.889E-03	473.15	829.85	14.24	0.1800
298.15	5.1474	2.537E-01	1.051E-02	478.15	903.35	15.16	0.1870
303.15	6.5546	3.107E-01	1.233E-02	483.15	981.52	16.11	0.1941
308.15	8.2705	3.773E-01	1.434E-02	488.15	1064.5	17.10	0.2013
313.15	10.345	4.545E-01	1.657E-02	493.15	1152.6	18.13	0.2087
318.15	12.835	5.433E-01	1.900E-02	498.15	1245.9	19.19	0.2162
323.15	15.800	6.448E-01	2.164E-02	503.15	1344.6	20.29	0.2240
328.15	19.306	7.601E-01	2.450E-02	508.15	1448.8	21.43	0.2320
333.15	23.426	8.902E-01	2.758E-02	513.15	1558.9	22.61	0.2402
338.15	28.235	1.036	3.088E-02	518.15	1675.0	23.83	0.2488
343.15	33.817	1.199	3.439E-02	523.15	1797.3	25.10	0.2576
348.15	40.259	1.381	3.811E-02	528.15	1926.1	26.41	0.2669
353.15	47.654	1.581	4.203E-02	533.15	2061.5	27.77	0.2766
358.15	56.100	1.801	4.617E-02	538.15	2203.8	29.18	0.2868
363.15	65.701	2.043	5.049E-02	543.15	2353.3	30.64	0.2976
368.15	76.564	2.306	5.501E-02	548.15	2510.3	32.15	0.3089
373.15	88.804	2.593	5.971E-02	553.15	2675.0	33.73	0.3210
377.73	101.32	2.877	6.417E-02	558.15	2847.7	35.36	0.3338
378.15	102.54	2.904	6.459E-02	563.15	3028.7	37.07	0.3476
383.15	117.88	3.239	6.963E-02	568.15	3218.5	38.84	0.3622
388.15	134.97	3.600	7.483E-02	573.15	3417.3	40.69	0.3780
393.15	153.93	3.988	8.018E-02	578.15	3625.5	42.62	0.3950
398.15	174.90	4.402	8.567E-02	583.15	3843.7	44.64	0.4133
403.15	198.00	4.845	9.129E-02	588.15	4072.1	46.76	0.4331
408.15	223.39	5.316	9.704E-02	593.15	4311.4	48.98	0.4547
413.15	251.21	5.815	1.029E-01	598.15	4562.1	51.31	0.4783
418.15	281.59	6.345	1.089E-01	603.15	4824.7	53.76	0.5044
423.15	314.70	6.904	1.149E-01	606.00	4980.0	55.23	0.5213

critical state, which are effected by the dipole and quadrupole moments. The extended corresponding-states parameter θ reflects the physical behavior displayed by the dipole and quadrupole moments. The extended corresponding-states parameter measures the behavior of the deviation of a highly nonspherical molecule from that of the spherical molecule argon, as the similar definition of the acentric factor. The relation between the critical compression factor and acentric factor $Z_c = 0.29 - 0.08\omega$ [Pitzer *et al.* (1955)], is only approximate for nonpolar substances and cannot be applicable to highly nonspherical substances. It should be noted that the extended corresponding-states parameter θ is independent for a real molecule, which significantly improves to reflect the behavior of polar substances. It may be deduced that the extended corresponding-states principle corresponds to adding a quadratic term $0.0064\omega^2$ to the theory of Pitzer *et al.* for normal fluids.

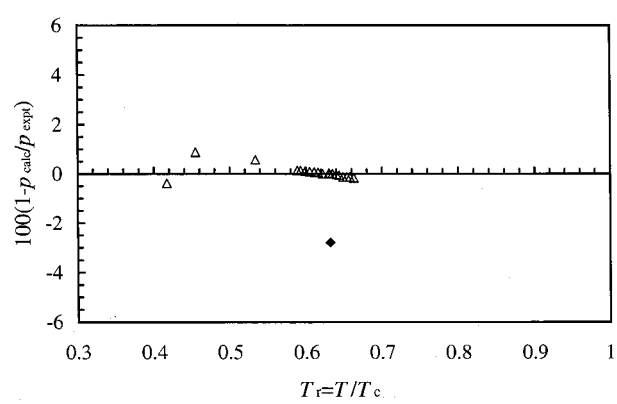

FIG. 3. Comparison of vapor-pressure data for $CBrClF_2$ with values calculated from the extended corresponding-states principle: (△) Glew (1960); (◆) Miller and Smyth (1957).

TABLE 7. The smoothed pressures, along with their first and second derivatives, as function of temperature for $CBrClF_2$

T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)	T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)
113.66	9.6347E-06	2.446E-06	5.811E-07	273.15	118.03	4.415	0.1284
118.15	2.8929E-05	6.832E-06	1.505E-06	278.15	141.77	5.089	0.1413
123.15	9.0028E-05	1.965E-05	3.981E-06	283.15	169.04	5.829	0.1546
128.15	2.5725E-04	5.196E-05	9.697E-06	288.15	200.17	6.636	0.1683
133.15	6.8019E-04	1.273E-04	2.192E-05	293.15	235.51	7.512	0.1823
138.15	1.6760E-03	2.912E-04	4.628E-05	298.15	275.41	8.460	0.1967
143.15	3.8724E-03	6.252E-04	9.186E-05	303.15	320.23	9.480	0.2114
148.15	8.4374E-03	1.268E-03	1.724E-04	308.15	370.33	10.57	0.2263
153.15	1.7425E-02	2.439E-03	3.074E-04	313.15	426.10	11.74	0.2415
158.15	3.4264E-02	4.476E-03	5.232E-04	318.15	487.89	12.99	0.2569
163.15	6.4422E-02	7.862E-03	8.536E-04	323.15	556.12	14.31	0.2726
168.15	0.1162	1.327E-02	1.340E-03	328.15	631.15	15.72	0.2885
173.15	0.2020	2.160E-02	2.030E-03	333.15	713.40	17.20	0.3047
178.15	0.3390	3.400E-02	2.979E-03	338.15	803.27	18.76	0.3212
183.15	0.5512	5.191E-02	4.244E-03	343.15	901.16	20.41	0.3382
188.15	0.8702	7.708E-02	5.888E-03	348.15	1007.5	22.15	0.3556
193.15	1.3374	0.1115	7.971E-03	353.15	1122.8	23.97	0.3737
198.15	2.0049	0.1576	1.055E-02	358.15	1247.4	25.88	0.3925
203.15	2.9373	0.2180	1.369E-02	363.15	1381.8	27.89	0.4121
208.15	4.2132	0.2955	1.743E-02	368.15	1526.5	30.01	0.4329
213.15	5.9261	0.3933	2.181E-02	373.15	1682.0	32.23	0.4549
218.15	8.1855	0.5147	2.687E-02	378.15	1848.9	34.56	0.4784
223.15	11.118	0.6632	3.264E-02	383.15	2027.8	37.01	0.5037
228.15	14.868	0.8423	3.912E-02	388.15	2219.2	39.60	0.5311
233.15	19.598	1.056	4.633E-02	393.15	2424.0	42.33	0.5610
238.15	25.487	1.307	5.427E-02	398.15	2642.8	45.21	0.5938
243.15	32.735	1.599	6.292E-02	403.15	2876.4	48.27	0.6300
248.15	41.557	1.937	7.227E-02	408.15	3125.8	51.52	0.6701
253.15	52.187	2.323	8.229E-02	413.15	3392.0	54.98	0.7149
258.15	64.876	2.761	9.295E-02	418.15	3676.0	58.68	0.7652
263.15	79.889	3.254	0.1042	423.15	3979.2	62.64	0.8224
268.15	97.510	3.804	0.1161	426.90	4220.0	65.82	0.8724
269.14	101.325	3.920	0.1185				

The extended corresponding-states principle for vapor pressure was developed as follows:

$$\ln p_r = \ln p_r^{(0)} + \omega \ln p_r^{(1)} + \theta \ln p_r^{(2)}, \tag{8}$$

where the acentric factor [Pitzer *et al.*, (1955)],

$$\omega = -1 - \log p_r|_{T_r=0.7}$$
$$= -1 - (a_0 + 0.3^{1.89} a_1 + 0.3^{5.67} a_2) \log 0.7, \tag{9}$$

and the aspherical factor [Xiang (1998), (2000), (2001a), (2001b), (2001c)]

$$\theta = (Z_c - 0.29)^2 \tag{10}$$

are corresponding-states parameters, here $Z_c = p_c / R\rho_c T_c$ is the critical compression factor and $R = 8.314\,51$ J/(mol K) is the universal gas constant recommended by Cohen and Tayler (1988).

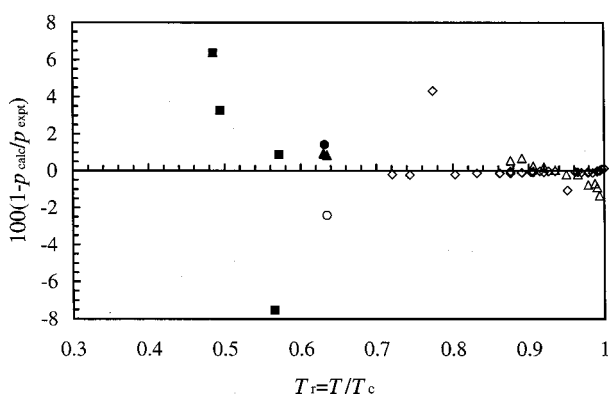

FIG. 4. Comparison of vapor-pressure data for $CBrF_3$ with values calculated from the extended corresponding-states principle: (■) Davidson (1951); (●) Haszeldine (1951); (△) Hongo *et al.* (1990); (▲) McDonald *et al.* (1959); (○) Miller and Smyth (1957); (◇) Okano *et al.* (1987).

TABLE 8. The smoothed pressures, along with their first and second derivatives, as function of temperature for $CBrF_3$

T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)	T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)
105.16	5.6626E-04	1.342E-04	2.928E-05	228.15	178.96	7.519	0.2420
108.15	1.1281E-03	2.528E-04	5.192E-05	233.15	219.69	8.793	0.2678
113.15	3.2888E-03	6.719E-04	1.250E-04	238.15	267.11	10.20	0.2944
118.15	8.7334E-03	1.630E-03	2.752E-04	243.15	321.90	11.74	0.3216
123.15	2.1336E-02	3.647E-03	5.597E-04	215.46	101.32	4.844	0.1806
128.15	4.8379E-02	7.586E-03	1.061E-03	248.15	384.73	13.42	0.3494
133.15	1.0261E-01	1.479E-02	1.887E-03	253.15	456.30	15.23	0.3778
138.15	2.0498E-01	2.723E-02	3.175E-03	258.15	537.31	17.20	0.4067
143.15	3.8801E-01	4.757E-02	5.082E-03	263.15	628.49	19.30	0.4363
148.15	6.9974E-01	7.936E-02	7.780E-03	268.15	730.58	21.56	0.4665
153.15	1.2080	1.270E-01	1.145E-02	273.15	844.33	23.97	0.4977
158.15	2.0048	1.957E-01	1.626E-02	278.15	970.53	26.54	0.5299
163.15	3.2107	2.917E-01	2.237E-02	283.15	1110.0	29.27	0.5636
168.15	4.9787	4.218E-01	2.991E-02	288.15	1263.5	32.18	0.5992
173.15	7.4978	5.934E-01	3.901E-02	293.15	1432.1	35.27	0.6371
178.15	10.995	8.146E-01	4.973E-02	298.15	1616.5	38.55	0.6779
183.15	15.740	1.093	6.211E-02	303.15	1817.9	42.05	0.7223
188.15	22.040	1.438	7.618E-02	308.15	2037.4	45.78	0.7712
193.15	30.249	1.858	9.190E-02	313.15	2276.2	49.77	0.8256
198.15	40.758	2.360	1.092E-01	318.15	2535.6	54.05	0.8867
203.15	54.002	2.953	1.281E-01	323.15	2817.3	58.65	0.9558
208.15	70.452	3.644	1.485E-01	328.15	3122.8	63.62	1.0350
213.15	90.616	4.440	1.701E-01	333.15	3454.2	69.02	1.1260
218.15	115.04	5.347	1.930E-01	338.15	3813.8	74.91	1.2330
223.15	144.28	6.372	2.170E-01	340.20	3970.0	77.49	1.2850

To predict the vapor pressure from the corresponding-states principle, the proper reference equation must be selected which is valid from the triple point to the critical point. Equation (1) fulfills this requirement in that it can be used effectively to correlate and extrapolate the vapor-pressure behavior of simple, nonpolar, polar, hydrogen-bonding, and associating compounds. Therefore, the corresponding-states method can be used to represent the entire range vapor pressure as

$$\ln p_r^{(0)} = (a_{00} + a_{10}\tau^{n_1} + a_{20}\tau^{n_2}) \ln T_r,$$
$$\ln p_r^{(1)} = (a_{01} + a_{11}\tau^{n_1} + a_{21}\tau^{n_2}) \ln T_r, \qquad (11)$$
$$\ln p_r^{(2)} = (a_{02} + a_{12}\tau^{n_1} + a_{22}\tau^{n_2}) \ln T_r.$$

The general coefficients a_{ij} of Eq. (11), given in Table 1, were found from fitting the vapor-pressure data for argon, the weakly nonspherical molecules ethane, propane, difluoromethane, 1,1,1,2-tetrafluoroethane, 1,1-difluoroethane, and the highly nonspherical molecule water. The coefficients are

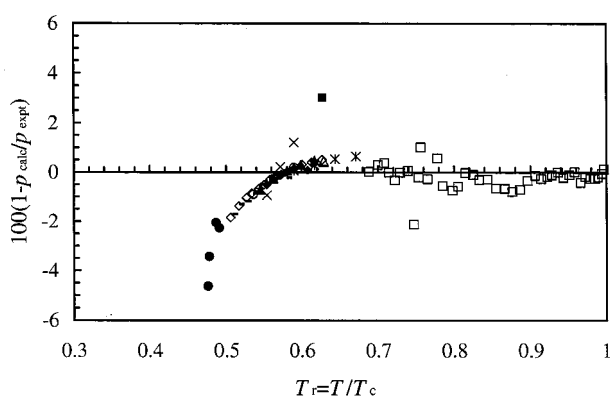

FIG. 5. Comparison of vapor-pressure data for CCl_4 with values calculated from the extended corresponding-states principle: (◇) Boublik and Aim (1972); (□) Campbell and Chatterjee (1969); (△) Ivin and Dainton (1947); (×) Jain *et al.* (1971); (*) Liu *et al.* (1981); (○) McGlashan *et al.* (1954); (+) Mueller and Ignatowski (1960); (−) Perez *et al.* (1994); (●) Rastogi *et al.* (1967); (▲) Scatchard *et al.* (1939); (◆) Wang *et al.* (1970).

TABLE 9. The smoothed pressures, along with their first and second derivatives, as function of temperature for CCl_4

T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)	T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)
250.33	1.1702	7.700E-02	4.359E-03	403.15	399.53	8.803	0.1458
253.15	1.4055	9.013E-02	4.958E-03	408.15	445.40	9.551	0.1534
258.15	1.9229	0.1179	6.168E-03	413.15	495.11	10.34	0.1612
263.15	2.5950	0.1521	7.580E-03	418.15	548.84	11.16	0.1690
268.15	3.4570	0.1940	9.208E-03	423.15	606.80	12.03	0.1769
273.15	4.5497	0.2446	1.107E-02	428.15	669.18	12.93	0.1850
278.15	5.9196	0.3051	1.317E-02	433.15	736.19	13.88	0.1932
283.15	7.6193	0.3767	1.553E-02	438.15	808.03	14.86	0.2015
288.15	9.7078	0.4608	1.815E-02	443.15	884.90	15.89	0.2100
293.15	12.250	0.5587	2.104E-02	448.15	967.03	16.96	0.2186
298.15	15.320	0.6716	2.420E-02	453.15	1054.6	18.08	0.2274
303.15	18.994	0.8011	2.764E-02	458.15	1147.9	19.24	0.2365
308.15	23.361	0.9485	3.136E-02	463.15	1247.1	20.44	0.2459
313.15	28.512	1.115	3.535E-02	468.15	1352.4	21.70	0.2555
318.15	34.547	1.303	3.962E-02	473.15	1464.1	23.00	0.2655
323.15	41.573	1.512	4.416E-02	478.15	1582.5	24.35	0.2760
328.15	49.704	1.745	4.897E-02	483.15	1707.8	25.76	0.2869
333.15	59.060	2.002	5.402E-02	488.15	1840.2	27.22	0.2983
338.15	69.767	2.285	5.933E-02	493.15	1980.1	28.75	0.3104
343.15	81.958	2.596	6.488E-02	498.15	2127.8	30.33	0.3231
348.15	95.771	2.934	7.065E-02	503.15	2283.5	31.98	0.3367
350.00	101.325	3.067	7.284E-02	508.15	2447.7	33.70	0.3512
353.15	111.35	3.302	7.664E-02	513.15	2620.6	35.49	0.3666
358.15	128.85	3.701	8.283E-02	518.15	2802.7	37.37	0.3832
363.15	148.41	4.131	8.921E-02	523.15	2994.4	39.33	0.4011
368.15	170.21	4.594	9.578E-02	528.15	3196.1	41.38	0.4205
373.15	194.40	5.089	0.1025	533.15	3408.4	43.53	0.4414
378.15	221.16	5.619	0.1094	538.15	3631.6	45.80	0.4642
383.15	250.65	6.183	0.1164	543.15	3866.5	48.18	0.4892
388.15	283.05	6.783	0.1236	548.15	4113.6	50.69	0.5166
393.15	318.55	7.420	0.1309	553.15	4373.7	53.35	0.5471
398.15	357.31	8.093	0.1383	556.40	4550.0	55.16	0.5697

independent of the specific substance and are expected to be universal for all classes of molecules [Xiang (1998), (2001a), (2001b)].

