Thermodynamic Properties of Oxygen from the Triple Point to 300 K with Pressures to 80 MPa

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A joint project by the authors has resulted in two new thermodynamic property formulations for oxygen. The fundamental equation explicit in Helmholtz energy by Schmidt and Wagner has been used for the calculation of the property tables presented here, and for comparisons of calculated properties to the experimental data. The formulation by Stewart and Jacobsen is used in this paper in comparisons of properties calculated by the two formulations. These comparisons provide the basis for independent assessment of the accuracy of the available data and calculated properties. The procedures used in determining the formulations by Wagner and Schmidt, and by Stewart and Jacobsen were published earlier.

The fundamental equation is valid for thermodynamic properties of oxygen from the freezing line to 300 K at pressures to 80 MPa. A separate vapor pressure equation and equations for the saturated liquid and saturated vapor densities and the ideal gas heat capacity are included. Functions for calculating internal energy, enthalpy, entropy, isochoric heat capacity (C_v), isobaric heat capacity (C_p) and velocity of sound are also included. Tables of thermodynamic properties of oxygen are given within the range of validity of the fundamental equation.

The fundamental equation reported here may be used to calculate densities with an uncertainty of 0.10 percent, heat capacities within 2.0 percent, and velocity of sound values within 1.0 percent. These uncertainty values are valid for the range outside of the critical region. Comparisons of calculated properties to experimental data are included to verify the accuracy of the formulation.

Key words: density; enthalpy; entropy; equation of state; heat capacity; oxygen; property table; thermodynamic properties; velocity of sound.

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Nomenclature

Symbol	*Physical quantity*	*Unit*
T	Temperature	K
P	Pressure	MPa
ρ	Density	mol/dm^3
v	Molar volume	dm^3/mol
Z	Compressibility factor, $Z = P/(\rho RT)$	
U	Internal energy	J/mol
A	Helmholtz energy	J/mol
G	Gibbs energy	J/mol
H	Enthalpy	J/mol
S	Entropy	J/(mol K)
C_p	Isobaric heat capacity	J/(mol K)
C_v	Isochoric heat capacity	J/(mol K)

Symbol	*Physical quantity*	*Unit*
C_σ	Saturation heat capacity	J/(mol K)
W	Velocity of sound	m/s
B	Second virial coefficient	dm^3/mol
C	Third virial coefficient	$(dm^3/mol)^2$
R	Gas constant (8.31434)	J/(mol K)
M	Molar mass of oxygen (31.9988 g/mol)	
α	Nondimensional Helmholtz energy, $\alpha = A/(RT)$	
τ,Θ	Reduced temperature, $\tau = T_c/T$ or $\tau = (T_c-T)/T$, $\Theta = T/T_c$	
δ	Reduced density, $\delta = \rho/\rho_c$	
π	Reduced pressure, $\pi = P/P_c$	

Superscripts

$^\circ$	Ideal gas property
$'$	Saturated liquid property
$''$	Saturated vapor property

Subscripts

$_o$	Reference state property
$_c$	Critical point property
$_\sigma$	Property at saturation
$_{tp}$	Triple point property
$_{nbp}$	Normal boiling point value
$_{eqn}$	Calculated using an equation
$_{data}$	Experimental value
$_{Maxwell}$	Saturation value calculated with the fundamental equation using the Maxwell criteria
$_{virial}$	Calculated with a truncated virial equation

Additional abbreviations

exp	Exponential function
Δ	Difference

Fixed Points for Oxygen

Symbol		*QuantityValue*
T_c	Critical temperature	154.581 K
P_c	Critical pressure	5.043 MPa
ρ_c	Critical density	13.63 mol/dm^3
T_{tp}	Triple point temperature	54.361 K
P_{tp}	Triple point pressure	146.33 Pa
T_{nbp}	Normal boiling point temp.	90.188 K
T_0	Reference temperature	298.15 K
P_0	Reference pressure	0.101325 MPa
H_0°	Reference enthalpy at T_0 (ideal gas value)	8682 J/mol
S_0°	Reference entropy at T_0 and P_0 (ideal gas value)	205.037 J/(mol K)

1. Introduction

This paper is one of a series from the Center for Applied Thermodynamic Studies published in the Journal of Physical and Chemical Reference Data. This series includes formulations and tables for nitrogen[1], ethylene[2] and argon[3], in addition to this work on oxygen. A similar format has been used in these papers. Studies are now in progress on a formulation for the thermodynamic properties of air. The work on air includes procedures for the prediction of air properties from the properties of nitrogen, argon and oxygen which utilize the formulations for the constituents[1,3] and this work on oxygen.

The project for determining new thermodynamic property formulations for oxygen was instituted in 1976 as a joint project between W. Wagner of the Institut für Thermo- und Fluiddynamik of the Ruhr-Universität Bochum (of Germany) and R. B. Stewart and R. T Jacobsen of the Center for Applied Thermodynamic Studies at the University of Idaho (U.S.A.). In the ensuing years, the emphasis of this work has been the development of new procedures for determining accurate equations of state. The result of this collaboration has been the development of two accurate formulations for oxygen, one by Schmidt and Wagner[4] and the second by Stewart and Jacobsen with Wagner as coauthor[5].

A book of thermodynamic properties of oxygen[6] was published in 1987 as the ninth volume in the series from the International Union of Pure and Applied Chemistry. This book was written and compiled by W. Wagner and K. M. de Reuck on the basis of the work by W. Wagner, R. Schmidt and J. Ewers at the Ruhr Universität Bochum, F.R.G. and R. B. Stewart and R. T Jacobsen at the University of Idaho, U.S.A. The formulation by Schmidt and Wagner[4] was selected by the collaborators for this book[6]. The paper by Schmidt and Wagner[4] does not include tabulated thermodynamic properties of oxygen.

The formulation by Schmidt and Wagner[4] has been used to calculate the thermodynamic properties presented here. This formulation is presented in Sec. 5. Comparisons between experimental thermodynamic property data and calculated values are given in Sec. 6.