3. Experimental Vapor-Pressure Data from the Literature

The sources for the vapor pressure measurements for halomethanes are given in Tables 2 and 3 together with the experimental techniques and the precision and accuracy cited for that technique by the authors. All literature data were converted to ITS-90, the temperature scale used throughout this work. Table 3 lists the number of data points, the minimum and maximum measured temperature and pressure, and the estimated uncertainties in the measurements at the minimum and maximum temperatures. The total uncertainties

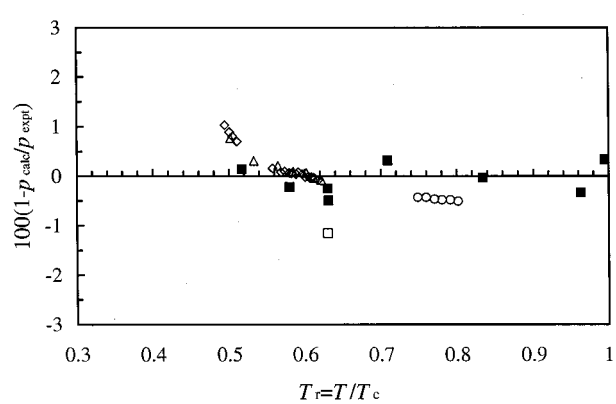

FIG. 6. Comparison of vapor-pressure data for CCl_3F with values calculated from the extended corresponding-states principle: (■) Benning and McHarness (1940); (◇) Fernandez-Fassnacht and del Rio (1985); (△) Osborne *et al.* (1941); (○) Yurttas *et al.* (1990); (□) Varshni and Mohan (1954).

TABLE 10. The smoothed pressures, along with their first and second derivatives, as function of temperature for CCl_3F

T(K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)	T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)
162.05	6.2629E-03	8.792E-04	1.120E-04	318.15	204.26	6.189	0.1437
163.15	7.3007E-03	1.010E-03	1.268E-04	323.15	237.05	6.935	0.1548
168.15	1.4270E-02	1.852E-03	2.168E-04	328.15	273.71	7.737	0.1661
173.15	2.6762E-02	3.261E-03	3.566E-04	333.15	314.51	8.596	0.1776
178.15	4.8313E-02	5.533E-03	5.656E-04	338.15	359.76	9.513	0.1893
183.15	8.4198E-02	9.072E-03	8.679E-04	343.15	409.75	10.49	0.2012
188.15	0.1420	1.441E-02	1.292E-03	348.15	464.76	11.53	0.2133
193.15	0.2325	2.225E-02	1.869E-03	353.15	525.11	12.62	0.2256
198.15	0.3701	3.342E-02	2.636E-03	358.15	591.10	13.78	0.2381
203.15	0.5740	4.898E-02	3.630E-03	363.15	663.04	15.00	0.2508
208.15	0.8692	7.016E-02	4.890E-03	368.15	741.26	16.29	0.2637
213.15	1.2874	9.839E-02	6.455E-03	373.15	826.06	17.64	0.2768
218.15	1.8676	0.1353	8.365E-03	378.15	917.79	19.06	0.2903
223.15	2.6577	0.1827	1.066E-02	383.15	1016.8	20.55	0.3041
228.15	3.7151	0.2425	1.336E-02	388.15	1123.4	22.10	0.3183
233.15	5.1074	0.3170	1.651E-02	393.15	1237.9	23.73	0.3330
238.15	6.9134	0.4084	2.013E-02	398.15	1360.8	25.43	0.3484
243.15	9.2235	0.5191	2.423E-02	403.15	1492.4	27.21	0.3644
248.15	12.141	0.6516	2.885E-02	408.15	1633.1	29.08	0.3812
253.15	15.780	0.8084	3.397E-02	413.15	1783.3	31.03	0.3990
258.15	20.269	0.9922	3.962E-02	418.15	1943.5	33.07	0.4180
263.15	25.751	1.2050	4.578E-02	423.15	2114.2	35.21	0.4383
268.15	32.377	1.4510	5.246E-02	428.15	2295.8	37.46	0.4601
273.15	40.316	1.7310	5.964E-02	433.15	2488.9	39.81	0.4837
278.15	49.748	2.0480	6.731E-02	438.15	2694.1	42.30	0.5093
283.15	60.863	2.4050	7.546E-02	443.15	2912.1	44.91	0.5372
288.15	73.865	2.8030	8.405E-02	448.15	3143.5	47.67	0.5679
293.15	88.970	3.2460	9.308E-02	453.15	3389.1	50.59	0.6017
296.76	101.33	3.5950	9.986E-02	458.15	3649.7	53.69	0.6390
298.15	106.40	3.7350	0.1025	463.15	3926.3	56.99	0.6807
303.15	126.40	4.2720	0.1123	468.15	4220.0	60.51	0.7278
308.15	149.20	4.8590	0.1225	471.20	4408.0	62.78	0.7609
313.15	175.07	5.4970	0.1330				

(Δp) in the vapor pressure at both the minimum and maximum measured temperatures for each set of measurements, were determined from

$$\Delta p=[(\Delta p/p)^2+(\Delta T/p)^2(dp/dT)^2]^{0.5}p, \qquad (12)$$

where Δp and ΔT are the experimental pressure and temperature uncertainties listed in Table 2. The vapor pressure p and the first derivative dp/dT are obtained using Eqs. (4) and (11). The uncertainties at the minimum and maximum temperatures generally correspond to the minimum and maximum uncertainties in p. The molar mass, critical parameters, corresponding-states parameters, normal-boiling-point and triple-point temperatures of each halomethane are listed in Table 4. The critical parameters and acentric factor for most substances basically come from Reid *et al.* (1987), Daubert and Danner (1989), and Smith and Srivastava (1986).

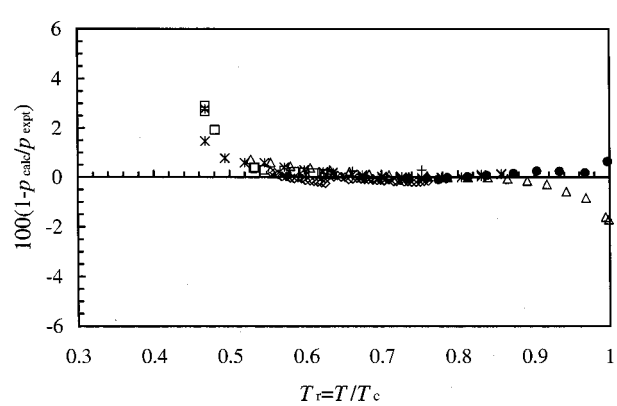

FIG. 7. Comparison of vapor-pressure data for CCl_2F_2 with values calculated from the extended corresponding-states principle: (□) Blanke and Weiss (1992); (◇) Fernandez-Fassnacht and del Rio (1985); (△) Gilkey *et al.* (1931); (◆) Gordon and McWilliam (1946); (*) Haendel *et al.* (1992); (●) Michels *et al.* (1966); (+) Mollerup and Fredenslund (1976).

TABLE 11. The smoothed pressures, along with their first and second derivatives, as function of temperature for CCl_2F_2

T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)	T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)
115.16	2.3275E-04	5.235E-05	1.088E-05	253.15	150.62	5.873	0.1767
118.15	4.4841E-04	9.588E-05	1.889E-05	258.15	182.27	6.801	0.1946
123.15	1.2507E-03	2.461E-04	4.436E-05	263.15	218.79	7.820	0.2131
128.15	3.2163E-03	5.832E-04	9.635E-05	268.15	260.63	8.933	0.2321
133.15	7.6871E-03	1.287E-03	1.951E-04	273.15	308.28	10.14	0.2515
138.15	1.7194E-02	2.662E-03	3.709E-04	278.15	362.22	11.45	0.2714
143.15	3.6220E-02	5.194E-03	6.659E-04	283.15	422.94	12.86	0.2916
148.15	7.2257E-02	9.612E-03	1.136E-03	288.15	490.95	14.37	0.3121
153.15	0.1372	1.696E-02	1.850E-03	293.15	566.77	15.98	0.3330
158.15	0.24906	2.865E-02	2.889E-03	298.15	650.91	17.70	0.3544
163.15	0.4340	4.654E-02	4.344E-03	303.15	743.91	19.52	0.3762
168.15	0.7286	7.294E-02	6.312E-03	308.15	846.32	21.46	0.3986
173.15	1.1823	0.1107	8.894E-03	313.15	958.70	23.51	0.4216
178.15	1.8598	0.1631	1.219E-02	318.15	1081.6	25.68	0.4456
183.15	2.8436	0.2339	1.628E-02	323.15	1215.7	27.97	0.4706
188.15	4.2362	0.3273	2.125E-02	328.15	1361.5	30.38	0.4969
193.15	6.1622	0.4480	2.718E-02	333.15	1519.7	32.94	0.5248
198.15	8.7697	0.6008	3.411E-02	338.15	1691.1	35.64	0.5547
203.15	12.232	0.7908	4.208E-02	343.15	1876.4	38.49	0.5870
208.15	16.749	1.0230	5.111E-02	348.15	2076.3	41.51	0.6221
213.15	22.545	1.3040	6.121E-02	353.15	2291.8	44.72	0.6607
218.15	29.875	1.6370	7.237E-02	358.15	2523.8	48.12	0.7033
223.15	39.015	2.0290	8.455E-02	363.15	2773.4	51.76	0.7508
228.15	50.271	2.4840	9.774E-02	368.15	3041.8	55.64	0.8040
233.15	63.973	3.0080	0.1119	373.15	3330.3	59.81	0.8640
238.15	80.474	3.6050	0.1269	378.15	3640.4	64.30	0.9325
243.15	100.15	4.2780	0.1428	383.15	3973.9	69.15	1.0120
243.42	101.325	4.3180	0.1436	384.95	4100.0	71.00	1.0450
248.15	123.39	5.0330	0.1594				

4. Comparisons and Results

4.1. Difluorodibromomethane (CBr_2F_2)

There is a large variation in the normal-boiling temperature values and no experimental details reported to evaluate the values. Davidson (1951) measured the vapor pressure data (20 to 480 mm Hg) with an accuracy of 0.2 K in temperature and 0.5 mm Hg in pressure. McDonald *et al.* (1959) reported pressures (between 90 and 780 mm Hg); the uncertainties of the temperatures and pressures are reported to a hundredth of a degree and 1 mm, respectively. The experimental data are compared with values calculated from the present method in Table 3 and Fig. 1. The smoothed pressures, along with their first and second derivatives, as a function of temperature in the range between the triple point and the critical point from the present method are presented in Table 5.

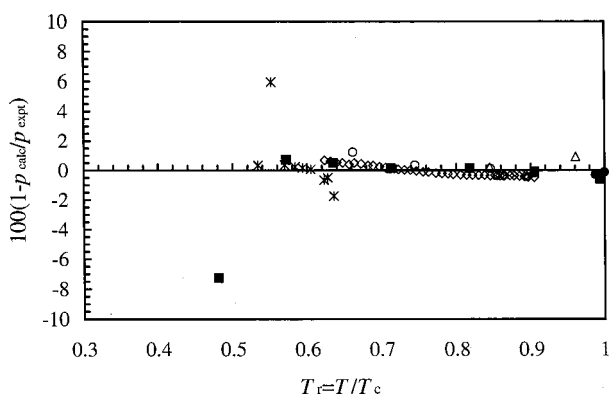

FIG. 8. Comparison of vapor-pressure data for $CClF_3$ with values calculated from the extended corresponding-states principle: (■) Albright and Martin (1952); (◇) Fernandez-Fassnacht and del Rio (1985); (△) Mollerup and Fredenslund (1976); (○) Stein and Proust (1971); (*) Thorton *et al.* (1953); (●) Weber (1989).

TABLE 12. The smoothed pressures, along with their first and second derivatives, as function of temperature for $CClF_3$

T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)	T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)
92.16	4.3974E-04	1.189E-04	2.962E-05	198.15	140.49	6.988	0.2687
93.15	5.7312E-04	1.517E-04	3.696E-05	203.15	178.94	8.419	0.3039
98.15	2.0136E-03	4.801E-04	1.045E-04	208.15	224.98	10.03	0.3405
103.15	6.2522E-03	1.346E-03	2.627E-04	213.15	279.54	11.83	0.3784
108.15	1.7415E-02	3.394E-03	5.950E-04	218.15	343.56	13.82	0.4174
113.15	4.4082E-02	7.800E-03	1.231E-03	223.15	418.02	16.00	0.4574
118.15	1.0253E-01	1.651E-02	2.352E-03	228.15	503.91	18.39	0.4983
123.15	2.2128E-01	3.252E-02	4.191E-03	233.15	602.27	20.99	0.5404
128.15	4.4687E-01	6.008E-02	7.023E-03	238.15	714.13	23.80	0.5836
133.15	8.5075E-01	1.049E-01	1.115E-02	243.15	840.59	26.83	0.6284
138.15	1.5367	1.743E-01	1.688E-02	248.15	982.77	30.08	0.6751
143.15	2.6488	2.769E-01	2.451E-02	253.15	1141.8	33.58	0.7244
148.15	4.3781	4.230E-01	3.430E-02	258.15	1319.0	37.33	0.7770
153.15	6.9699	6.239E-01	4.646E-02	263.15	1515.6	41.36	0.8339
158.15	10.729	8.918E-01	6.115E-02	268.15	1733.1	45.68	0.8963
163.15	16.022	1.240	7.846E-02	273.15	1973.0	50.33	0.9656
168.15	23.282	1.681	9.841E-02	278.15	2237.0	55.35	1.043
173.15	33.007	2.228	1.210E-01	283.15	2527.2	60.79	1.132
178.15	45.762	2.895	1.461E-01	288.15	2845.7	66.69	1.234
183.15	62.174	3.693	1.736E-01	293.15	3195.0	73.15	1.353
188.15	82.929	4.634	2.033E-01	298.15	3578.3	80.26	1.493
191.81	101.32	5.421	2.264E-01	301.90	3890.0	86.08	1.620
193.15	108.77	5.729	0.2351				

4.2. Trichlorobromomethane ($CBrCl_3$)

Only four vapor-pressure data points (between 11 and 745 mm Hg) are available from Davidson and Sullivan (1949). Normal-boiling point data are also available from Miller and Smyth (1957) and from Varshni and Mohan (1954). The experimental data are compared with values calculated from the present method in Table 3 and Fig. 2. The smoothed pressures, along with their first and second derivatives, as a function of temperature in the range between the triple point and the critical point from the present method are presented in Table 6.

4.3. Difluorochlorobromomethane ($CBrClF_2$)

Miller and Smyth (1957) reported a normal-boiling point temperature of 269.85 K. Accurate low-pressure data are available from Glew (1960) who used a 99.9 mole % sample and measured temperatures accurate to 3 mK. No high-pressure data are available for this compound. The experimental data are compared with values calculated from the present method in Table 3 and Fig. 3. The smoothed pressures, along with their first and second derivatives, as a function of temperature in the range between the triple point and the critical point from the present method are presented in Table 7.

4.4. Trifluorobromomethane ($CBrF_3$)

McDonald *et al.* (1959) measured vapor pressures for a 99.9 mole % sample and reported the result to one hundredth of a degree. Hence these values are selected as the best available data. The accurate high-pressure data from Hongo *et al.* (1990) and Okano *et al.* (1987) are in very good agreement

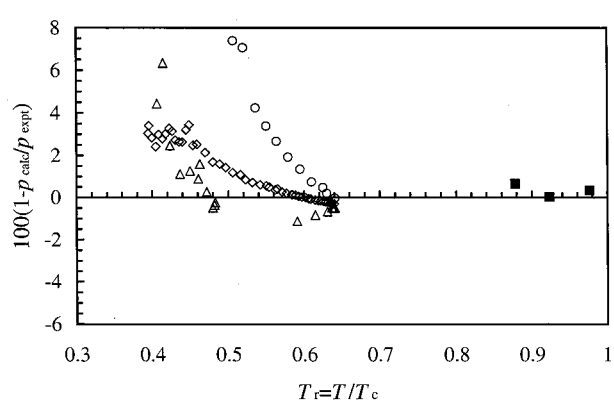

FIG. 9. Comparison of vapor-pressure data for CF_4 with values calculated from the extended corresponding-states principle: (■) Kubic and Stein (1981); (△) Menzel and Mohry (1933); (◇) Simon *et al.* (1967); (○) Smith and Pace (1969).

TABLE 13. The smoothed pressures, along with their first and second derivatives, as function of temperature for CF_4

T(K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)	T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)
89.57	1.0408E-01	2.224E-02	4.200E-03	158.15	233.89	13.61	0.6008
93.15	2.1645E-01	4.237E-02	7.274E-03	163.15	309.81	16.83	0.6869
98.15	5.4468E-01	9.474E-02	1.428E-02	168.15	402.91	20.49	0.7759
103.15	1.2389	1.924E-01	2.558E-02	173.15	515.42	24.59	0.8676
108.15	2.5842	3.597E-01	4.238E-02	178.15	649.62	29.17	0.9624
113.15	5.0026	6.271E-01	6.575E-02	183.15	807.89	34.22	1.061
118.15	9.080	1.029	9.647E-02	188.15	992.70	39.79	1.166
123.15	15.586	1.605	1.350E-01	193.15	1206.7	45.89	1.278
128.15	25.483	2.393	1.815E-01	198.15	1452.6	52.59	1.402
133.15	39.934	3.433	2.357E-01	203.15	1733.6	59.94	1.542
138.15	60.294	4.762	2.972E-01	208.15	2053.3	68.04	1.704
143.15	88.099	6.416	3.653E-01	213.15	2415.5	77.03	1.895
145.10	101.32	7.156	3.935E-01	218.15	2825.3	87.06	2.126
148.15	125.05	8.425	4.392E-01	223.15	3288.3	98.38	2.411
153.15	172.99	10.82	5.180E-01	227.50	3740.0	109.5	2.726

with the present results as shown in Table 3 and Fig. 4. The smoothed pressures, along with their first and second derivatives, as function of temperature in the range between the triple point and the critical point from the present method are presented in Table 8.

4.5. Tetrachloromethane (CCl_4)

Only one data set in the high-temperature range is available from Campbell and Chatterjee (1969). The experimental data in the low temperature range are from Boublik and Aim (1972). Both sets of data are in agreement with the present method in Table 3 and Fig. 5. The smoothed pressures, along with their first and second derivatives, as function of temperature in the range between the triple point and the critical point from the present method are presented in Table 9.

4.6. Fluorotrichloromethane (CCl_3F)

Benning and McHarness (1939) used a static method with a pure sample to measure the normal-boiling-point temperature 296.84 K. Benning and McHarness (1940) later measured, using an isoteniscope on a carefully purified sample up to the critical point, the normal-boiling point temperature of 296.91 K. Osborne *et al.* (1941) reported accurate low-pressure data on a sample containing impurities of about 0.05 mole %. Varshni and Mohan (1954) reported a normal-boiling point temperature of 297.05 K. The low-pressure data obtained by Benning and McHarness (1940), by Osborne *et al.* (1941), and by Fernandez-Fassnacht and del Rio (1985) are in quite good agreement with one another, while the high-pressure data of Benning and McHarness (1939) are in agreement with that of Yurttas *et al.* (1990). These experimental results agree well with the present model in Table 3

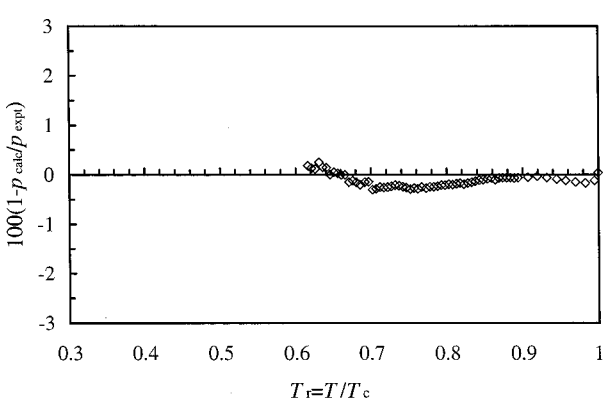

FIG. 10. Comparison of vapor-pressure data for CF_3I with values calculated from the extended corresponding-states principle: (◇) Duan *et al.* (1996).

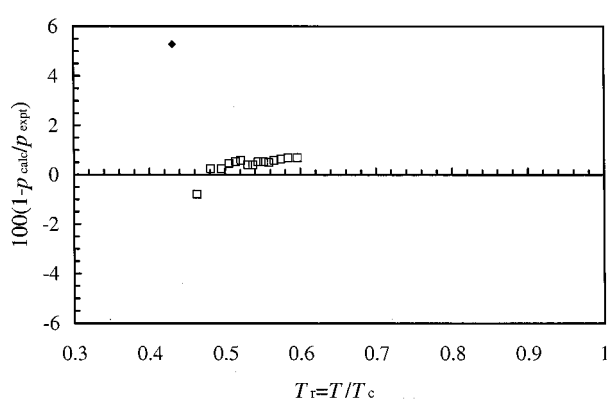

FIG. 11. Comparison of vapor-pressure data for $CHBr_3$ with values calculated from the extended corresponding-states principle: (□) Boublik and Aim (1972); (◆) Philippe *et al.* (1973).

TABLE 14. The smoothed pressures, along with their first and second derivatives, as function of temperature for CF_3I

T(K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)	T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)
198.15	5.8098	0.4100	2.415E-02	298.15	493.58	13.83	0.2879
203.15	8.1855	0.5453	3.012E-02	303.15	566.42	15.32	0.3065
208.15	11.316	0.7127	3.697E-02	308.15	646.93	16.90	0.3254
213.15	15.373	0.9165	4.472E-02	313.15	735.57	18.57	0.3448
218.15	20.550	1.161	5.336E-02	318.15	832.84	20.35	0.3648
223.15	27.062	1.452	6.291E-02	323.15	939.22	22.22	0.3854
228.15	35.149	1.792	7.333E-02	328.15	1055.2	24.20	0.4068
233.15	45.072	2.186	8.461E-02	333.15	1181.4	26.29	0.4292
238.15	57.111	2.639	9.671E-02	338.15	1318.4	28.50	0.4529
243.15	71.570	3.155	1.096E-01	343.15	1466.6	30.82	0.4780
248.15	88.769	3.736	1.232E-01	348.15	1626.8	33.28	0.5048
251.34	101.32	4.144	1.322E-01	353.15	1799.7	35.88	0.5338
253.15	109.05	4.388	1.375E-01	358.15	1985.8	38.62	0.5654
258.15	132.77	5.112	1.524E-01	363.15	2186.2	41.53	0.5999
263.15	160.30	5.912	1.678E-01	368.15	2401.5	44.63	0.6380
268.15	192.02	6.791	1.838E-01	373.15	2632.8	47.92	0.6803
273.15	228.34	7.751	2.002E-01	378.15	2881.1	51.44	0.7276
278.15	269.67	8.794	2.170E-01	383.15	3147.6	55.21	0.7807
283.15	316.42	9.922	2.342E-01	388.15	3433.6	59.26	0.8411
288.15	369.03	11.14	2.518E-01	393.15	3740.7	63.63	0.9108
293.15	427.93	12.44	2.697E-01	395.00	3860.0	65.35	0.9408

and Fig. 6. The smoothed pressures, along with their first and second derivatives, as a function of temperature in the range between the triple point and the critical point from the present method are presented in Table 10.

4.7. Difluorodichloromethane (CCl_2F_2)

Gilkey *et al.* (1931) measured the vapor pressure from 90 mm Hg up to the critical point using a static method and a purified sample. They did not report the experimental data but gave a vapor-pressure equation, which accurately represented their data. The uncertainty of their measurements was 0.5% in temperature and pressure, which seems to be very large in the high-temperature range. Michels *et al.* (1966) used a 99.95 mole % sample and reported accurate high-pressure data, which is found to be in good agreement with the data obtained by Haendel *et al.* (1992), which is probably the most accurate. In the low-pressure range, the experimental data obtained by Blanke and Weiss (1992), Fernandez-Fassnacht and del Rio (1985), and Haendel *et al.* (1992) are in agreement with the values calculated from the present

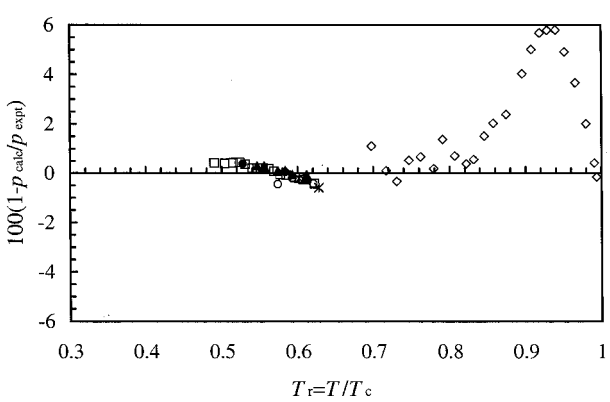

FIG. 12. Comparison of vapor-pressure data for $CHCl_3$ with values calculated from the extended corresponding-states principle: (□) Boublik and Aim (1972); (◇) Campbell and Chatterjee (1968); (*) Findlay and Kenyon (1969); (●) Handa *et al.* (1975); (▲) Philippe *et al.* (1971); (○) Scatchard and Raymond (1938).

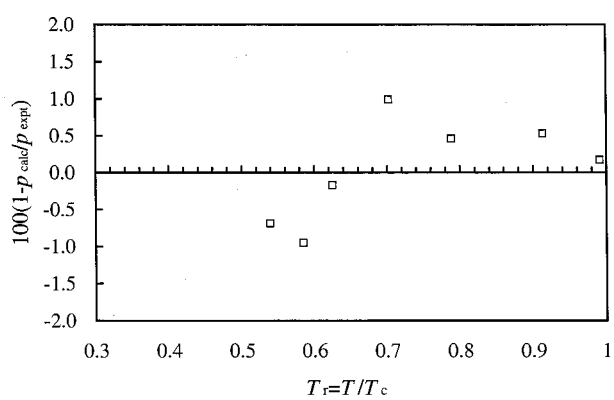

FIG. 13. Comparison of vapor-pressure data for $CHCl_2F$ with values calculated from the extended corresponding-states principle: (□) Benning and McHarness (1940).

TABLE 15. The smoothed pressures, along with their first and second derivatives, as function of temperature for $CHBr_3$

T(K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)	T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)
281.20	0.2346	1.586E-02	9.450E-04	483.15	370.95	7.180	0.1056
283.15	0.2673	1.779E-02	1.042E-03	488.15	408.19	7.721	0.1106
288.15	0.3705	2.370E-02	1.330E-03	493.15	448.20	8.287	0.1157
293.15	0.5070	3.119E-02	1.676E-03	498.15	491.10	8.878	0.1209
298.15	0.6855	4.057E-02	2.090E-03	503.15	537.02	9.495	0.1260
303.15	0.9165	5.221E-02	2.579E-03	508.15	586.09	10.14	0.1313
308.15	1.2120	6.650E-02	3.150E-03	513.15	638.45	10.81	0.1366
313.15	1.5866	8.387E-02	3.813E-03	518.15	694.22	11.50	0.1420
318.15	2.0566	0.1048	4.575E-03	523.15	753.54	12.23	0.1474
323.15	2.6413	0.1298	5.444E-03	528.15	816.54	12.98	0.1528
328.15	3.3623	0.1594	6.427E-03	533.15	883.36	13.76	0.1583
333.15	4.2442	0.1943	7.530E-03	538.15	954.15	14.56	0.1639
338.15	5.3147	0.2349	8.761E-03	543.15	1029.0	15.40	0.1696
343.15	6.6045	0.2821	1.012E-02	548.15	1108.1	16.26	0.1753
348.15	8.1476	0.3364	1.163E-02	553.15	1191.7	17.15	0.1811
353.15	9.9818	0.3986	1.327E-02	558.15	1279.7	18.07	0.1870
358.15	12.148	0.4694	1.506E-02	563.15	1372.4	19.02	0.1930
363.15	14.691	0.5495	1.701E-02	568.15	1469.9	20.00	0.1991
368.15	17.660	0.6397	1.910E-02	573.15	1572.4	21.01	0.2054
373.15	21.106	0.7408	2.135E-02	578.15	1680.1	22.05	0.2118
378.15	25.087	0.8534	2.375E-02	583.15	1793.0	23.13	0.2183
383.15	29.661	0.9785	2.631E-02	588.15	1911.4	24.24	0.2250
388.15	34.894	1.117	2.902E-02	593.15	2035.4	25.38	0.2320
393.15	40.852	1.269	3.189E-02	598.15	2165.3	26.56	0.2392
398.15	47.608	1.436	3.490E-02	603.15	2301.1	27.77	0.2466
403.15	55.237	1.618	3.807E-02	608.15	2443.0	29.02	0.2543
408.15	63.818	1.817	4.139E-02	613.15	2591.4	30.32	0.2624
413.15	73.434	2.032	4.484E-02	618.15	2746.3	31.65	0.2708
418.15	84.171	2.266	4.844E-02	623.15	2907.9	33.02	0.2796
423.15	96.120	2.517	5.217E-02	628.15	3076.6	34.44	0.2889
425.18	101.33	2.624	5.372E-02	633.15	3252.5	35.91	0.2986
428.15	109.37	2.787	5.603E-02	638.15	3435.8	37.43	0.3088
433.15	124.03	3.078	6.002E-02	643.15	3626.9	39.00	0.3197
438.15	140.18	3.388	6.413E-02	648.15	3825.9	40.63	0.3312
443.15	157.94	3.719	6.836E-02	653.15	4033.2	42.32	0.3434
448.15	177.41	4.072	7.269E-02	658.15	4249.2	44.06	0.3564
453.15	198.69	4.446	7.713E-02	663.15	4474.0	45.88	0.3702
458.15	221.91	4.843	8.166E-02	668.15	4708.1	47.77	0.3850
463.15	247.16	5.263	8.629E-02	673.15	4951.8	49.73	0.4009
468.15	274.58	5.706	9.101E-02	678.15	5205.6	51.78	0.4179
473.15	304.26	6.173	9.580E-02	683.15	5469.8	53.91	0.4363
478.15	336.35	6.664	0.1007	696.00	6200.0	59.86	0.4919

method in Table 3 and Fig. 7. The smoothed pressures, along with their first and second derivatives, as a function of temperature in the range between the triple point and the critical point from the present method are presented in Table 11.