The formulation by Stewart and Jacobsen is published in their report[5], which includes comparisons between the formulations from the Ruhr-Universität Bochum and the Center for Applied Thermodynamic Studies. The comparisons given in this report[5] show that, with the exception of the critical region and of the saturation properties, the accuracy of the formulations is approximately the same. Thermodynamic properties obtained from both agree within the estimated accuracies of the formulations. This close agreement provides assurance that the calculated property values and property tables given in this work are consistent with the available experimental data within the limits of current correlation techniques. A brief summary of the comparisons of calculated properties is given in Appendix B.

Throughout this manuscript the word "data" is used to refer to experimental measurements. The term "formulation" refers to the equation or equations required for calculation of thermodynamic properties. The term "fundamental equation" is used to describe the equation of state used in this work. This equation is explicit in dimensionless Helmholtz energy and therefore represents

the thermodynamic surface without additional functions. Separate ancillary equations are given as a convenience. These ancillary equations include functions for the ideal gas heat capacity, the vapor pressure, saturated liquid density, and saturated vapor density. The equations for the vapor pressure and for the coexistence densities were used to define liquid-vapor coexistence states as a part of the data set used in determining the coefficients of the fundamental equation. These ancillary equations are useful as estimating functions for iterative calculations, e.g., the definition of coexistence states from the fundamental equation using the Maxwell criterion.

1.1. Prior Correlations of Thermodynamic Properties of Oxygen

Compilations of thermodynamic properties for oxygen published prior to 1960 were limited in range by the paucity of the data, and in accuracy by the imprecision of the limited data that had been published. Until 1960, the only available P-ρ-T measurements of liquid oxygen were for the saturated liquid. The imprecision and scarcity of these saturation data for pressures above one atmosphere made any compilation for liquid properties subject to considerable uncertainty. The vapor P-ρ-T data available prior to 1960 were limited to relatively few measurements at low temperatures, and data at ambient temperatures. The available measurements omitted wide ranges of values, making it necessary to make many estimations, and extensive interpolations and extrapolations.

In 1965, preliminary P-ρ-T data from a measurement program then in progress at the National Bureau of Standards in Boulder, Colorado were made available to R. B. Stewart for use in his doctoral studies at the University of Iowa. The final P-ρ-T measurements were made available shortly thereafter. The first wide range formulation for oxygen based on modern data was published by Stewart[7] in 1966. The data which formed the primary basis for this formulation were published by Weber[8] in 1970. As a consequence, Stewart's dissertation received wide spread distribution. For example, this work was used extensively at NASA centers for design of spacecraft systems and for monitoring life support systems.

The 1970 publication of Weber[8] included a new thermodynamic property formulation and a table of thermodynamic properties. The formulation included four different procedures for property calculation for four specified ranges of temperature and density. Although this formulation represents the data with high accuracy, the calculation of derived thermodynamic properties is cumbersome and this formulation was not widely used for property calculations for system design and analysis.

In 1973, Bender[9] published pressure explicit equations of state for nitrogen, argon and oxygen in a monograph which presents a mixture equation of state derived from the equations of state for the pure substances. The equation of state for oxygen was based on the new P-ρ-T and C_v measurements from the National Bureau of Standards. Phase equilibrium data were also used in determining the equations of state to provide equations which conformed closely to the Maxwell criteria. Thermodynamic property tables were not included in this monograph.

In 1977, Stewart and Jacobsen[10] published a formulation for the thermodynamic properties of oxygen which was derived using new procedures for determining an accurate equation of state that had been developed during the period 1969 to 1977. The primary basis for this formulation was the P-ρ-T data published by Weber[8].

In 1977, Weber[11] published new P-ρ-T data for oxygen which extended the range in pressure from 33 MPa, the maximum pressure of the earlier data[8], to 80 MPa. In 1978 Weber[12] published a new thermodynamic property formulation based on his earlier measurements and the new high pressure data[11]. The form of the equation of state selected by Weber was a 32-term pressure-explicit equation introduced by Jacobsen and Stewart[1] for the correlation of the thermodynamic properties of nitrogen.

Also in 1977, extensive new P-ρ-T data for oxygen were published by Pentermann and Wagner[13]. These data supplement the data from Weber[8] and provide an independent set of P-ρ-T data for oxygen.

In 1981, a thermodynamic property formulation for oxygen was published by Sychev *et al.*[14] This work superseded earlier works by Vasserman, Kozavchinskii and Rabinovich (1966), and Vasserman and Rabinovich (1968), which are not referenced here. The equation of state used in this work gives the compressibility factor as a polynomial in reduced temperature and reduced density. Graphical comparisons of the P-ρ-T data from Weber[8] to calculated values indicate this equation deviates from the data with differences of 0.2 percent.

In 1981 and 1982, a fundamental equation, explicit in reduced Helmholtz energy was published by Ewers[15], and by Ewers and Wagner[16]. This equation was determined using a new optimization method. The equation published by Schmidt and Wagner[4] supersedes this work.

1.2. The Fundamental Equation

The fundamental equations by Schmidt and Wagner[4] and by Stewart and Jacobsen[5] are explicit in reduced Helmholtz energy. The Helmholtz energy is given by the fundamental equation

$$A(\rho,T) = A^{\circ}(\rho,T) + \bar{A}(\rho,T) , \qquad (1)$$

where $A^{\circ}(\rho,T)$ is the ideal gas contribution to the Helmholtz energy, and $\bar{A}(\rho,T)$ is the contribution represented by the compressibility of the real gas. The reduced form of the fundamental equation is a nondimensional potential function,

$$\alpha(\delta,\tau) = \alpha^{\circ}(\delta,\tau) + \bar{\alpha}(\delta,\tau) , \qquad (2)$$

where $\tau = T_c/T$, $\delta = \rho/\rho_c$, $\alpha^{\circ} = A^{\circ}/(RT)$ and $\bar{\alpha} = \bar{A}/(RT)$. Other thermodynamic properties are accessible as

derivative functions of the fundamental equation, and are given in Appendix A.

The range of validity of the fundamental equation for oxygen is from the triple point temperature to 300 K with pressures to 80 MPa. With a few exceptions, this equation represents the selected experimental P-ρ-T data to within the estimated accuracies of the available data.

In this paper, comparisons of calculated properties to experimental data illustrate the validity and the accuracy of the correlation. In all the comparisons, percentage deviations are defined as,

$$[(X_{\text{data}} - X_{\text{eqn}})/(X_{\text{data}})] \times 100 \qquad (3)$$

where X is the property compared. Detailed comparisons of calculated thermodynamic properties to experimental data are given in Sec. 6.