4.8. Trifluorochloromethane ($CClF_3$)

Thornton *et al.* (1933) used a tensiometric method to measure vapor pressures (104 to 757 mm Hg). Albright and Martin (1952) used a 99.9 mole % sample and a static method to report data from 25 mm Hg to the critical point with a temperature accuracy of 0.01 K. Mollerup and Fredenslund (1976) measured vapor pressures at two temperatures in a high-pressure ebullioscopic cell with a 99.8 mole % sample. Fernandez-Fassnacht and del Rio (1985) measured vapor pressures from 84 to 1967 kPa with a 99.9 mole % sample. These data are in quite good agreement with the calculated

TABLE 16. The smoothed pressures, along with their first and second derivatives, as function of temperature for $CHCl_3$

T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)	T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)
209.64	8.2694E-02	8.042E-03	6.962E-04	373.15	312.81	7.984	0.1555
213.15	0.11561	1.083E-02	9.004E-04	378.15	354.72	8.786	0.1654
218.15	0.18247	1.622E-02	1.274E-03	383.15	400.76	9.638	0.1754
223.15	0.28141	2.376E-02	1.763E-03	388.15	451.18	10.54	0.1856
228.15	0.42473	3.409E-02	2.393E-03	393.15	506.25	11.49	0.1960
233.15	0.62821	4.796E-02	3.187E-03	398.15	566.22	12.50	0.2066
238.15	0.91177	6.628E-02	4.172E-03	403.15	631.35	13.56	0.2173
243.15	1.3001	9.004E-02	5.374E-03	408.15	701.91	14.67	0.2281
248.15	1.8232	0.1204	6.819E-03	413.15	778.18	15.84	0.2392
253.15	2.5174	0.1587	8.532E-03	418.15	860.43	17.07	0.2504
258.15	3.4255	0.2062	1.054E-02	423.15	948.94	18.35	0.2617
263.15	4.5977	0.2646	1.286E-02	428.15	1044.0	19.68	0.2734
268.15	6.0921	0.3354	1.552E-02	433.15	1145.9	21.08	0.2852
273.15	7.9752	0.4203	1.853E-02	438.15	1254.9	22.54	0.2974
278.15	10.322	0.5213	2.190E-02	443.15	1371.3	24.06	0.3099
283.15	13.218	0.6400	2.566E-02	448.15	1495.5	25.64	0.3228
288.15	16.755	0.7785	2.981E-02	453.15	1627.8	27.28	0.3362
293.15	21.039	0.9387	3.435E-02	458.15	1768.5	29.00	0.3501
298.15	26.182	1.123	3.928E-02	463.15	1917.9	30.79	0.3647
303.15	32.308	1.332	4.462E-02	468.15	2076.5	32.65	0.3799
308.15	39.550	1.569	5.034E-02	473.15	2244.6	34.59	0.3960
313.15	48.052	1.836	5.646E-02	478.15	2422.5	36.61	0.4130
318.15	57.966	2.135	6.296E-02	483.15	2610.8	38.72	0.4312
323.15	69.455	2.466	6.982E-02	488.15	2809.9	40.92	0.4505
328.15	82.690	2.833	7.704E-02	493.15	3020.2	43.23	0.4712
333.15	97.851	3.237	8.461E-02	498.15	3242.3	45.64	0.4935
334.21	101.33	3.328	8.625E-02	503.15	3476.8	48.16	0.5176
338.15	115.13	3.680	9.250E-02	508.15	3724.2	50.82	0.5437
343.15	134.72	4.163	0.1007	513.15	3985.2	53.61	0.5721
348.15	156.83	4.688	0.1092	518.15	4260.5	56.54	0.6031
353.15	181.67	5.256	0.1180	523.15	4550.9	59.64	0.6371
358.15	209.46	5.868	0.1270	528.15	4857.2	62.92	0.6746
363.15	240.42	6.526	0.1363	533.15	5180.4	66.39	0.7166
368.15	274.80	7.231	0.1458	536.40	5400.0	68.77	0.7477

results although the deviations were larger than the experimental uncertainties as shown in Table 3 and Fig. 8. The smoothed pressures, along with their first and second derivatives, as a function of temperature in the range between the triple point and the critical point from the present method are presented in Table 12.

4.9. Tetrafluoromethane (CF_4)

Only one data set in the high-temperature region from Kubic and Stein (1981) is in good agreement with the calculated result as shown in Fig. 9. In the low-temperature region, vapor-pressure data from several sources do not agree well with each other to compare the present calculated result as shown in Table 3 and Fig. 9. The smoothed pressures, along with their first and second derivatives, as a function of temperature in the range between the triple point and the critical point from the present method are presented in Table 13.

4.10. Trifluoroiodomethane (CF_3I)

Only one data set from Duan *et al.* (1996) is available for this substance. The experimental results are in good agreement with the present calculations as shown in Table 3 and Fig. 10. The smoothed pressures, along with their first and second derivatives, as a function of temperature in the range between the triple point and the critical point from the present method are presented in Table 14.

4.11. Tribromomethane ($CHBr_3$)

Boublik and Aim (1972) measured the vapor pressures between 18 and 578 mm Hg. Temperatures were measured to

TABLE 17. The smoothed pressures, along with their first and second derivatives, as function of temperature for $CHCl_2F$

T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)	T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)
138.16	2.9416E-04	5.626E-05	9.949E-06	298.15	181.67	6.165	0.1622
143.15	7.3888E-04	1.316E-04	2.157E-05	303.15	214.58	7.012	0.1767
148.15	1.7457E-03	2.898E-04	4.406E-05	308.15	251.91	7.933	0.1917
153.15	3.8923E-03	6.029E-04	8.514E-05	313.15	294.03	8.930	0.2071
158.15	8.2297E-03	1.191E-03	1.564E-04	318.15	341.33	10.00	0.2229
163.15	1.6573E-02	2.244E-03	2.741E-04	323.15	394.21	11.16	0.239
168.15	3.1911E-02	4.046E-03	4.605E-04	328.15	453.06	12.40	0.2555
173.15	5.8963E-02	7.010E-03	7.440E-04	333.15	518.30	13.71	0.2722
178.15	0.10489	1.171E-02	1.160E-03	338.15	590.35	15.12	0.2892
183.15	0.18017	1.890E-02	1.750E-03	343.15	669.62	16.61	0.3066
188.15	0.29966	2.957E-02	2.561E-03	348.15	756.56	18.18	0.3242
193.15	0.48375	4.497E-02	3.648E-03	353.15	851.61	19.85	0.3422
198.15	0.75972	6.660E-02	5.065E-03	358.15	955.21	21.61	0.3606
203.15	1.1631	9.627E-02	6.872E-03	363.15	1067.8	23.46	0.3795
208.15	1.7393	0.1361	9.126E-03	368.15	1189.9	25.40	0.3989
213.15	2.5446	0.1884	1.189E-02	373.15	1322.0	27.45	0.4189
218.15	3.6482	0.2558	1.520E-02	378.15	1464.6	29.59	0.4397
223.15	5.1332	0.3414	1.913E-02	383.15	1618.1	31.85	0.4615
228.15	7.0977	0.4482	2.370E-02	388.15	1783.2	34.21	0.4843
233.15	9.6561	0.5795	2.896E-02	393.15	1960.4	36.69	0.5084
238.15	12.94	0.739	3.493E-02	398.15	2150.3	39.30	0.534
243.15	17.099	0.9301	4.163E-02	403.15	2353.6	42.03	0.5614
248.15	22.30	1.157	4.908E-02	408.15	2570.9	44.91	0.5909
253.15	28.729	1.422	5.728E-02	413.15	2803.0	47.95	0.6228
258.15	36.593	1.731	6.623E-02	418.15	3050.6	51.15	0.6575
263.15	46.113	2.086	7.591E-02	423.15	3314.7	54.53	0.6955
268.15	57.533	2.491	8.631E-02	428.15	3596.2	58.11	0.7373
273.15	71.112	2.950	9.740E-02	433.15	3896.2	61.91	0.7834
278.15	87.128	3.466	0.1092	438.15	4215.7	65.95	0.8346
282.01	101.33	3.905	0.1187	443.15	4556.1	70.26	0.8919
283.15	105.87	4.043	0.1216	448.15	4918.9	74.88	0.9569
288.15	127.66	4.683	0.1346	451.60	5183.0	78.27	1.009
293.15	152.81	5.389	0.1481				

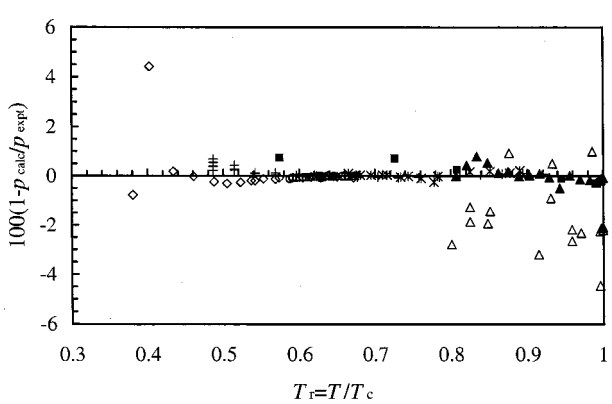

FIG. 14. Comparison of vapor-pressure data for $CHClF_2$ with values calculated from the extended corresponding-states principle: (■) Benning and McHarness (1940); (◇) Blanke and Weiss (1992); (△) Booth and Swinehart (1935); (*) Giuliani *et al.* (1995); (○) Goodwin *et al.* (1992); (+) Haendel *et al.* (1992); (▲) Hongo *et al.* (1990).

1 mK using a calibrated platinum resistance thermometer–Mueller bridge assembly and the pressure was maintained constant to 0.05 mm Hg. Boublik and Aim did not report their sample purity. The experimental data are compared to the calculated values as shown in Table 3 and Fig. 11. The smoothed pressures, along with their first and second derivatives, as a function of temperature in the range between the triple point and the critical point from the present method are presented in Table 15.

4.12. Trichloromethane ($CHCl_3$)

The only data set in the high temperature range is available from Campbell and Chatterjee (1968) that seems to have a systemic error in the experimental measurement as shown

TABLE 18. The smoothed pressures, along with their first and second derivatives, as function of temperature for $CHClF_2$

T(K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)	T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)
115.74	4.2579E-04	9.639E-05	2.014E-05	243.15	163.92	6.928	0.2278
118.15	7.2650E-04	1.577E-04	3.151E-05	248.15	201.52	8.131	0.2537
123.15	2.0558E-03	4.097E-04	7.472E-05	253.15	245.46	9.467	0.2806
128.15	5.3463E-03	9.799E-04	1.634E-04	258.15	296.41	10.94	0.3084
133.15	1.2886E-02	2.176E-03	3.321E-04	263.15	355.08	12.55	0.3371
138.15	2.9000E-02	4.519E-03	6.325E-04	268.15	422.18	14.31	0.3665
143.15	6.1346E-02	8.838E-03	1.136E-03	273.15	498.45	16.22	0.3967
148.15	0.1227	1.637E-02	1.935E-03	278.15	584.63	18.28	0.4275
153.15	0.2333	2.888E-02	3.145E-03	283.15	681.50	20.50	0.4591
158.15	0.4237	4.873E-02	4.898E-03	288.15	789.85	22.87	0.4914
163.15	0.7379	7.900E-02	7.340E-03	293.15	910.49	25.41	0.5247
168.15	1.2374	0.1235	1.063E-02	298.15	1044.2	28.12	0.5590
173.15	2.0046	0.1869	1.491E-02	303.15	1192.0	31.00	0.5946
178.15	3.1471	0.2746	2.035E-02	308.15	1354.6	34.07	0.6317
183.15	4.8009	0.3925	2.707E-02	313.15	1533.0	37.32	0.6709
188.15	7.1342	0.5476	3.519E-02	318.15	1728.2	40.78	0.7124
193.15	10.351	0.7470	4.482E-02	323.15	1941.1	44.45	0.7568
198.15	14.691	0.9984	5.603E-02	328.15	2173.1	48.36	0.8049
203.15	20.435	1.310	6.886E-02	333.15	2425.1	52.51	0.8573
208.15	27.904	1.690	8.333E-02	338.15	2698.6	56.94	0.9150
213.15	37.460	2.146	9.945E-02	343.15	2995.0	61.67	0.9790
218.15	49.506	2.687	0.1172	348.15	3315.9	66.74	1.0510
223.15	64.484	3.320	0.1365	353.15	3663.0	72.19	1.1310
228.15	82.878	4.054	0.1573	358.15	4038.5	78.07	1.2230
232.35	101.32	4.753	0.1758	363.15	4444.5	84.44	1.3280
233.15	105.21	4.896	0.1795	368.15	4883.8	91.37	1.4510
238.15	132.02	5.851	0.2030	369.28	4988.0	93.03	1.4830

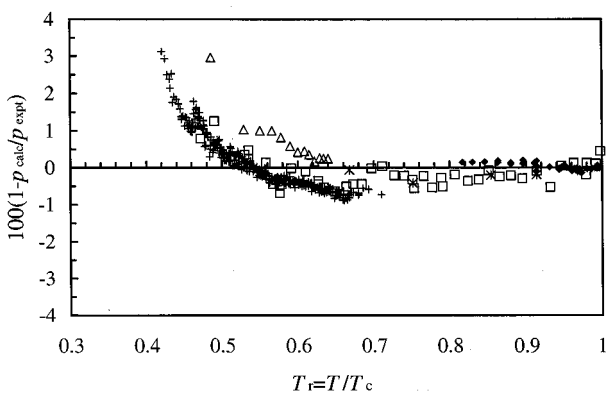

FIG. 15. Comparison of vapor-pressure data for CHF_3 with values calculated from the extended corresponding-states principle: (♦) Hori *et al.* (1981); (□) Hou and Martin (1959); (+) Popowicz *et al.* (1982); (*) Stein and Proust (1971); (△) Valentine *et al.* (1962).

in Fig. 12. For the low-temperature region, the experimental data obtained by Boublik and Aim (1972), by Philippe *et al.* (1971), by Findlay and Kenyon (1969), and by Handa *et al.* (1975) all agree well with the present results as shown in Table 3 and Fig. 12. The smoothed pressures, along with their first and second derivatives, as a function of temperature in the range between the triple point and the critical point from the present method are presented in Table 16.

4.13. Fluorodichloromethane ($CHCl_2F$)

Henne (1937) used a purified sample and reported a normal-boiling point of 272.25 K. Benning and McHarness (1939), (1940) used a static method with a purified sample and reported a normal-boiling point temperature of 282.07 K and seven data points from 130 mm Hg to the critical point. The data included only three low pressure points. Phillips and Nurphy (1970) reported a normal-boiling point tempera-

TABLE 19. The smoothed pressures, along with their first and second derivatives, as function of temperature for CHF_3

T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)	T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)
117.98	5.7087E-02	1.013E-02	1.606E-03	213.15	314.11	14.19	0.4915
118.15	5.8833E-02	1.041E-02	1.644E-03	218.15	391.43	16.79	0.5486
123.15	0.13685	2.205E-02	3.146E-03	223.15	482.46	19.68	0.6078
128.15	0.29553	4.348E-02	5.618E-03	228.15	588.70	22.87	0.6692
133.15	0.59748	8.048E-02	9.442E-03	233.15	711.67	26.37	0.7328
138.15	1.1392	0.1409	1.504E-02	238.15	852.97	30.20	0.7989
143.15	2.0615	0.2346	2.286E-02	243.15	1014.2	34.37	0.8680
148.15	3.5607	0.3738	3.332E-02	248.15	1197.2	38.89	0.9408
153.15	5.8992	0.5729	4.683E-02	253.15	1403.7	43.78	1.018
158.15	9.4157	0.8478	6.373E-02	258.15	1635.7	49.08	1.102
163.15	14.533	1.216	8.427E-02	263.15	1895.3	54.81	1.193
168.15	21.765	1.697	0.1086	268.15	2184.6	61.02	1.293
173.15	31.721	2.309	0.1369	273.15	2506.4	67.77	1.406
178.15	45.108	3.073	0.1691	278.15	2863.3	75.11	1.534
183.15	62.732	4.007	0.2052	283.15	3258.6	83.14	1.681
188.15	85.494	5.131	0.2450	288.15	3696.0	91.96	1.852
193.15	114.39	6.463	0.2883	293.15	4179.8	101.7	2.052
198.15	150.50	8.019	0.3349	298.15	4714.9	112.6	2.296
203.15	194.98	9.816	0.3844	298.90	4800.0	114.3	2.339
208.15	249.08	11.87	0.4367				

ture of 282.05 K, which agrees with the value of Benning and McHarness. The experimental results agree well with the present calculation as shown in Table 3 and Fig. 13. The smoothed pressures, along with their first and second derivatives, as a function of temperature in the range between the triple point and the critical point from the present method are presented in Table 17.

4.14. Difluorochloromethane ($CHClF_2$)

Neilson and David (1957) used a high purity sample, however, their normal-boiling point value was higher than that of Benning and McHarness (1939), who measured the vapor pressures from about 75 mm Hg to the critical point. Booth and Swinehart (1935) reported high-pressure data from 9 atm to the critical point using a purified sample and a static method. The temperatures were measured to 0.1 K. Benning and McHarness (1939) measured six data points from 263 mm Hg to the critical point using a purified sample, but only two data points were below 3000 mm Hg. The recent data obtained by Blanke and Weiss (1992), by Giuliani *et al.* (1995), by Goodwin *et al.* (1992), by Haendel *et al.* (1992), and by Hongo *et al.* (1990) are in excellent agreement with the calculated results from the present method as shown in Table 3 and Fig. 14. The smoothed pressures, along with their first and second derivatives, as a function of temperature in the range between the triple point and the critical point from the present method are presented in Table 18.

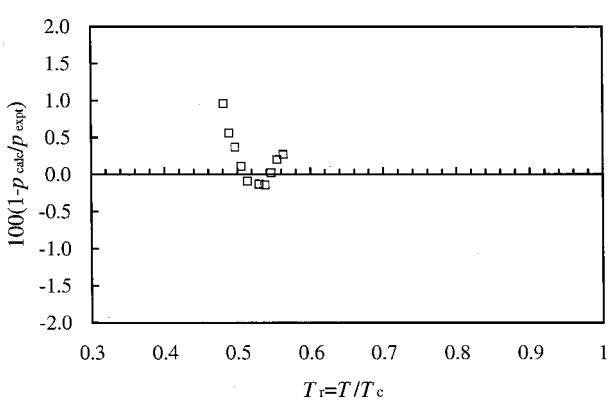

FIG. 16. Comparison of vapor-pressure data for CH_2Br_2 with values calculated from the extended corresponding-states principle: (□) Philippe *et al.* (1973).

4.15. Trifluoromethane (CHF_3)

A wide range of experimental data is available for this compound. In the low-temperature region, the experimental data obtained by Valentine *et al.* (1962) and by Popowicz *et al.* (1982) are generally in agreement with each other. In the high-temperature region, the experimental data obtained by Hori *et al.* (1981), by Hou and Martin (1959), and by Stein and Proust (1971) are in good agreement with the calculated results from the present method as shown in Table 3 and Fig. 15. The smoothed pressures, along with their first

TABLE 20. The smoothed pressures, along with their first and second derivatives, as function of temperature for CH_2Br_2

T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)	T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)
220.61	2.4059E-02	2.401E-03	2.161E-04	418.15	360.15	8.261	0.1449
223.15	3.0903E-02	3.008E-03	2.635E-04	423.15	403.30	9.006	0.1532
228.15	4.9699E-02	4.610E-03	3.832E-04	428.15	450.28	9.793	0.1617
233.15	7.8164E-02	6.911E-03	5.455E-04	433.15	501.3	10.62	0.1703
238.15	0.1204	1.015E-02	7.613E-04	438.15	556.58	11.50	0.1790
243.15	0.1814	1.463E-02	1.043E-03	443.15	616.33	12.41	0.1878
248.15	0.2694	2.072E-02	1.404E-03	448.15	680.77	13.37	0.1968
253.15	0.3923	2.884E-02	1.860E-03	453.15	750.14	14.38	0.2058
258.15	0.5620	3.951E-02	2.427E-03	458.15	824.65	15.43	0.2150
263.15	0.7926	5.332E-02	3.121E-03	463.15	904.54	16.53	0.2242
268.15	1.1016	7.096E-02	3.960E-03	468.15	990.03	17.67	0.2336
273.15	1.5098	9.319E-02	4.961E-03	473.15	1081.4	18.87	0.2432
278.15	2.0425	0.1209	6.142E-03	478.15	1178.8	20.11	0.2528
283.15	2.7291	0.1549	7.520E-03	483.15	1282.5	21.40	0.2626
288.15	3.6042	0.1964	9.111E-03	488.15	1392.8	22.73	0.2726
293.15	4.7075	0.2464	1.093E-02	493.15	1509.9	24.12	0.2828
298.15	6.0846	0.3061	1.300E-02	498.15	1634.1	25.56	0.2932
303.15	7.7871	0.3768	1.531E-02	503.15	1765.6	27.05	0.3038
308.15	9.8731	0.4597	1.790E-02	508.15	1904.7	28.60	0.3148
313.15	12.407	0.5563	2.077E-02	513.15	2051.7	30.20	0.3261
318.15	15.461	0.6679	2.392E-02	518.15	2206.9	31.86	0.3377
323.15	19.113	0.796	2.736E-02	523.15	2370.4	33.58	0.3498
328.15	23.450	0.942	3.110E-02	528.15	2542.8	35.36	0.3624
333.15	28.566	1.107	3.513E-02	533.15	2724.1	37.20	0.3755
338.15	34.560	1.294	3.947E-02	538.15	2914.9	39.12	0.3893
343.15	41.541	1.503	4.411E-02	543.15	3115.4	41.10	0.4038
348.15	49.626	1.735	4.904E-02	548.15	3326.0	43.16	0.4191
353.15	58.937	1.993	5.426E-02	553.15	3547.1	45.29	0.4352
358.15	69.605	2.278	5.977E-02	558.15	3779.1	47.51	0.4524
363.15	81.768	2.592	6.556E-02	563.15	4022.4	49.82	0.4707
368.15	95.571	2.934	7.162E-02	568.15	4277.4	52.22	0.4902
370.07	101.33	3.074	7.401E-02	573.15	4544.7	54.72	0.5111
373.15	111.16	3.308	7.795E-02	578.15	4824.8	57.33	0.5335
378.15	128.71	3.714	8.452E-02	583.15	5118.2	60.06	0.5577
383.15	148.36	4.154	9.134E-02	588.15	5425.6	62.91	0.5838
388.15	170.31	4.628	9.839E-02	593.15	5747.6	65.90	0.6121
393.15	194.71	5.138	0.1057	598.15	6084.9	69.04	0.6429
398.15	221.75	5.685	0.1131	603.15	6438.2	72.34	0.6766
403.15	251.62	6.270	0.1208	608.15	6808.5	75.81	0.7142
408.15	284.51	6.894	0.1287	610.00	6950.0	77.15	0.7299
413.15	320.62	7.557	0.1367				

and second derivatives, as a function of temperature in the range between the triple point and the critical point from the present method are presented in Table 19.

4.16. Dibromomethane (CH_2Br_2)

The only available data set of Philippe *et al.* (1973) near to the normal-boiling point is compared to the present method as shown in Table 3 and Fig. 16. The smoothed pressures, along with their first and second derivatives, as a function of temperature in the range between the triple point and the critical point from the present method are presented in Table 20.

4.17. Chlorobromomethane (CH_2BrCl)

The only available data set of McDonald *et al.* (1959) near to the normal-boiling point is compared to the present

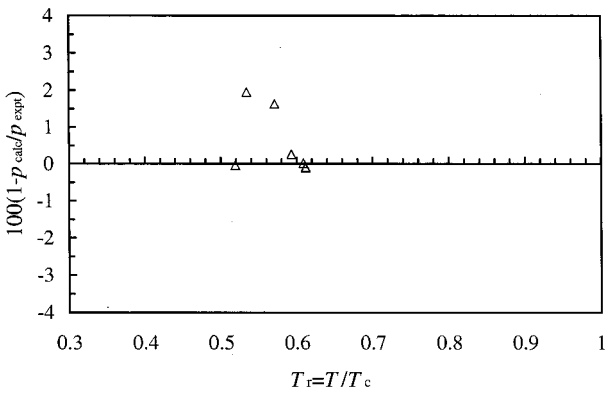

FIG. 17. Comparison of vapor-pressure data for CH_2BrCl with values calculated from the extended corresponding-states principle: (△) McDonld *et al.* (1959).

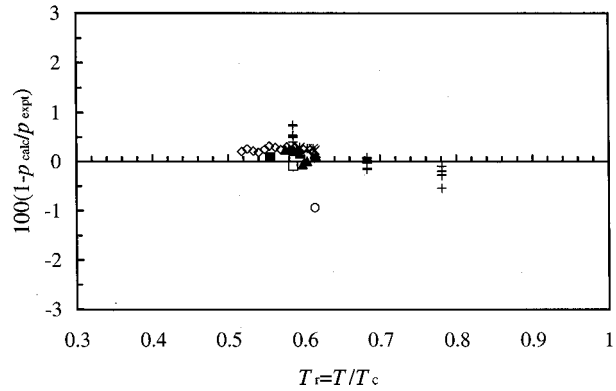

FIG. 18. Comparison of vapor-pressure data for CH_2Cl_2 with values calculated from the extended corresponding-states principle: (◇) Boublik and Aim (1972); (■) Handa *et al.* (1975); (+) Khurma *et al.* (1983); (●) Moelwyn-Hughes and Missen (1956); (○) Morgan and Yager (1940); (*) Mueller and Ignatowski (1960); (▲) Philippe *et al.* (1973); (□) Wong and Eckert (1969).

TABLE 21. The smoothed pressures, along with their first and second derivatives, as function of temperature for CH_2BrCl

T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)	T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)
185.21	2.6177E-03	3.478E-04	4.229E-05	373.15	263.38	7.080	0.1472
188.15	3.8440E-03	4.941E-04	5.800E-05	378.15	300.66	7.841	0.1575
193.15	7.1828E-03	8.735E-04	9.662E-05	383.15	341.88	8.655	0.1681
198.15	1.2980E-02	1.495E-03	1.559E-04	388.15	387.31	9.523	0.1789
203.15	2.2734E-02	2.481E-03	2.441E-04	393.15	437.20	10.44	0.1899
208.15	3.8674E-02	4.001E-03	3.718E-04	398.15	491.84	11.42	0.2011
213.15	6.4018E-02	6.286E-03	5.519E-04	403.15	551.51	12.46	0.2125
218.15	0.1033	9.633E-03	7.998E-04	408.15	616.50	13.55	0.2241
223.15	0.1628	1.443E-02	1.133E-03	413.15	687.09	14.70	0.2359
228.15	0.2508	2.114E-02	1.572E-03	418.15	763.57	15.91	0.2478
233.15	0.3783	3.036E-02	2.140E-03	423.15	846.25	17.18	0.2600
238.15	0.5597	4.279E-02	2.859E-03	428.15	935.44	18.51	0.2723
243.15	0.8130	5.925E-02	3.757E-03	433.15	1031.4	19.90	0.2848
248.15	1.1606	8.070E-02	4.858E-03	438.15	1134.5	21.35	0.2975
253.15	1.6301	0.1082	6.191E-03	443.15	1245.1	22.87	0.3105
258.15	2.2549	0.1430	7.781E-03	448.15	1363.4	24.46	0.3237
263.15	3.0749	0.1865	9.655E-03	453.15	1489.8	26.11	0.3372
268.15	4.1368	0.2401	1.184E-02	458.15	1624.6	27.83	0.3512
273.15	5.4955	0.3054	1.435E-02	463.15	1768.2	29.62	0.3655
278.15	7.2136	0.3842	1.722E-02	468.15	1921.0	31.49	0.3803
283.15	9.3630	0.4782	2.046E-02	473.15	2083.2	33.43	0.3956
288.15	12.025	0.5894	2.408E-02	478.15	2255.4	35.45	0.4116
293.15	15.289	0.7197	2.811E-02	483.15	2437.8	37.54	0.4283
298.15	19.257	0.8712	3.255E-02	488.15	2631.0	39.73	0.4458
303.15	24.040	1.046	3.740E-02	493.15	2835.3	42.00	0.4643
308.15	29.758	1.246	4.268E-02	498.15	3051.2	44.37	0.4838
313.15	36.545	1.473	4.838E-02	503.15	3279.2	46.84	0.5045
318.15	44.541	1.730	5.451E-02	508.15	3519.8	49.42	0.5266
323.15	53.902	2.019	6.105E-02	513.15	3773.6	52.11	0.5502
328.15	64.789	2.342	6.801E-02	518.15	4041.1	54.93	0.5756
333.15	77.378	2.700	7.537E-02	523.15	4323.1	57.87	0.6030
338.15	91.852	3.096	8.313E-02	528.15	4620.1	60.96	0.6325
341.09	101.33	3.347	8.787E-02	533.15	4932.9	64.20	0.6645
343.15	108.40	3.532	9.126E-02	538.15	5262.4	67.61	0.6994
348.15	127.24	4.009	9.976E-02	543.15	5609.3	71.20	0.7375
353.15	148.57	4.530	0.1086	548.15	5974.7	74.99	0.7794
358.15	172.62	5.096	0.1178	553.15	6359.6	79.00	0.8260
363.15	199.61	5.709	0.1273	557.00	6670.0	82.26	0.8668
368.15	229.78	6.369	0.1371				

TABLE 22. The smoothed pressures, along with their first and second derivatives, as function of temperature for CH_2Cl_2

T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)	T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)
178.02	8.5579E-03	1.115E-03	1.319E-04	343.15	267.61	7.750	0.1732
178.15	8.7040E-03	1.132E-03	1.337E-04	348.15	308.58	8.648	0.1862
183.15	1.6366E-02	2.006E-03	2.223E-04	353.15	354.20	9.612	0.1995
188.15	2.9683E-02	3.432E-03	3.571E-04	358.15	404.81	10.64	0.2132
193.15	5.2060E-02	5.683E-03	5.556E-04	363.15	460.75	11.74	0.2271
198.15	8.8503E-02	9.130E-03	8.393E-04	368.15	522.37	12.91	0.2412
203.15	0.1462	1.426E-02	1.234E-03	373.15	590.02	14.16	0.2556
208.15	0.2350	2.170E-02	1.769E-03	378.15	664.06	15.47	0.2703
213.15	0.3683	3.224E-02	2.477E-03	383.15	744.86	16.86	0.2851
218.15	0.5641	4.682E-02	3.395E-03	388.15	832.78	18.32	0.3002
223.15	0.8452	6.660E-02	4.560E-03	393.15	928.21	19.86	0.3156
228.15	1.2409	9.290E-02	6.011E-03	398.15	1031.5	21.48	0.3312
233.15	1.7876	0.1273	7.790E-03	403.15	1143.1	23.18	0.3472
238.15	2.5298	0.1714	9.935E-03	408.15	1263.4	24.95	0.3635
243.15	3.5212	0.2273	1.248E-02	413.15	1392.8	26.81	0.3801
248.15	4.8257	0.2970	1.547E-02	418.15	1531.7	28.75	0.3973
253.15	6.5180	0.3828	1.893E-02	423.15	1680.5	30.78	0.4150
258.15	8.6847	0.4872	2.290E-02	428.15	1839.7	32.90	0.4333
263.15	11.425	0.6126	2.738E-02	433.15	2009.7	35.12	0.4523
268.15	14.851	0.7619	3.242E-02	438.15	2191.0	37.43	0.4722
273.15	19.088	0.9377	3.801E-02	443.15	2384.1	39.84	0.4930
278.15	24.277	1.143	4.417E-02	448.15	2589.6	42.36	0.5150
283.15	30.571	1.380	5.091E-02	453.15	2807.9	44.99	0.5384
288.15	38.140	1.653	5.823E-02	458.15	3039.7	47.75	0.5632
293.15	47.165	1.964	6.611E-02	463.15	3285.6	50.63	0.5898
298.15	57.844	2.315	7.457E-02	468.15	3546.3	53.65	0.6183
303.15	70.388	2.710	8.358E-02	473.15	3822.4	56.82	0.6492
308.15	85.023	3.152	9.312E-02	478.15	4114.7	60.14	0.6825
312.97	101.325	3.624	0.1028	483.15	4424.1	63.65	0.7189
313.15	101.99	3.642	0.1032	488.15	4751.5	67.34	0.7585
318.15	121.53	4.184	0.1138	493.15	5097.8	71.24	0.8020
323.15	143.92	4.781	0.1248	498.15	5464.2	75.37	0.8500
328.15	169.43	5.433	0.1363	503.15	5851.9	79.75	0.9033
333.15	198.35	6.144	0.1482	508.15	6262.2	84.41	0.9634
338.15	230.97	6.916	0.1605	510.00	6420.0	86.22	0.9888

method in Table 3 and Fig. 17. The smoothed pressures, along with their first and second derivatives, as a function of temperature in the range between the triple point and the critical point from the present method are presented in Table 21.

4.18. Dichloromethane (CH_2Cl_2)

Although several data sets are available for this compound, the experimental data obtained by Boublik and Aim (1972) and by Khurma *et al.* (1983) cover a middle temperature range. These experimental data agree well with the present results in Table 3 and Fig. 18. The smoothed pressures, along with their first and second derivatives, as a function of temperature in the range between the triple point and the critical point from the present method are presented in Table 22.

4.19. Fluorochloromethane (CH_2ClF)

Only the experimental data near to the normal-boiling point are available for this substance from Phillips and Murphy (1970) and from Zellhoefer *et al.* (1938) as shown in Table 3 and Fig. 19. The smoothed pressures, along with their first and second derivatives, as a function of temperature in the range between the triple point and the critical point from the present method are presented in Table 23.