The fundamental equation may be used for the calculation of accurate tables of thermodynamic properties of oxygen within its range of applicability. The fundamental equation conforms closely to the Maxwell criteria for liquid-vapor phase equilibrium. Thus, the vapor pressures, the densities and the caloric properties of the coexistence states may be calculated with the fundamental equation using the Maxwell criteria. The saturation states may also be determined using the vapor pressure calculated from the vapor pressure equation. Vapor pressures from the fundamental equation are closely approximated by the vapor pressure equation, and the thermodynamic inconsistency with other states is very small. In the critical region, the fundamental equation for oxygen may be used for the calculation of pressure with only a small reduction in accuracy as compared to the remainder of the P-ρ-T surface.

2. Experimental Data for the Single Phase Region

The experimental data for oxygen are summarized below. These data were the basis for the development of the thermodynamic property formulation reported here. Some of the data in the data sets selected for determining the fundamental equation were not used in fitting the fundamental equation. However, all the data in the selected sets are compared to values calculated with the fundamental equation in Sec. 6. Sources for the property data with temperature, pressure and density ranges are tabulated. The data for the liquid-vapor coexistence states are summarized in Sec. 3.

2.1. P-ρ-T Data

The experimental P-ρ-T data for oxygen are summarized in Table 1. The distribution of the modern data is shown in Figs. 1 and 2. The older data have been superseded by the newer data and are only of historic interest. Comparisons to the older data are given by Stewart[7].

2.2. Heat capacity data

The measurements of the heat capacity data are summarized in Table 2. Other data of historical interest are included in listings given by Wagner *et al.*[6] Heat capacity values for the saturated liquid[36] were determined from the two-phase data by the experimenter. Figure 3 illustrates the loci of the more recent experimental data for the isochoric heat capacity, which were included in the data used for determining the fundamental equation.

2.3. Velocity of Sound Data

The published measurements of the velocity of sound for oxygen are summarized in Table 3. Figure 3 shows the distribution of the velocity of sound data from Straty and Younglove[42] and Van Itterbeek and Van Paemel[47].

2.4. Virial Coefficients

Values for the second and third virial coefficients have been determined in a correlation by Wagner, Ewers and Schmidt[59]. The P-ρ-T data used in this correlation were the measurements reported by Weber[8] and by Pentermann and Wagner[13] for densities below 6.815 mol/dm^3 at temperatures from 100 K to 300 K. Enthalpy of vaporization data were used to extend the data set to lower temperatures and included values from Frank and Clusius[60] at 90.188 K, from Clusius and Konnertz[61] at 90.188 K, from Furukawa and McCoskey[62] for temperatures from 68 K to 91.3 K, and from Suyama and Oishi[63] for temperatures from 84.9 to 90.4 K. The P-ρ-T data set was also extrapolated along the unity compressibility line to the Boyle temperature (406.29 K) by Ewers[15]. The coefficients reported here are for the virial equation of the form,

$$P/(\rho RT) = 1 + B(T)\rho + C(T)\rho^2 + \ldots \qquad (4)$$

The temperature dependence of the second and third virial coefficients, as determined by Wagner *et al.*[59], is represented by the following functions.

$$B(T) = b_1 + b_2 T^{-0.25} + b_3 T^{-3.5} + b_4 T^{-4.5} + b_5 T^{-5.5}, \qquad (5)$$

$$C(T) = c_1 T^{-0.25} + c_2 T^{-6} + c_3 T^{-6.75}, \qquad (6)$$

where temperature is in K, $B(T)$ in dm^3/mol, and $C(T)$ in (dm^3/mol)^2.

The coefficients for Eqs. (5) and (6) are given below.

$b_1 = 0.143389$ $\quad c_1 = 0.451336 \times 10^{-2}$
$b_2 = -0.629863$ $\quad c_2 = 0.987169 \times 10^{11}$
$b_3 = -0.577814 \times 10^{7}$ $\quad c_3 = -0.364928 \times 10^{13}$
$b_4 = 0.695858 \times 10^{9}$
$b_5 = -0.246023 \times 10^{11}$

TABLE 1. Summary of P-ρ-T data for oxygen

Source	Date	Range of values Temperature (K)	Range of values Pressure (MPa)	Number of data points
Amagat[17]	1893	273 to 473	10 to 304	123
Baidakov and Gurina[18]	1985	115 to 150	0.16 to 5.3	83
Baxter and Starkweather[19]	1924	273	0.1	1
Baxter and Starkweather[20]	1926	273	0.025 to 0.1	4
Ewers[15] [a]	1981	305 to 406	0.0 to 30.8	21
Hoge[21]	1950	154 to 155	4.9 to 5.1	26
Holborn and Otto[22]	1922	273 to 373	2 to 10	27
Kamerlingh Onnes and Hyndman[23]	1902	273 to 293	2.3 to 6.6	31
Kamerlingh Onnes and Kuypers[24]	1924	156 to 233	2.1 to 6.3	75
Kuypers and Kamerlingh Onnes[25]	1923	273 to 293	2.2 to 6.3	50
Masson and Dolley[26]	1923	298	3.0 to 12.7	20
Michels, Schamp and de Graaff[27]	1954	273 to 323	2.3 to 13.6	40
Nijhoff and Keesom[28]	1925	120 to 233	0.3 to 1.0	43
Pentermann and Wagner[13] [a]	1978	65 to 300	0.04 to 7.1	320
Streett and Sagan[29]	1975	96 to 250	0.4 to 69.3	70
Timrot and Borisoglebskii[30]	1961	83 to 153	1.0 to 19.6	283
Tsiklis and Kulikova[31]	1965	293 to 673	101 to 1013	37
Van Itterbeek and Verbeke[32]	1960	64 to 90	0.2 to 14.6	68
Van Itterbeek and Verbeke[33]	1961	77, 90	9.6 to 83.5	15
Van Urk and Nijhoff[34]	1924	273 to 293	3.6 to 6.3	28
Weber[8] [a]	1970	56 to 300	0.04 to 36.2	1481
Weber[11] [a]	1977	58 to 300	3.6 to 81.8	346

[a]Data selected for determining the fundamental equation.