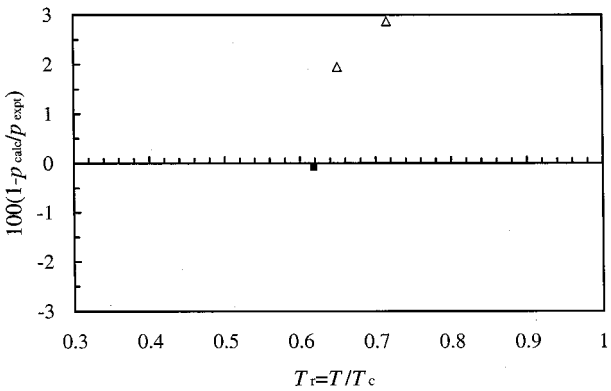

FIG. 19. Comparison of vapor-pressure data for CH_2ClF with values calculated from the extended corresponding-states principle: (■) Phillips and Murphy (1970); (△) Zellhoefer *et al.* (1938).

4.20. Difluoromethane (CH_2F_2)

The highly accurate experimental data for this substance are available over a wide temperature region. The experimental data obtained by Kobayashi and Nishiumi (1998) and by Widiatmo *et al.* (1994) have relatively large uncertainties. The experimental data obtained by Defibaugh *et al.* (1994), by de Vries (1997), by Fu *et al.* (1995), by Magee (1996), by Weber and Goodwin (1993), and by Weber and Silva (1994) all agree very well with the present results as shown in Table 3 and Fig. 20. The smoothed pressures, along with their first and second derivatives, as a function of temperature in the range between the triple point and the critical point from the present method are presented in Table 24.

4.21. Diiodomethane (CH_2I_2)

It is extremely difficult to select a good value for the normal-boiling point for this substance. Gregory and Style (1936) reported 19 low-pressure data points (0.67 to 7.53 mm Hg) on a purified sample. Some scattered data points are available between 10 and 40 mm Hg but they do not seem to be reliable enough for selection. There are virtually no good data values between 10 and 760 mm Hg. An uncertainty in

TABLE 23. The smoothed pressures, along with their first and second derivatives, as function of temperature for CH_2ClF

T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)	T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)
138.01	2.2778E-03	3.851E-04	5.954E-05	283.15	209.11	7.335	0.2004
138.15	2.3323E-03	3.935E-04	6.071E-05	288.15	248.36	8.384	0.2193
143.15	5.2639E-03	8.268E-04	1.182E-04	293.15	293.10	9.529	0.2389
148.15	1.1237E-02	1.646E-03	2.181E-04	298.15	343.82	10.77	0.2592
153.15	2.2800E-02	3.117E-03	3.837E-04	303.15	401.01	12.12	0.2800
158.15	4.4154E-02	5.643E-03	6.457E-04	308.15	465.21	13.57	0.3014
163.15	8.1935E-02	9.801E-03	1.044E-03	313.15	536.94	15.14	0.3233
168.15	0.1462	1.639E-02	1.627E-03	318.15	616.76	16.81	0.3457
173.15	0.2517	2.648E-02	2.453E-03	323.15	705.22	18.59	0.3687
178.15	0.4191	4.143E-02	3.586E-03	328.15	802.90	20.50	0.3922
183.15	0.6769	6.297E-02	5.098E-03	333.15	910.38	22.52	0.4163
188.15	1.0631	9.316E-02	7.064E-03	338.15	1028.3	24.66	0.4411
193.15	1.6271	0.1345	9.562E-03	343.15	1157.2	26.93	0.4667
198.15	2.4313	0.1898	1.267E-02	348.15	1297.8	29.33	0.4930
203.15	3.5540	0.2623	1.646E-02	353.15	1450.7	31.86	0.5204
208.15	5.0893	0.3557	2.101E-02	358.15	1616.7	34.54	0.5490
213.15	7.1517	0.4738	2.637E-02	363.15	1796.3	37.35	0.5789
218.15	9.8753	0.6208	3.261E-02	368.15	1990.5	40.33	0.6105
223.15	13.416	0.8014	3.976E-02	373.15	2199.9	43.46	0.6440
228.15	17.952	1.020	4.786E-02	378.15	2425.4	46.77	0.6798
233.15	23.687	1.282	5.695E-02	383.15	2667.9	50.27	0.7182
238.15	30.848	1.591	6.703E-02	388.15	2928.4	53.96	0.7597
243.15	39.687	1.954	7.810E-02	393.15	3207.8	57.87	0.8048
248.15	50.480	2.374	9.017E-02	398.15	3507.4	62.01	0.854
253.15	63.530	2.857	0.1032	403.15	3828.4	66.42	0.9081
258.15	79.162	3.408	0.1172	408.15	4172.1	71.10	0.9679
263.15	97.727	4.031	0.1322	413.15	4540.0	76.11	1.034
264.03	101.32	4.148	0.1349	418.15	4933.7	81.46	1.109
268.15	119.60	4.731	0.1480	423.15	5355.2	87.21	1.193
273.15	145.17	5.512	0.1647	427.00	5700.0	91.94	1.268
278.15	174.86	6.379	0.1821				

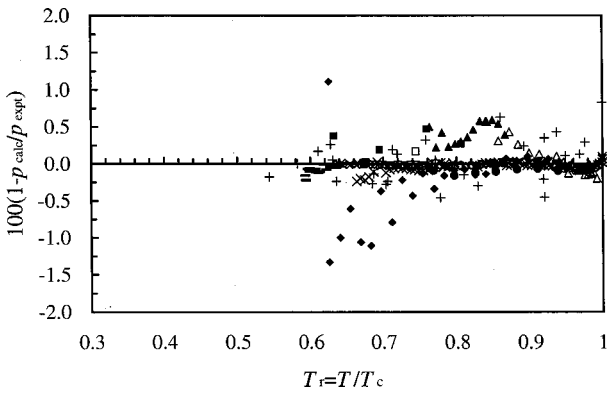

FIG. 20. Comparison of vapor-pressure data for CH_2F_2 with values calculated from the extended corresponding-states principle: (■) Adams and Stein (1971); (○) Defibaugh *et al.* (1994); (◇) de Vries (1997); (×) Fu *et al.* (1995); (△) Holcomb *et al.* (1993); (▲) Kobayashi and Nishiumi (1998); (●) Magee (1996); (+) Malbrunot *et al.* (1968); (*) Sato *et al.* (1994); (−) Weber and Goodwin (1993); (□) Weber and Silva (1994); (◆) Widiatmo *et al.* (1994).

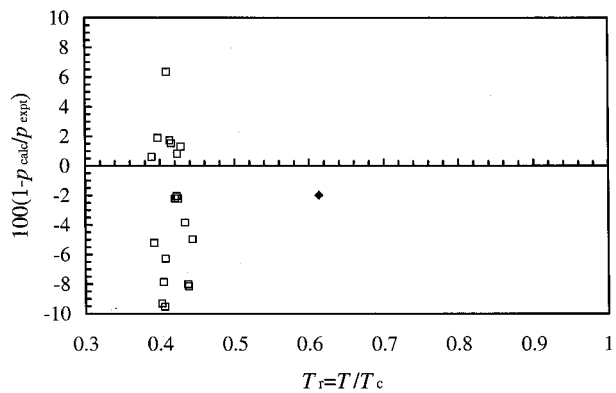

FIG. 21. Comparison of vapor-pressure data for CH_2I_2 with values calculated from the extended corresponding-states principle: (□) Gregory and Style (1936); (◆) Morgan and Yager (1940).

temperature of 0.5 K was assigned to the data of Gregory and Style, which were compared with the present method in Table 3 and Fig. 21. The smoothed pressures, along with their first and second derivatives, as a function of temperature in the range between the triple point and the critical point from the present method are presented in Table 25.

4.22. Bromomethane (CH_3Br)

Egan and Kemp (1938) used a 99.9 mole % sample to measure pressures from 13 to 790 mm Hg with an accuracy of 0.05 K in temperature and 0.01 mm Hg in pressure. High-pressure data are not available for this compound. Along with the data obtained by Beersmans and Jungers (1947), these data sets are compared to the present method in Table 3

TABLE 24. The smoothed pressures, along with their first and second derivatives, as function of temperature for CH_2F_2

T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)	T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)
137.01	5.6905E-02	8.621E-03	1.169E-03	243.15	273.44	11.29	0.3629
138.15	6.7528E-02	1.005E-02	1.335E-03	248.15	334.58	13.20	0.4035
143.15	0.13809	1.900E-02	2.319E-03	253.15	405.81	15.33	0.4459
148.15	0.26775	3.412E-02	3.833E-03	258.15	488.19	17.66	0.4899
153.15	0.49472	5.852E-02	6.060E-03	263.15	582.83	20.23	0.5355
158.15	0.87511	9.626E-02	9.206E-03	268.15	690.85	23.02	0.5828
163.15	1.4880	0.1525	1.349E-02	273.15	813.45	26.06	0.6318
168.15	2.4411	0.2335	1.915E-02	278.15	951.85	29.34	0.6827
173.15	3.8761	0.3466	2.640E-02	283.15	1107.3	32.89	0.7356
178.15	5.9749	0.5004	3.545E-02	288.15	1281.2	36.70	0.7910
183.15	8.9641	0.7045	4.651E-02	293.15	1474.8	40.80	0.8492
188.15	13.121	0.9692	5.974E-02	298.15	1689.7	45.20	0.9108
193.15	18.776	1.306	7.527E-02	303.15	1927.4	49.92	0.9766
198.15	26.318	1.726	9.321E-02	308.15	2189.5	54.98	1.047
203.15	36.195	2.242	0.1136	313.15	2477.8	60.40	1.124
208.15	48.918	2.866	0.1365	318.15	2794.2	66.23	1.209
213.15	65.060	3.611	0.1619	323.15	3140.8	72.51	1.302
218.15	85.254	4.490	0.1898	328.15	3520.0	79.27	1.406
221.49	101.33	5.156	0.2097	333.15	3934.4	86.58	1.523
223.15	110.20	5.513	0.2200	338.15	4386.9	94.52	1.655
228.15	140.65	6.694	0.2526	343.15	4880.8	103.2	1.806
233.15	177.42	8.043	0.2873	348.15	5419.9	112.6	1.982
238.15	221.37	9.571	0.3241	351.26	5780.0	119.0	2.111

TABLE 25. The smoothed pressures, along with their first and second derivatives, as function of temperature for CH_2I_2

T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)	T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)
268.15	1.8816E-02	1.580E-03	1.199E-04	503.15	309.43	6.072	9.17E-02
273.15	2.8395E-02	2.290E-03	1.664E-04	508.15	340.95	6.542	9.63E-02
278.15	4.2164E-02	3.268E-03	2.274E-04	513.15	374.89	7.035	0.1010
279.25	4.5899E-02	3.527E-03	2.430E-04	518.15	411.35	7.552	0.1058
283.15	6.1653E-02	4.594E-03	3.062E-04	523.15	450.45	8.093	0.1106
288.15	8.8843E-02	6.366E-03	4.068E-04	528.15	492.32	8.658	0.1155
293.15	0.1263	8.705E-03	5.333E-04	533.15	537.08	9.248	0.1204
298.15	0.1771	1.175E-02	6.907E-04	538.15	584.85	9.863	0.1255
303.15	0.2452	1.567E-02	8.839E-04	543.15	635.75	10.5	0.1305
308.15	0.3356	2.066E-02	1.119E-03	548.15	689.92	11.17	0.1356
313.15	0.4540	2.694E-02	1.401E-03	553.15	747.47	11.86	0.1408
318.15	0.6075	3.476E-02	1.737E-03	558.15	808.55	12.58	0.1461
323.15	0.8046	4.441E-02	2.133E-03	563.15	873.29	13.32	0.1514
328.15	1.0551	5.620E-02	2.596E-03	568.15	941.80	14.09	0.1567
333.15	1.3707	7.048E-02	3.132E-03	573.15	1014.2	14.89	0.1622
338.15	1.7648	8.765E-02	3.748E-03	578.15	1090.7	15.71	0.1676
343.15	2.2527	0.1081	4.451E-03	583.15	1171.4	16.56	0.1732
348.15	2.8520	0.1323	5.247E-03	588.15	1256.4	17.44	0.1789
353.15	3.5828	0.1607	6.142E-03	593.15	1345.9	18.35	0.1846
358.15	4.4673	0.1939	7.142E-03	598.15	1440.0	19.29	0.1904
363.15	5.5306	0.2323	8.254E-03	603.15	1538.9	20.26	0.1964
368.15	6.8005	0.2766	9.481E-03	608.15	1642.6	21.25	0.2024
373.15	8.3076	0.3274	1.083E-02	613.15	1751.4	22.28	0.2086
378.15	10.086	0.3851	1.230E-02	618.15	1865.5	23.34	0.2149
383.15	12.172	0.4506	1.391E-02	623.15	1984.9	24.43	0.2214
388.15	14.606	0.5244	1.564E-02	628.15	2109.9	25.56	0.2281
393.15	17.431	0.6072	1.751E-02	633.15	2240.5	26.71	0.2350
398.15	20.694	0.6997	1.952E-02	638.15	2377.0	27.91	0.2421
403.15	24.446	0.8026	2.166E-02	643.15	2519.6	29.13	0.2495
408.15	28.739	0.9166	2.394E-02	648.15	2668.5	30.40	0.2571
413.15	33.631	1.042	2.637E-02	653.15	2823.7	31.71	0.2651
418.15	39.183	1.180	2.893E-02	658.15	2985.6	33.05	0.2734
423.15	45.458	1.332	3.163E-02	663.15	3154.3	34.44	0.2820
428.15	52.524	1.497	3.447E-02	668.15	3330.1	35.87	0.2911
433.15	60.452	1.677	3.745E-02	673.15	3513.1	37.35	0.3006
438.15	69.317	1.872	4.056E-02	678.15	3703.7	38.88	0.3106
443.15	79.196	2.083	4.381E-02	683.15	3902.0	40.46	0.3211
448.15	90.171	2.310	4.718E-02	688.15	4108.4	42.09	0.3322
452.76	101.32	2.535	5.040E-02	693.15	4323.0	43.78	0.344
453.15	102.33	2.555	5.068E-02	698.15	4546.3	45.53	0.3564
458.15	115.75	2.817	5.430E-02	703.15	4778.5	47.35	0.3697
463.15	130.53	3.098	5.804E-02	708.15	5019.9	49.23	0.3837
468.15	146.76	3.398	6.189E-02	713.15	5270.9	51.19	0.3988
473.15	164.53	3.717	6.586E-02	718.15	5531.9	53.22	0.4148
478.15	183.96	4.056	6.993E-02	723.15	5803.2	55.34	0.4320
483.15	205.13	4.416	7.410E-02	728.15	6085.4	57.54	0.4504
488.15	228.16	4.797	7.837E-02	733.15	6378.8	59.84	0.4704
493.15	253.14	5.200	8.273E-02	740.00	6800.0	63.17	0.5014
498.15	280.20	5.625	8.718E-02				

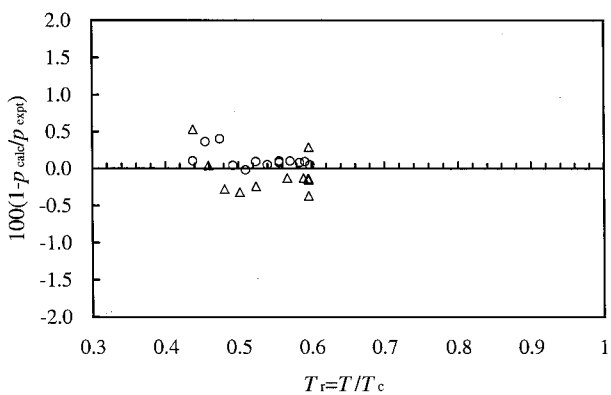

FIG. 22. Comparison of vapor-pressure data for CH_3Br with values calculated from the extended corresponding-states principle: (△) Beersmans and Jungers (1947); (○) Egan and Kemp (1938).

and Fig. 22. The smoothed pressures, along with their first and second derivatives, as a function of temperature in the range between the triple point and the critical point from the present method are presented in Table 26.

4.23. Chloromethane (CH_3Cl)

Highly accurate experimental data are available for this substance. The data obtained by Messerly and Aston (1940), by Holldorff and Knapp (1988), and by Mansoorian *et al.* (1981) are in very good agreement with the values calculated from the present method in Table 3 and Fig. 23. The smoothed pressures, along with their first and second derivatives, as a function of temperature in the range between the triple point and the critical point from the present method are presented in Table 27.