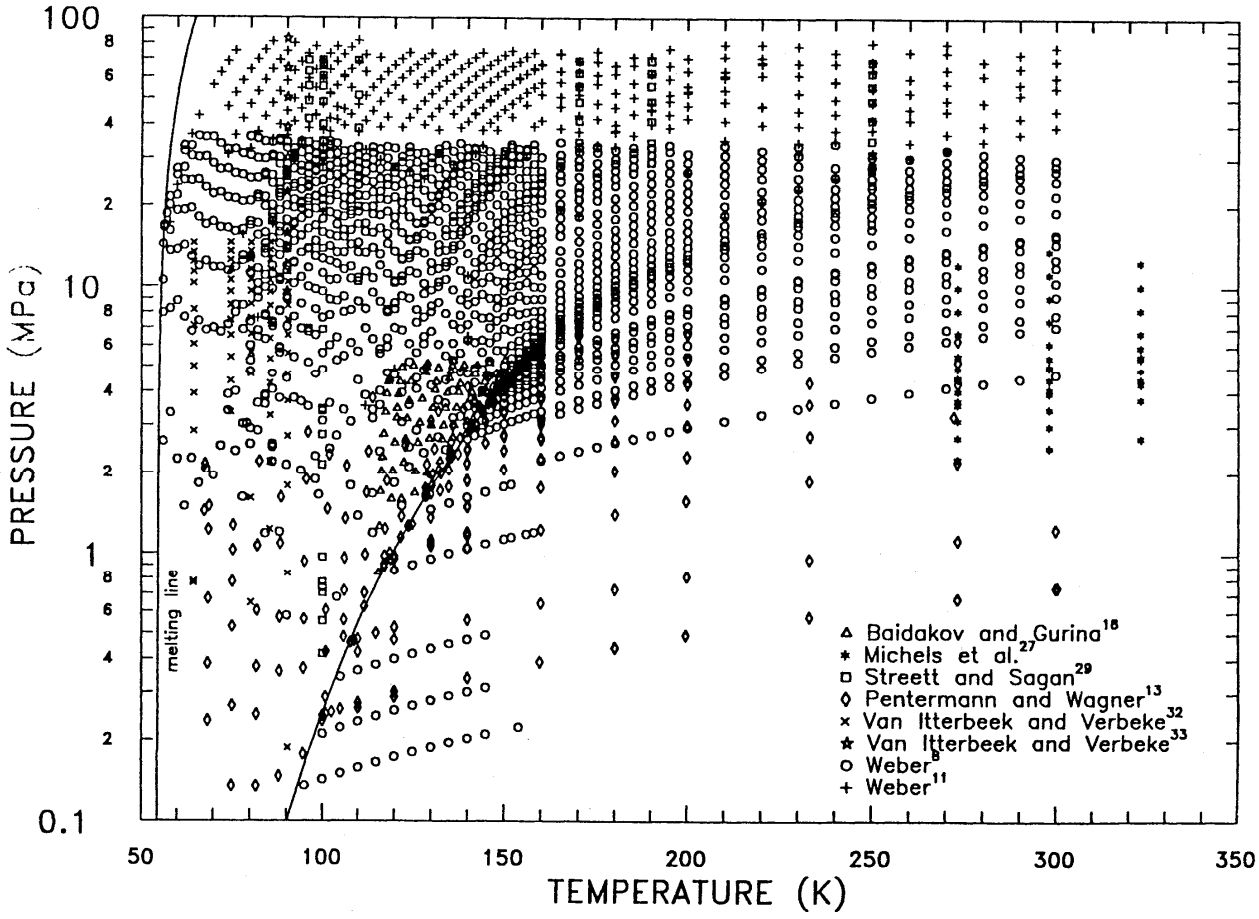

FIG. 1. P-ρ-T Data (P-T coordinates).

TABLE 2. Summary of heat capacity data for oxygen

Source	Date	Range of values Temperature (K)	Pressure (MPa)	Data form	Number of data points
Giauque and Johnston[35]	1929	57 to 90	vapor pressure	C_σ	24
Goodwin and Weber[36]	1969	57 to 152		C_σ	88
Goodwin and Weber[37]*	1969	56 to 284	0.3 to 35	C_v	159
Voronel *et al.*[38]	1964	154.6 to 160	(ρ = 0.408 g/dm^3)	C_v	45
Workman[39]	1931	299, 333	1 to 12.7	C_p	14

*Data selected for determining the fundamental equation.

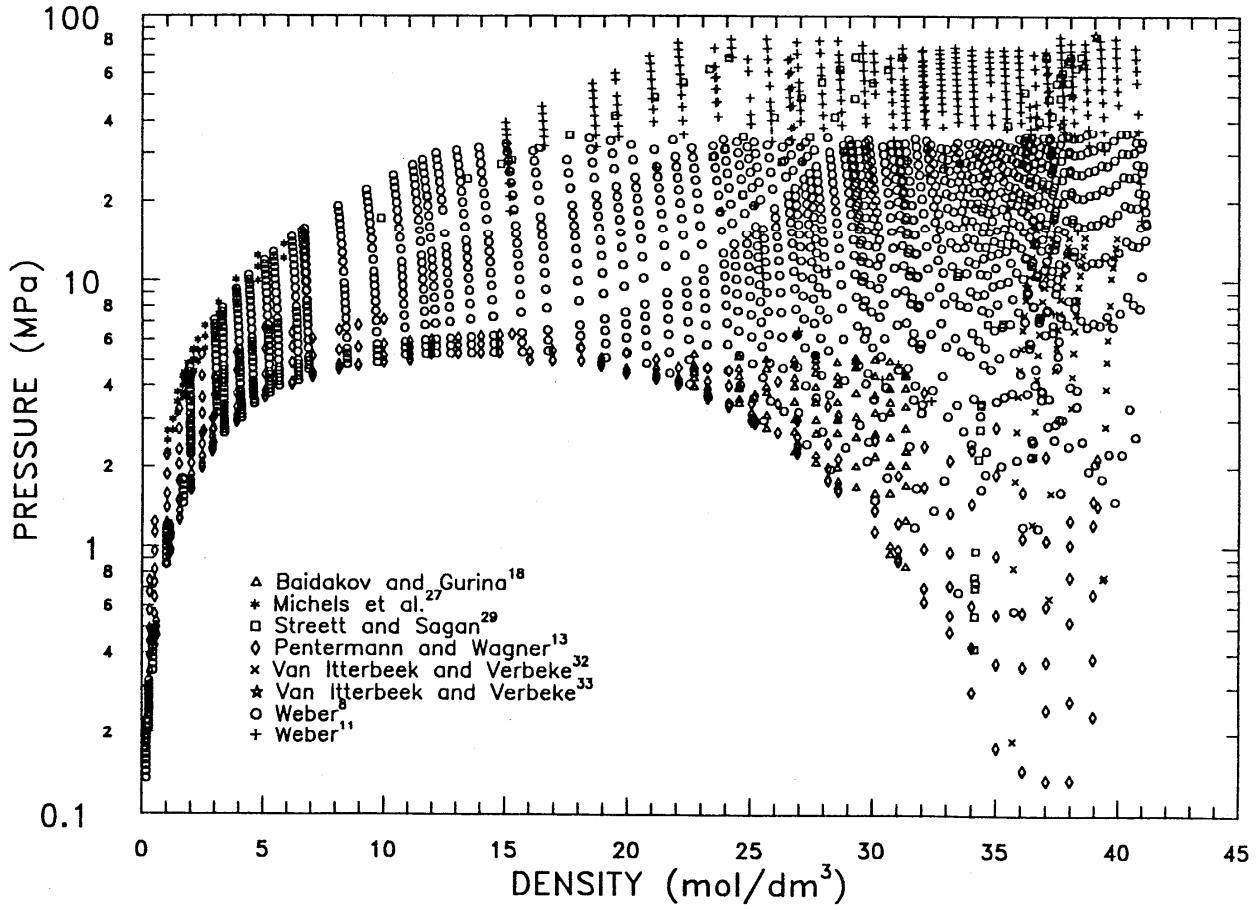

FIG. 2. P-ρ-T Data (P-ρ coordinates).

Equation (4), with the second and third virial coefficients represented by Eqs. (5,6), is valid for densities up to one-half the critical density. This permits the calculation of saturated vapor density values for temperatures up to 150 K. Comparisons between experimental thermodynamic properties and values calculated with Eq. (4) are given by Wagner *et al.*[59]. These comparisons include P-ρ-T data, saturated vapor density values, velocity of sound data, and other published data for the second and third virial coefficients.

2.5. The Critical Point

The values of the critical point P-ρ-T selected for this formulation are those published by Weber[8]. The critical point parameters are, P_c = 5.043 MPa, ρ_c = 13.63 mol/dm^3 and T_c = 154.581 K. The value for T_c has been corrected to the International Practical Temperature Scale of 1968 (IPTS–68) from the value given by Weber[8] which was 154.576 K on IPTS–48. There is a paucity of data of all forms in the critical region of

TABLE 3. Summary of velocity of sound data for oxygen

Single phase region

Source	Date	Range of values Temperature (K)	Pressure (MPa)	Phase	Number of data points
Boyer[40]	1951	273	0.03 to 0.1	vapor	14
Keesom *et al.*[41]	1931	77 to 273	0.01 to 0.1	vapor	27
Straty and Younglove[42]	1973	70 to 300	2.7 to 35	liq. & vap.	117
Van Itterbeek and Mariens[43]	1937	90, 290	0.01 to 0.1	vapor	9
Van Itterbeek and Mariens[44]	1937	177 to 374	0.01 to 0.1	vapor	6
Van Itterbeek and Van Dael[45]	1958	77, 90	0.4 to 7.2	liquid	32
Van Itterbeek and Van Dael[46]	1962	68 to 90	0.04 to 92	liquid	85
Van Itterbeek and Van Paemel[47] [a]	1938	72 to 92	0.003 to 0.1	vapor	41
Van Itterbeek and Zink[48]	1958	232 to 303	0.1 to 7	vapor	93

Saturated liquid

Source	Date	Temperature range (K)	Number of data points
Blagoi *et al.*[49]	1967	78 to 120	10
Blagoi *et al.*[50]	1969	83 to 140	7
Clouter and Kiette[51]	1973	54.4 to 90	37
Clouter *et al.*[52]	1975	87 to 154	27
Liepmann[53]	1938	63 to 90	23
Straty and Younglove[42]	1973	58 to 150	35
Van Dael *et al.*[54]	1966	61 to 154	40
Van Itterbeek[55]	1950	78 to 90	4
Van Itterbeek and DeBock[56]	1948	73 to 90	8
Van Itterbeek *et al.*[57]	1949	60 to 90	8
Van Itterbeek and Van Dael[46]	1962	67 to 91	30
Verhaegen[58]	1952	60 to 90	10

[a]Data selected for determining the fundamental equation.

oxygen. When new measurements are made in the critical region, it is reasonable to expect that small changes in the critical parameters may be adopted.

2.6. The Triple Point

A review of the published triple point data of oxygen is given by Wagner *et al.*[65] The selected temperature and pressure for the triple point used in this work are 54.361 K and 146.33 Pa, which are the values recommended by Wagner *et al.*[65]

3. Liquid-Vapor Coexistence Properties

Equations for the vapor pressure and for the saturated liquid and saturated vapor densities were used to calculate P-ρ-T data values for the coexistence states for fitting the fundamental equation. The use of coexistence data in the least squares fit of the equation provides for a fundamental equation which conforms closely to the Maxwell criteria for coexistence states. These coexistence values were determined as follows:

1. vapor pressure – Eq. (7);
2. saturated vapor density – Eqs. (4, 5, 6, 7) for temperatures below 69 K and Eq. (8) for temperatures from 69 K to 149 K;
3. saturated liquid density – Eq. (10) for temperatures from the triple point to 149 K; and
4. The P-ρ'-ρ''-T data from Weber[66] were used for temperatures from 150 K to 154.571 K.

For thermodynamically consistent properties, it is suggested that the vapor pressure and the saturation densities be calculated from the fundamental equation as noted in Sec. 1.2. The ancillary equations, Eqs. (7, 8, 10), are useful as estimating functions for iterative calculations.