TABLE 26. The smoothed pressures, along with their first and second derivatives, as function of temperature for CH_3Br

T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)	T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)
179.48	0.2044	2.108E-02	1.919E-03	323.15	464.42	12.81	0.2669
183.15	0.2960	2.921E-02	2.535E-03	328.15	531.88	14.19	0.2846
188.15	0.4779	4.446E-02	3.617E-03	333.15	606.45	15.66	0.3026
193.15	0.7509	6.593E-02	5.033E-03	338.15	688.59	17.22	0.3208
198.15	1.1506	9.545E-02	6.844E-03	343.15	778.76	18.87	0.3394
203.15	1.7223	0.1351	9.111E-03	348.15	877.40	20.61	0.3581
208.15	2.5229	0.1874	1.189E-02	353.15	985.01	22.45	0.3772
213.15	3.6221	0.2550	1.525E-02	358.15	1102.0	24.38	0.3965
218.15	5.1038	0.3410	1.924E-02	363.15	1229.0	26.41	0.4162
223.15	7.0679	0.4485	2.390E-02	368.15	1366.3	28.54	0.4363
228.15	9.6309	0.5811	2.927E-02	373.15	1514.6	30.78	0.4569
233.15	12.927	0.7425	3.539E-02	378.15	1674.3	33.11	0.4780
238.15	17.110	0.9363	4.228E-02	383.15	1845.9	35.56	0.4998
243.15	22.351	1.167	4.995E-02	388.15	2030.1	38.11	0.5223
248.15	28.842	1.437	5.842E-02	393.15	2227.2	40.78	0.5458
253.15	36.796	1.752	6.768E-02	398.15	2438.1	43.57	0.5705
258.15	46.444	2.115	7.773E-02	403.15	2663.2	46.49	0.5964
263.15	58.036	2.531	8.855E-02	408.15	2903.2	49.54	0.6240
268.15	71.844	3.002	0.1001	413.15	3158.8	52.73	0.6533
273.15	88.156	3.533	0.1124	418.15	3430.8	56.08	0.6847
276.67	101.33	3.945	0.1215	423.15	3719.9	59.58	0.7185
278.15	107.28	4.127	0.1254	428.15	4026.9	63.27	0.7552
283.15	129.54	4.788	0.1390	433.15	4352.9	67.14	0.7951
288.15	155.28	5.519	0.1533	438.15	4698.7	71.22	0.8386
293.15	184.85	6.322	0.1681	443.15	5065.5	75.53	0.8864
298.15	218.63	7.201	0.1835	448.15	5454.5	80.10	0.9392
303.15	256.99	8.158	0.1994	453.15	5866.9	84.94	0.9977
308.15	300.34	9.195	0.2157	458.15	6304.3	90.08	1.063
313.15	349.08	10.32	0.2324	463.15	6768.3	95.58	1.138
318.15	403.63	11.52	0.2495	464.00	6850.0	96.56	1.153

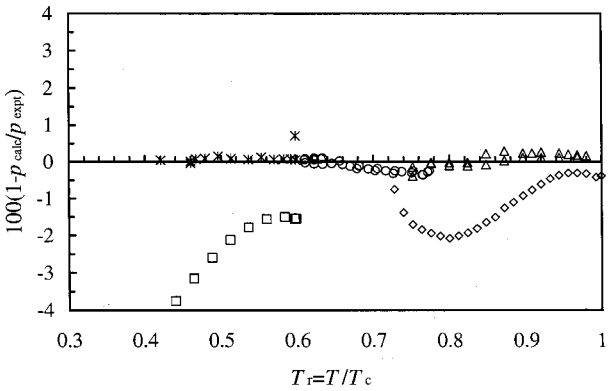

FIG. 23. Comparison of vapor-pressure data for CH_3Cl with values calculated from the extended corresponding-states principle: (□) Beersmans and Jungers (1947); (○) Holldorff and Knapp (1988); (◇) Hsu and McKetta (1964); (●) Kumagai and Iwasaki (1978); (△) Mansoorian *et al.* (1981); (*) Messerly and Aston (1940).

4.24. Fluoromethane (CH_3F)

The highly accurate experimental data for this substance are available over a wide temperature region. The old experimental data obtained by Collie (1889) and by Grosse *et al.* (1940) have large uncertainties. The experimental data over a wide temperature range obtained by Biswas *et al.* (1989), by Bominaar *et al.* (1987), by Demiriz *et al.* (1993), by Michels and Wassenaar (1948), and by Oi *et al.* (1983) agree well with the present results as shown in Table 3 and Fig. 24. The smoothed pressures, along with their first and second derivatives, as a function of temperature in the range between the triple point and the critical point from the present method are presented in Table 28.

4.25. Iodomethane (CH_3I)

Boublik and Aim (1972) measured vapor pressures below the normal-boiling point. Fahim and Moelwyn-Hughes

TABLE 27. The smoothed pressures, along with their first and second derivatives, as function of temperature for CH_3Cl

T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)	T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)
175.44	0.8750	8.378E-02	6.958E-03	298.15	578.27	16.78	0.3650
178.15	1.1293	0.1045	8.357E-03	303.15	666.84	18.67	0.3898
183.15	1.7685	0.1538	1.149E-02	308.15	765.15	20.68	0.4151
188.15	2.6964	0.2207	1.541E-02	313.15	873.85	22.82	0.4408
193.15	4.0115	0.3094	2.022E-02	318.15	993.57	25.09	0.4668
198.15	5.8342	0.4245	2.602E-02	323.15	1125.0	27.49	0.4934
203.15	8.3096	0.5713	3.287E-02	328.15	1268.7	30.02	0.5205
208.15	11.609	0.7551	4.083E-02	333.15	1425.4	32.69	0.5483
213.15	15.932	0.9816	4.996E-02	338.15	1595.9	35.51	0.5768
218.15	21.506	1.257	6.028E-02	343.15	1780.7	38.46	0.6063
223.15	28.589	1.586	7.181E-02	348.15	1980.8	41.57	0.6370
228.15	37.471	1.977	8.454E-02	353.15	2196.7	44.84	0.6692
233.15	48.468	2.434	9.847E-02	358.15	2429.4	48.27	0.7031
238.15	61.930	2.963	0.1136	363.15	2679.7	51.87	0.7390
243.15	78.233	3.571	0.1298	368.15	2948.4	55.66	0.7775
248.15	97.782	4.263	0.1471	373.15	3236.6	59.65	0.8189
248.97	101.33	4.385	0.1500	378.15	3545.3	63.86	0.8638
253.15	121.01	5.044	0.1654	383.15	3875.6	68.30	0.9127
258.15	148.38	5.919	0.1847	388.15	4228.7	72.99	0.9664
263.15	180.36	6.892	0.2048	393.15	4606.0	77.97	1.026
268.15	217.47	7.969	0.2258	398.15	5008.9	83.26	1.092
273.15	260.23	9.152	0.2476	403.15	5439.1	88.90	1.165
278.15	309.17	10.45	0.2699	408.15	5898.5	94.92	1.248
283.15	364.87	11.85	0.2929	413.15	6389.1	101.4	1.342
288.15	427.89	13.38	0.3165	416.25	6710.0	105.7	1.410
293.15	498.82	15.02	0.3405				

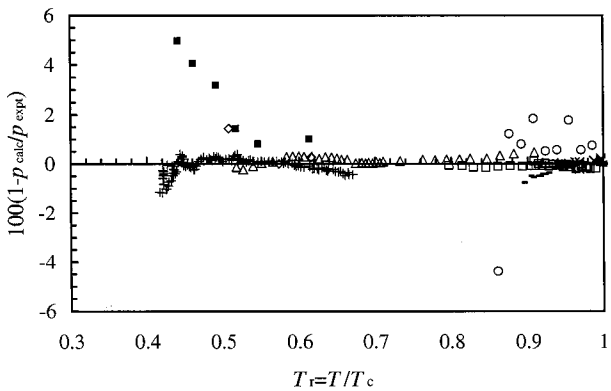

FIG. 24. Comparison of vapor-pressure data for CH_3F with values calculated from the extended corresponding-states principle: (−) Biswas *et al.* (1989); (×) Bominaar *et al.* (1987); (○) Collie (1889); (□) Demiriz *et al.* (1993); (◇) Fonseca and Lobo (1994); (■) Grosse *et al.* (1940); (△) Michels and Wassenaar (1948); (+) Oi *et al.* (1983).

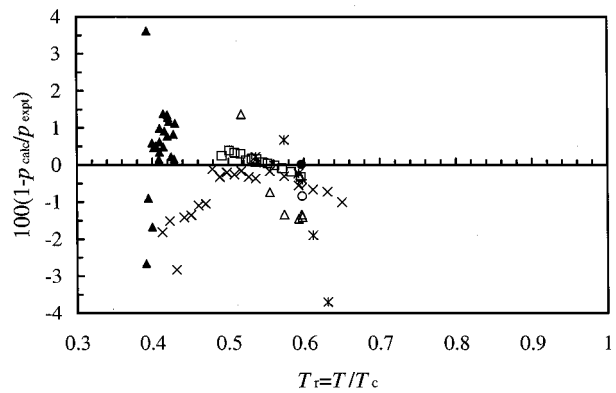

FIG. 25. Comparison of vapor-pressure data for CH_3I with values calculated from the extended corresponding-states principle: (△) Beersmans and Jungers (1947); (□) Boublik and Aim (1972); (●) Brown and Acree (1916); (*) Fahim and Moelwyn-Hughes (1956); (◇) Moelwyn-Hughes and Missen (1957); (○) Smyth and McAlpine (1934); (+) Thorpe and Rodger (1897); (×) Wolff *et al.* (1976); (▲) Wren and Vikis (1982).

(1956) reported the experimental data from 283.15 K to 333.15 K and 220 to 1300 mm Hg. Boublik and Aim (1972) used a carefully purified sample and reported data from 259.35 to 314.55 K. Temperatures were measured to 1 mK and pressures to 0.05 mm Hg. The low-temperature data agree with the values calculated from the present method in Table 3 and Fig. 25. The smoothed pressures, along with their first and second derivatives, as a function of temperature in the range between the triple point and the critical point from the present method are presented in Table 29.

5. The Present Method Uncertainty

Generally speaking, vapor pressures determined by the extended corresponding-states method lie within the experimental uncertainties for the most accurate data since the present method has been extensively tested in previous works. The average absolute deviations between the vapor pressures obtained from the present method, Eq. (11), and the experimental data are listed in Table 3 and shown in Figs. 1–25 for these substances. The uncertainties of the present

TABLE 28. The smoothed pressures, along with their first and second derivatives, as function of temperature for CH_3F

T(K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)	T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)
131.36	0.43127	5.728E-02	6.658E-03	223.15	389.21	15.96	0.5006
133.15	0.54512	7.029E-02	7.910E-03	228.15	475.50	18.60	0.5527
138.15	1.0125	0.1204	1.240E-02	233.15	575.60	21.49	0.6065
143.15	1.7935	0.1972	1.862E-02	238.15	690.88	24.66	0.6620
148.15	3.0442	0.3100	2.691E-02	243.15	822.71	28.12	0.7193
153.15	4.9726	0.4702	3.759E-02	248.15	972.53	31.86	0.7784
158.15	7.8462	0.6904	5.096E-02	253.15	1141.8	35.90	0.8397
163.15	12.000	0.9846	6.724E-02	258.15	1332.1	40.26	0.9036
168.15	17.841	1.368	8.663E-02	263.15	1545.0	44.94	0.9706
173.15	25.855	1.856	0.1092	268.15	1782.1	49.97	1.042
178.15	36.606	2.466	0.1351	273.15	2045.3	55.37	1.118
183.15	50.743	3.213	0.1643	278.15	2336.5	61.16	1.200
188.15	68.994	4.114	0.1967	283.15	2657.6	67.38	1.290
193.15	92.168	5.185	0.2322	288.15	3011.0	74.07	1.389
194.85	101.325	5.591	0.2449	293.15	3399.2	81.29	1.500
198.15	121.15	6.441	0.2706	298.15	3824.9	89.09	1.625
203.15	156.91	7.896	0.3119	303.15	4291.3	97.57	1.767
208.15	200.47	9.564	0.3557	308.15	4801.9	106.8	1.931
213.15	252.93	11.46	0.4019	313.15	5360.8	116.9	2.123
218.15	315.44	13.59	0.4502	317.42	5880.0	126.4	2.319

TABLE 29. The smoothed pressures, along with their first and second derivatives, as function of temperature for CH_3I

T(K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)	T (K)	p (kPa)	dp/dT (kPa/K)	d^2p/dT^2 (kPa/K^2)
206.71	0.2497	2.204E-02	1.714E-03	368.15	458.98	11.10	0.2026
208.15	0.2833	2.463E-02	1.883E-03	373.15	517.04	12.14	0.2143
213.15	0.4327	3.572E-02	2.580E-03	378.15	580.47	13.24	0.2263
218.15	0.6470	5.075E-02	3.466E-03	383.15	649.55	14.40	0.2383
223.15	0.9484	7.074E-02	4.572E-03	388.15	724.59	15.62	0.2506
228.15	1.3647	9.688E-02	5.929E-03	393.15	805.89	16.91	0.2630
233.15	1.9297	0.1305	7.569E-03	398.15	893.77	18.25	0.2755
238.15	2.6846	0.1731	9.522E-03	403.15	988.54	19.66	0.2882
243.15	3.6784	0.2263	1.182E-02	408.15	1090.5	21.14	0.3011
248.15	4.9683	0.2919	1.448E-02	413.15	1200.0	22.67	0.3142
253.15	6.6211	0.3718	1.754E-02	418.15	1317.4	24.28	0.3275
258.15	8.7132	0.4680	2.101E-02	423.15	1442.9	25.95	0.3411
263.15	11.331	0.5826	2.491E-02	428.15	1577.0	27.69	0.3549
268.15	14.573	0.7178	2.926E-02	433.15	1719.9	29.50	0.3692
273.15	18.548	0.8759	3.406E-02	438.15	1872.1	31.38	0.3839
278.15	23.374	1.059	3.932E-02	443.15	2033.9	33.34	0.3990
283.15	29.185	1.270	4.504E-02	448.15	2205.6	35.37	0.4148
288.15	36.123	1.510	5.123E-02	453.15	2387.7	37.49	0.4312
293.15	44.342	1.783	5.788E-02	458.15	2580.6	39.69	0.4484
298.15	54.009	2.090	6.497E-02	463.15	2784.8	41.97	0.4665
303.15	65.302	2.433	7.251E-02	468.15	3000.5	44.35	0.4856
308.15	78.408	2.816	8.047E-02	473.15	3228.5	46.83	0.5058
313.15	93.527	3.239	8.885E-02	478.15	3469.0	49.41	0.5274
315.48	101.32	3.451	9.289E-02	483.15	3722.8	52.11	0.5505
318.15	110.87	3.705	9.762E-02	488.15	3990.3	54.92	0.5753
323.15	130.65	4.216	0.1068	493.15	4272.2	57.87	0.6020
328.15	153.10	4.773	0.1163	498.15	4569.2	60.95	0.6309
333.15	178.46	5.379	0.1261	503.15	4882.0	64.18	0.6622
338.15	206.98	6.035	0.1363	508.15	5211.3	67.57	0.6963
343.15	238.90	6.742	0.1467	513.15	5558.0	71.15	0.7336
348.15	274.49	7.502	0.1574	518.15	5923.1	74.92	0.7747
353.15	314.01	8.317	0.1684	523.15	6307.5	78.90	0.8202
358.15	357.75	9.187	0.1796	528.00	6700.0	83.00	0.8710
363.15	405.97	10.11	0.1910				

method were determined to be approximately 0.05%–0.1% in the vapor pressure for substances which have highly accurate experimental data, even in a limited range, that are comparable to that accuracy. The uncertainties are less than 1% for the first derivative and are several percentages for the second derivative according to our mathematical experience. Considering that uncertainties in the available data for some substances studied in this work are not within 0.1%, the uncertainties of the present model would be higher so that the corresponding tabulated data are less accurate.