3.1. The Vapor Pressure Equation

The vapor pressure equation used in this work is from Wagner *et al.*[65], which includes information on the procedures used in determining the vapor pressure equation, a review of the published vapor pressure data, data selected for fitting the equation, and comparisons between values calculated with the equation and the data. The vapor pressure equation for oxygen from Wagner *et al.*[65] is,

$$\ln \pi = (T_c/T)(n_1\tau + n_2\tau^{3/2} + n_3\tau^3 + n_4\tau^7 + n_5\tau^9) \quad (7)$$

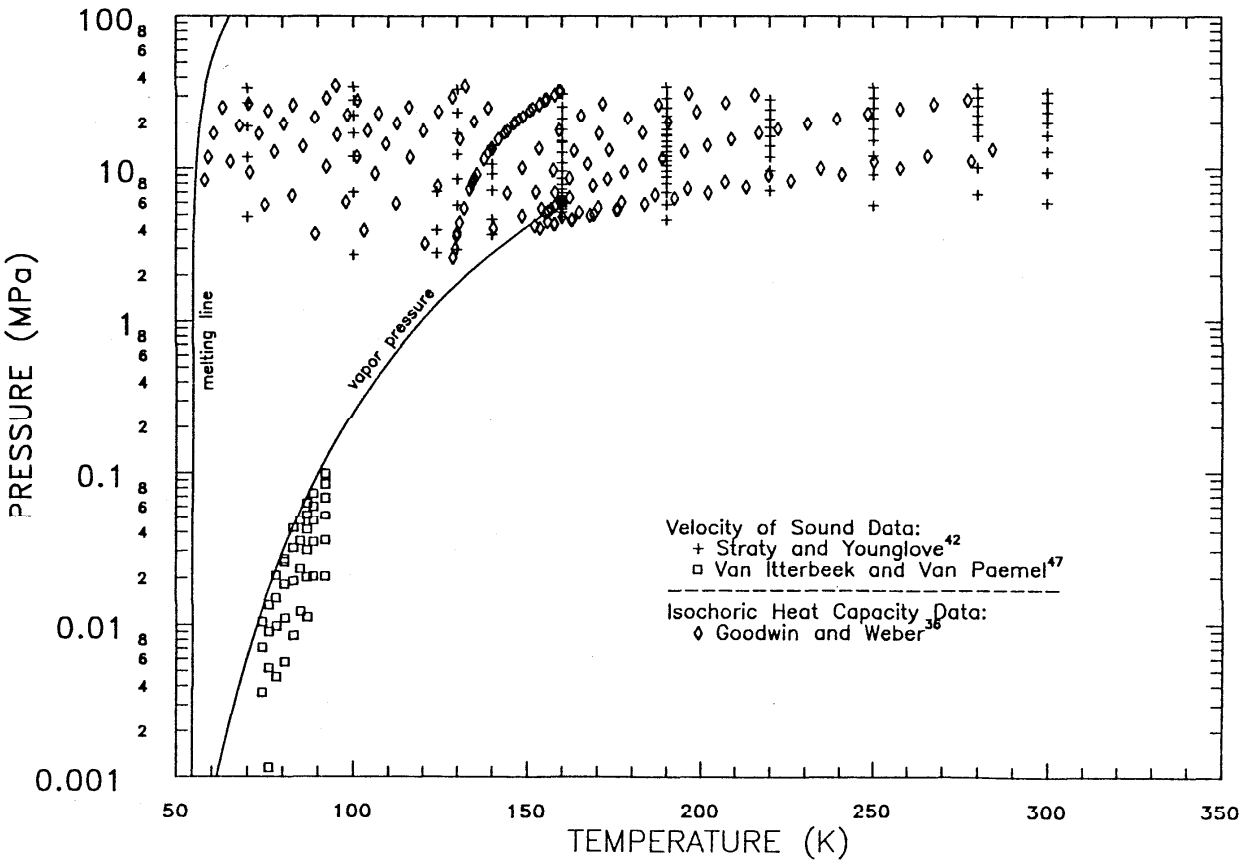

FIG. 3. Isochoric heat capacity data and velocity of sound data.

where $\pi = P_\sigma/P_c$, $\tau = (T_c - T)/T_c$, $P_c = 5.0430$ MPa, $T_c = 154.581$ K, and the coefficients are given below.

$n_1 = -6.043938$	$n_4 = -3.456781$
$n_2 = 1.175627$	$n_5 = 3.361499$
$n_3 = -0.994086$	

The data used by Wagner *et al.*[65] in determining the vapor pressure equation were new measurements from Wagner *et al.*[65] and the data from Hoge[67], Mochizuki *et al.*[68], Tiggelman[69], and Ancsin[70].

3.2. The Equation for the Saturated Vapor Density

Equation (8) was determined by Ewers[15] by a least squares fit to values up to 150 K calculated with Eq. (4) with the second and third virial coefficients as represented by Eqs. (5) and (6). For temperatures from 150 K to the critical temperature accurate values for the saturated vapor density were taken from Weber[66] based on measurements of the dielectric constant. The function for saturated vapor density given by Ewers[15] is,

$$\ln(\rho''/\rho_c) = n_1\tau^{1/3} + n_2\tau^{2/3} + n_3\tau + n_4\tau^{5/3} + n_5\tau^4 + n_6\tau^9, \quad (8)$$

where $\tau = (T_c - T)/T_c$, and ρ'' is the density of the saturated vapor and $\rho_c = 13.63$ mol/dm^3. The coefficients for Eq. (8) are given below.

$n_1 = -1.498431$	$n_4 = -5.659990$
$n_2 = -2.116826$	$n_5 = -18.90964$
$n_3 = -0.905713$	$n_6 = -53.780774$

The deviations of Eq. (8) from values calculated with the virial equation are illustrated in Fig. 4. The deviations in ρ'' in Fig. 4 are,

$$[(\rho''_{\text{virial}} - \rho''_{\text{Eq. 8}})/(\rho''_{\text{virial}})] \times 100. \quad (9)$$

3.3. The Equation for the Saturated Liquid Density

The saturated liquid density values used in determining Eq. (10) were selected by Pentermann and Wagner[13] as follows:

1. Values by Pentermann and Wagner[13] from an extrapolation of single phase liquid measurements reported by them for temperatures from 67 K to 150 K;

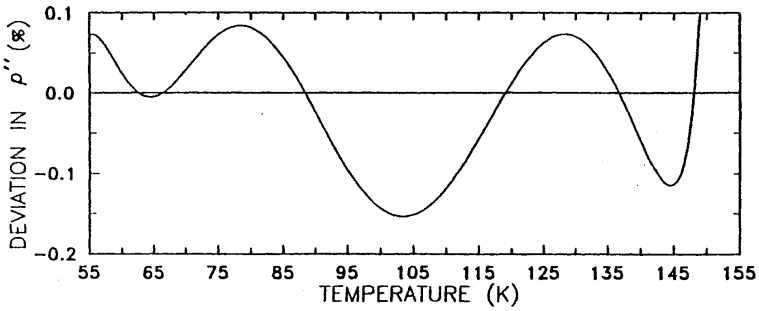

FIG. 4. Comparisons of values of the saturated vapor density from Eq. (8) with values calculated from the virial equation Eqs. (4, 5, and 6) at the vapor pressure from Eq. (7).

2. Values by Pentermann and Wagner[13] from an extrapolation of the liquid data from Weber[8] for temperatures from 61.4 K to 116.6 K;
3. Values by Weber[8] from an extrapolation of single phase liquid measurements in the same reference[8] for temperatures from 120 K to 149 K;
4. Values from Weber[66] derived from measurements of dielectric constants for temperatures from 150 K to 154.571 K;
5. An experimental data value at 83.828 K by Pool *et al.*[72]; and
6. The measurements by Baly and Donnan[73] for temperatures from 69.3 K to 89 K.

An equation for saturated liquid density was determined by a least squares fit of the selected data listed above by Schmidt[71]. The function for ρ' is,

$$\rho'/\rho_c = 1 + n_1\tau^{1/3} + n_2\tau^{2/3} + n_3\tau^3, \qquad (10)$$

here $\tau = (T_c - T)/T_c$, ρ' is the density of the saturated liquid and $\rho_c = 13.63$ mol/dm^3. The coefficients for Eq. (10) are given below:

$$n_1 = 1.507678 \quad n_2 = 0.85810805 \quad n_3 = 0.19035504$$

The deviations of calculated values from Eq. (10) with the experimental data and the published values obtained by extrapolation to the vapor pressure as noted above are illustrated in Fig. 5.

4. Ideal Gas Properties

The fundamental equation, Eq. (2), includes an ideal gas contribution which may also be used separately to calculate thermodynamic properties of the ideal gas. The ideal gas heat capacity equation used by Schmidt and Wagner[4] was published by Wagner, Ewers, and Schmidt[74] and was used for the calculation of the thermodynamic property tables in this paper. The ideal gas heat capacity equation from Wagner, Ewers, and Schmidt[74] is,

$$C_p^\circ/R = N_1T^{-1.5} + N_2 + N_3T^2 + N_4u^2e^u/(e^u-1)^2 + \frac{N_5\,(2/3)\eta^2e^{-\eta}}{[1 + (2/3)e^{-\eta}]^2}, \qquad (11)$$

where T is in K, $u = N_6/T$ and $\eta = N_7/T$. The fourth term is an approximation for the contribution by the vibration of the oxygen molecule, and the fifth term describes the influence of electronic excitation. The coefficients for Eq. (11) are given below.

$N_1 = 1.06778$ $\quad N_5 = 0.944365$
$N_2 = 3.50042$ $\quad N_6 = 2242.45$
$N_3 = 0.166961 \times 10^{-7}$ $\quad N_7 = 11580.4$
$N_4 = 1.01258$

Equation (11) was determined by a least squares fit to the data by Baehr *et al.*[75] for temperatures from 30 K to 1100 K, and the data by Gurvich *et al.*[76] for temperatures from 100 K to 3000 K. The maximum absolute difference between values calculated with Eq. (11) and tabular values from Baehr *et al.*[75] for temperatures from 30 K to 1100 K and the data by Gurvich *et al.*[76] for temperatures from 70 K to 3000 K is 0.003 J/(mol·K).

The equation by Stewart and Jacobsen[10,77] was included in their earlier compilations. This equation is included here as an alternate to Eq. (11). The ideal gas heat capacity equation from Stewart and Jacobsen[10,77] is,

$$C_p^\circ/R = \sum_{i=-3}^{3} n_{(i+4)}\,T^i + n_8u^2e^u/(e^u-1)^2, \qquad (12)$$

where T is in Kelvins and $u = n_9/T$. The fourth term was suggested by Barieau[78] and is an approximation for the contribution to the heat capacity by the vibration of the oxygen molecules. The coefficients for Eq. (12) are given below.

$n_1 = -0.49819985371193 \times 10^4$
$n_2 = 0.230247779995218 \times 10^3$
$n_3 = -3.45565323510732$
$n_4 = 3.52187677367116$
$n_5 = -0.435420216024420 \times 10^{-4}$
$n_6 = 0.134635345013162 \times 10^{-7}$
$n_7 = 0.162059825959105 \times 10^{-10}$
$n_8 = 1.03146851572565$
$n_9 = 2239.18105$

Equation (12) was determined by a least squares fit of the tabular values for C_p° published by Baehr *et al.*[75]. This

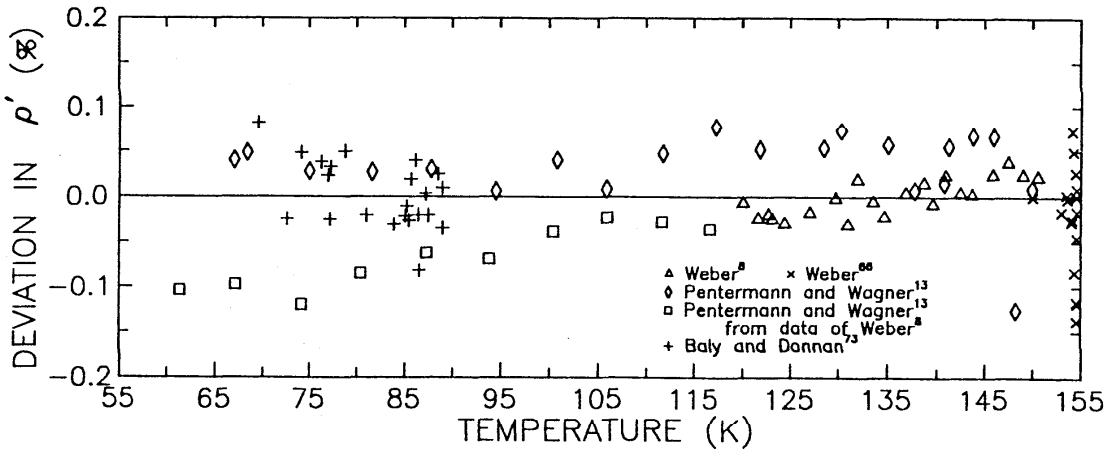

FIG. 5. Comparison of values of the saturated liquid density from Eq. (10) witn values derived from experimental data.