Note added in proof. A work by Magee and Duarte-Garza (2000) appeared in International Journal of Thermophysics after completion of this article requires brief mention. They have derived the vapor pressures of trifluoromethane between the normal boiling point and the triple point from the isochoric internal-energy measurements in the two-phase region. This result verifies the reproduced values from the present method within 1% at the triple point, where the direct measurements have shown systematic discrepancies in several percentages as shown in Fig. 15. At temperatures well below the normal boiling point, vapor pressures measured with traditional techniques are often inaccurate. In some cases, volatile impurities will influence the vapor pressure measurement, making it appear larger than the true value for the pure substance. Another common problem is that pressure gauges are not accurate enough under such a low-pressure fluid state. This situation can be remedied to some extent by the theoretical methods, for example, the derivative from the thermodynamic consistency or the extended corresponding-states principle.

6. Acknowledgments

The financial support from the Foundations of the Chinese Academy of Sciences, Departments of Personnel and of Education is gratefully appreciated. The author would like to thank numerous people: Dr. Douglas Ambrose at University College London, Dr. Walter Blanke at Physikalisch-Technische Bundesantalt, Braunschweig, Dr. Marcia L. Huber, Dr. Eric W. Lemmon, Dr. Joseph W. Magee, and Dr. Lloyd A. Weber at NIST for providing reprints, sharing professional experience, and making productive comments. The author would also like to thank Editor Malcolm W. Chase and Linda D. Decker during the review process of this manuscript. Special thanks are extended to Wei Li and Yan-Li Xie at Tsinghua University and Huai-Zhou Zhao at Beijing Nor-

mal University, and Yan Li and Shou-Gang Wang at the Chinese Academy of Sciences for partially assisting data collection and compilation.

7. References

Adams, R. A. and F. P. Stein, 1971, J. Chem. Eng. Data **16**, 146.
Albright, L. F. and J. J. Martin, 1952, Ind. Eng. Chem. **44**, 188.
Banks, A. A., H. J. Emeleus, R. N. Haszeldine, and V. Kerrigan, 1948, J. Chem. Soc. 2188.
Beersmans, J. and J. C. Jungers, 1947, Bull. Soc. Chim. Belg. **56**, 238.
Benning, A. F. and R. C. McHarness, 1939, Ind. Eng. Chem. **31**, 912.
Benning, A. F. and R. C. McHarness, 1940, Ind. Eng. Chem. **32**, 497.
Birchall, J. M. and R. N. Haszeldine, 1959, J. Chem. Soc. 13.
Biswas, S. N., C. A. Ten Seldam, S. A. R. C. Bominaar, and N. J. Trappeniers, 1989, Fluid Phase Equil. **49**, 1.
Blanke, W. and R. Weiss, PTB-Ber. W-48, Braunschweig, Feb., 1992.
Bominaar, S. A. R. C., S. N. Biswas, N. J. Trappeniers, and C. A. Ten Seldam, 1987, J. Chem. Thermodyn. **19**, 959.
Booth, H. S. and E. M. Bixby, 1932, Ind. Eng. Chem. **24**, 637.
Booth, H. S. and C. F. Swinehart, 1935, J. Am. Chem. Soc. **57**, 1337.
Brown, B. M. and S. F. Acree, 1916, J. Am. Chem. Soc. **38**, 2145.
Boublik, T. and K. Aim, 1972, Coll. Czechoslov. Chem. Commun. **37**, 3513.
Boublik, T., V. Fried, and E. Hala, *The Vapour Pressures of Pure Substances*, 2nd revised ed. (Elsevier, New York, 1984).
Campbell, A. N. and R. M. Chatterjee, 1968, Can. J. Chem. **46**, 575.
Campbell, A. N. and R. M. Chatterjee, 1969, Can. J. Chem. **47**, 3893.
Cohen, E. R. and B. N. Taylor, 1988, J. Phys. Chem. Ref. Data **17**, 1795.
Collie, N., 1889, J. Chem. Soc. **55**, 110.
Daubert, T. E. and R. P. Danner, *Physical and Thermodynamic Properties of Pure Chemicals, Data Compilation* (Hemisphere, Washington, 1989).
Davidson, N., 1951, J. Am. Chem. Soc. **73**, 467.
Davidson, N. and J. H. Sullivan, 1949, J. Chem. Phys. **17**, 176.
Defibaugh, D. R., G. Morrison, and L. A. Weber, 1994, J. Chem. Eng. Data **39**, 333.
Demiriz, A. M., R. Kohlen, C. Koopmann, D. Moeller, P. Sauermann, G. A. Iglesias-Silva, and F. Kohler, 1993, Fluid Phase Equil. **85**, 313.
de Vries, B., *Thermodynamische Eigenschaften der alternativen Kltemittel R-32, R-125, R-143a*, DKV-Forsch.-Ber. Nr. 55 (DKV, Stuttgart, 1997).
Duan, Y. Y., M. S. Zhu, and L. Z. Han, 1996, Fluid Phase Equil. **121**, 227.
Egan, C. J. and J. D. Kemp, 1938, J. Am. Chem. Soc. **60**, 2097.
Fahim, R. B. and E. A. Moelwyn-Hughes, 1956, J. Chem. Soc. 1035.
Fernandez-Fassnacht, E. and F. del Rio, 1985, Cryogenics **25**, 204.
Findlay, T. J. V. and R. S. Kenyon, 1969, Aust. J. Chem. **22**, 865.
Fonseca, I. M. A. and L. Q. Lobo, 1994, J. Chem. Thermodyn. **26**, 671.
Forbes, G. S. and H. H. Anderson, 1945, J. Am. Chem. Soc. **67**, 1911.
Fu, Y. D., L. Z. Han, and M. S. Zhu, 1995, Fluid Phase Equil. **111**, 273.
Gilkey, W. K., F. W. Gerard, and M. E. Bixler, 1931, Ind. Eng. Chem. **23**, 364.
Giuliani, G., S. Kumar, and F. Polonara, 1995, Fluid Phase Equil. **109**, 265.
Glew, D. N, 1960, Can. J. Chem. **38**, 208.
Goodwin, A. R. H., D. R. Defibaugh, and L. A. Weber, 1992, Int. J. Thermophys. **13**, 837.
Gordon, A. R. and E. A. MacWilliam, 1946, Can. J. Res. **24**, 292.
Gregory, R. A. and D. W. G. Style, 1936, Trans. Faraday Soc. **32**, 724.
Gross, P. M. and J. H. Saylor, 1931, J. Am. Chem. Soc. **53**, 1744.
Grosse, A. V., R. C. Wackher, and C. B. Linn, 1940, J. Phys. Chem. **44**, 275.
Haendel, G., R. Kleingahm, and W. Wagner, 1992, J. Chem. Thermodyn. **24**, 697.
Handa, Y. P., D. V. Fenby, and D. E. Jones, 1975, J. Chem. Thermodyn. **7**, 337.
Haszeldine, R. N., 1951, J. Chem. Soc. 584.
Haszeldine, R. N., 1952, J. Chem. Soc. 4259.
Henne, A. L., 1937, J. Am. Chem. Soc. **59**, 1200.
Holcomb, C. D., V. G. Niesen, L. J. van Poolen, and S. L. Outcalt, 1993, Fluid Phase Equil. **91**, 145.
Holldorff, H. and H. Knapp, 1988, Fluid Phase Equil. **40**, 113.
Hongo, M., M. Kusunoki, H. Matsuyama, T. Takagi, K. Mishima, and Y. Arai, 1990, J. Chem. Eng. Data **35**, 414.
Hori, K., S. Okazaki, M. Uematsu, and K. Watanabe, *An Experimental Study of Thermodynamic Properties of Trifluoromethane*, in Proceedings of the 8th Symposium on Thermophysical Properties, Gaithersburg, MD, 1981, Vol. 2, p. 380, edited by J. V. Sengers (ASME, NY, 1982).
Hou, Y. C. and J. J. Martin, 1959, AIChE J. **5**, 125.
Hsu, C. C. and J. J. McKetta, 1964, J. Chem. Eng. Data **9**, 45.
Huber, M. L. and H. J. M. Hanley, in *Transport Properties of Fluids: Their Correlation, Prediction and Estimation*, edited by J. Millat, J. H. Dymond, and C. A. Nieto de Castro (Cambridge University Press, New York, 1996).
Hudson, J. W. and M. van Winkle, 1969, J. Chem. Eng. Data **14**, 310.
Ivin, K. J. and F. S. Dainton, 1947, Trans. Faraday Soc. **43**, 32.
Jain, D. V. S., V. K. Gupta, and B. S. Lark, 1971, Indian J. Chem. **9**, 465.
Khurma, J. R., O. Muthu, S. Munjal, and B. D. Smith, 1983, J. Chem. Eng. Data **28**, 412.
Kobayashi, M. and H. Nishiumi, 1998, Fluid Phase Equil. **144**, 191.
Kohlen, R., H. Kratzke, and S. Mueller, 1985, J. Chem. Thermodyn. **17**, 1141.
Kubic, W. L. and F. P. Stein, 1981, Fluid Phase Equil. **5**, 289.
Kudchadker, A. P., S. A. Kudchadker, R. P. Shukla, and P. R. Patnaik, 1979, J. Phys. Chem. Ref. Data **8**, 499.
Kumagai, A. and H. Iwasaki, 1978, J. Chem. Eng. Data **23**, 193.
Leland, T. W. and P. S. Chappelear, 1968, Ind. Eng. Chem. **60**(7), 15.
Liu, Y., R. A. Greenkorn, and K. C. Chao, 1981, J. Chem. Eng. Data **26**, 386.
Magee, J. W., 1996, Int. J. Thermophys. **17**, 803.
Magee, J. W. and H. A. Duarte-Garza, 2000, Int. J. Thermophys. **21**, 1351.
Malbrunot, P. F., P. A. Meunier, G. M. Scatena, W. H. Mears, K. P. Murphy, and J. V. Sinka, 1968, J. Chem. Eng. Data **13**, 16.
Mansoorian, H., K. R. Hall, J. C. Holste, and P. T. Eubank, 1981, J. Chem. Thermodyn. **13**, 1001.
McDonald, R. A., S. A. Shrader, and D. R. Stull, 1959, J. Chem. Eng. Data **4**, 311.
McGlashan, M. L. and R. P. Rastogi, 1958, Trans. Faraday Soc. **54**, 496.
McGlashan, M. L., J. E. Prue, and I. E. J. Sainsbury, 1954, Trans. Faraday Soc. **50**, 1284.
Menzel, W. and F. Mohry, 1933, Z. Anorg. Chem. **210**, 257.
Messerly, G. H. and J. G. Aston, 1940, J. Am. Chem. Soc. **62**, 886.
Michels, A. and T. Wassenaar, 1948, Physica **14**, 104.
Michels, A., T. Wassenaar, G. J. Wolkers, C. Prins, and L. Klundert, 1966, J. Chem. Eng. Data **11**, 449.
Miller, R. C. and C. P. Smyth, 1957, J. Am. Chem. Soc. **79**, 20.
Moelwyn-Hughes, E. A. and R. W. Missen, 1957, Trans. Faraday Soc. **53**, 607.
Mollerup, J. and A. Fredenslund, 1976, J. Chem. Eng. Data **21**, 299.
Morgan, S. O. and W. A. Yager, 1940, Ind. Eng. Chem. **32**, 1519.
Mueller, C. R. and A. J. Ignatowski, 1960, J. Chem. Phys. **32**, 1430.
Neilson, E. F. and D. White, 1957, J. Am. Chem. Soc. **79**, 5618.
Nodiff, E. A., A. V. Grosse, and M. Hauptschein, 1953, J. Org. Chem. 235.
Oi, T., J. Shulman, A. Popowicz, and T. Ishida, 1983, J. Phys. Chem. **87**, 3153.
Okano, T., M. Uematsu, and K. Watanabe, 1987, Int. J. Thermophys. **8**, 217.
Osborne, D. W., C. S. Garner, R. N. Doescher, and D. M. Yost, 1941, J. Am. Chem. Soc. **63**, 3496.
Perez, P., J. Valero, and M. Gracia, 1994, J. Chem. Eng. Data **39**, 789.
Philippe, R., C. Jambon, and P. Clechet, 1973, J. Chem. Thermodyn. **5**, 431.
Philippe, R., J. Jose and P. Clechet, 1971, Bull. Soc. Chim. France **8**, 2866.
Phillips, T. W. and K. P. Murphy, 1970, J. Chem. Eng. Data **15**, 304.
Pitzer, K. S. and R. F. Curl, 1957, J. Am. Chem. Soc. **79**, 2369.
Pitzer, K. S., D. Z. Lippmann, R. F. Curl, C. M. Huggins, and D. E. Petersen, 1955, J. Am. Chem. Soc. **77**, 3433.
Popowicz, A., T. Oi, J. Shulman, and T. Ishida, 1982, J. Chem. Phys. **76**, 3732.
Rastogi, R. P., J. Nath, and J. Misra, 1967, J. Phys. Chem. **71**, 1277.
Reid, R. C., J. M. Prausnitz, and B. E. Poling, *The Properties of Gases and Liquids*, 4th ed. (McGraw–Hill, New York, 1987).
Riedel, L., 1954, Chem. Ing. Tech. **26**, 83.
Sato, T., H. Sato, and K. Watanabe, 1994, J. Chem. Eng. Data **39**, 851.
Scatchard, G. and C. L. Raymond, 1938, J. Am. Chem. Soc. **60**, 1278.
Scatchard, G., S. E. Wood, and J. M. Mochel, 1939, J. Am. Chem. Soc. **61**, 3206.
Simon, M., C. M. Knobler, and A. G. Duncan, 1967, Cryogenics **7**, 138.
Smith, J. H. and E. L. Pace, 1969, J. Phys. Chem. **73**, 4232.

Smith, B. D. and R. Srivastava, *Thermodynamic Data for Pure Compounds* (Elsevier, Amsterdam, 1986).
Smyth, C. P. and K. B. McAlpine, 1934, J. Chem. Phys. **2**, 499.
Stein, F. P. and P. C. Proust, 1971, J. Chem. Eng. Data **16**, 389.
Thornton, N. V., A. B. Burg, and H. I. Schlesinger, 1933, J. Am. Chem. Soc. **55**, 3177.
Thorpe, T. E. and J. W. Rodger, 1897, J. Chem. Soc. **71**, 360.
Valentine, R. H., G. E. Brodale, and W. F. Giauque, 1962, J. Phys. Chem. **66**, 392.
van der Waals, J. D. *On the Continuity of the Gaseous and Liquid States*, edited by J. S. Rowlinson, Studies in Statistical Mechanics, Vol. 14 (North-Holland, Amsterdam, 1988).
Varshni, Y. P. and H. Mohan, 1954, J. Indian Chem. Soc. **32**, 211.
Wang, J. L. H., L. Boublikova, and B. C. Y. Lu, 1970, J. Appl. Chem. **20**, 172.
Weber, L. A., 1989, J. Chem. Eng. Data **34**, 452.
Weber, L. A. and A. R. H. Goodwin, 1993, J. Chem. Eng. Data **38**, 254.
Weber, L. A. and A. M. Silva, 1994, J. Chem. Eng. Data **39**, 808.
Widiatmo, J. V., H. Sato, and K. Watanabe, 1994, J. Chem. Eng. Data **39**, 304.
Williams, D. and C. C. Meeker, 1948, Anal. Chem. **20**, 733.
Willock, J. M. and M. van Winkle, 1970, J. Chem. Eng. Data **15**, 281.
Wolff, H., R. Götz, and O. Schiller, 1976, Bericht. Bunsen-Gesellschaft **80**, 1321.
Wong, K. F. and C. A. Eckert, 1969, J. Chem. Eng. Data **14**, 432.
Wren, D. J. and A. C. Vikis, 1982, J. Chem. Thermodyn. **14**, 435.
Xiang, H. W., 1998, ''A new simple extended corresponding-states principle for polar fluids: vapor pressure and second virial coefficient,'' in Proceeding of the 15th IUPAC International Conference on Chemical Thermodynamics, Porto, Portugal, July, 1998.
Xiang, H. W., Properties and the corresponding-states principle, in Proceeding of the AIChE 2000 Annual Meeting, Los Angeles, USA, November, 2000.
Xiang, H. W., Int. J. Thermophys. **22**, 919 (2001a).
Xiang, H. W., Fluid Phase Equil. **187**, 221 (2001b).
Xiang, H. W., Chem. Eng. Sci. (in press, 2001c).
Xiang, H. W. and L. C. Tan, 1994, Int. J. Thermophys. **15**, 711.
Yurttas, L., J. C. Holste, K. R. Hall, B. E. Gammon, and K. N. Marsh, 1990, Fluid Phase Equil. **59**, 217.
Zellhoefer, G. F., M. J. Copley, and C. S. Marvel, 1938, J. Am. Chem. Soc. **60**, 1337.