equation is valid for temperatures from 70 K to 1100 K. The maximum absolute difference between values calculated with Eq. (12) and tabular values from Baehr *et al.*[75] and tabular values from Gurvich *et al.*[76] for temperatures from 70 K to 1100 K is 0.002 J/(mol·K).

Ideal gas properties calculated with either Eq. (11) or Eq. (12) are essentially the same for temperatures from 70 K to 1100 K. A table of ideal gas properties, calculated with functions derived from Eq. (11) are given in Table 9. Maximum absolute differences of ideal gas properties calculated with Eq. (11) from those of Eq. (12) with the same number of significant figures as Table 9 are as follows:

Temperature (K)	$S°$ J/(mol K)	$H°$ J/mol	$C_v°$ J/(mol K)	$C_p°$ J/(mol K)
35 to 50	0.01	0.6	0.1	0.1
55 to 115	0.00	0.2	0.005	0.005
120 to 950	0.00	0.3	0.003	0.003
950 to 1100	0.00	0.4	0.005	0.005

These differences provide an assessment of the probable accuracy of ideal gas properties calculated using these formulations.

5. The Fundamental Equation for Oxygen

Information on the development of the fundamental equation for oxygen at the Ruhr Universität Bochum was published by Schmidt and Wagner[4] and is not repeated here. In developing the fundamental equation, a new form for the equation of state was used which is an extension of the equations of previous work by the authors. The use of new exponential terms increases the flexibility of the equation, which is required for accurately fitting the thermodynamic surface near the critical region.

The units for this work were (MPa) for pressure, (mol/dm^3) for density, (K) for temperature, and (J) for energy. Units of experimental data were converted as required from those of the original publications. Temperatures were converted to the International Practical Temperature Scale of 1968 (IPTS–68) as suggested by Douglas[79].

Each data point used in the least squares determination of the fundamental equation was assigned a weighting factor based on estimates of uncertainties of the variables. The statistical weights used in the fitting process were calculated using the error propagation formula (the theorem of propagation of variance). The functions for weighting were calculated using a preliminary formulation for the partial derivative functions required for estimating variances by the error propagation formula. The estimated variances were determined with the standard approximations for simple functions given by Ku[80]. In several instances the error propagation weights were modified by arbitrary multipliers to increase or lessen the effect of a particular data set on the overall representation of the thermodynamic surface.

The fundamental equation used in this work is explicit in Helmholtz energy as a function of density and temperature. The Helmholtz energy is given by Eq. (1), Sec. 1.2. The Helmholtz energy for the ideal gas is,

$$A° = H° - RT - TS°. \tag{13}$$

Values of the ideal gas enthalpy and entropy, $H°$ and $S°$, may be calculated with integral functions for the equation of the ideal gas heat capacity, given as Eq. (11).

The functional form used for the fundamental equation is the nondimensional potential function given by Eq. (2). The ideal gas contribution to the dimensionless Helmholtz energy is,

$$\alpha° = [H°_o\tau/(RT_c)] - (S°_o/R) - 1 + \ln[\delta\tau_o/(\delta°\tau)] - (\tau/R)\int_{\tau_o}^{\tau}(C_p°/\tau^2)d\tau + (1/R)\int_{\tau_o}^{\tau}(C_p°/\tau)d\tau, \tag{14}$$

where δ° is evaluated at P_o = 0.101325 MPa and T_o = 298.15 K and $\tau_o = \tau_c/298.15$. Equation (11) for the ideal gas heat capacity is used with Eq. (14) in this work to develop the complete expression for α°. The ideal gas reference values of enthalpy (H°) and entropy (S°) are taken from CODATA Bulletin No. 28[81].

The real fluid contribution to dimensionless Helmholtz energy, $\bar{\alpha}$, is given by,

$$\bar{\alpha}(\delta,\tau) = \sum_{k=1}^{m} N_k \delta^i \tau^j \exp(-\gamma\delta^\ell) , \qquad (15)$$

where the N_k are the coefficients of the fundamental equation and m is the number of terms determined in the fitting procedure. The nonlinear variable γ is 0 if $\ell = 0$ and 1 if ℓ is greater than 0. The values of i and j selected for the initial bank of terms are arbitrary. However, j is generally expected to be greater than zero, and i and ℓ are integers greater than or equal to zero. Values of N_k, i, j and ℓ are given in Table 4.

TABLE 4. Coefficients and exponents for the fundamental equation for oxygen

k	i	ℓ	j	Coefficient
1	1	0	0.0	0.3983768749
2	1	0	1.5	−1.846157454
3	1	0	2.5	0.4183473197
4	2	0	−0.5	0.2370620711 × 10^{-1}
5	2	0	1.5	0.9771730573 × 10^{-1}
6	2	0	2.0	0.3017891294 × 10^{-1}
7	3	0	0.0	0.2273353212 × 10^{-1}
8	3	0	1.0	0.1357254086 × 10^{-1}
9	3	0	2.5	−0.4052698943 × 10^{-1}
10	6	0	0.0	0.5454628515 × 10^{-3}
11	7	0	2.0	0.5113182277 × 10^{-3}
12	7	0	5.0	0.2953466883 × 10^{-6}
13	8	0	2.0	−0.8687645072 × 10^{-4}
14	1	2	5.0	0.2127082589
15	1	2	6.0	0.8735941958 × 10^{-1}
16	2	2	3.5	0.1275509190
17	2	2	5.5	−0.9067701064 × 10^{-1}
18	3	2	3.0	−0.3540084206 × 10^{-1}
19	3	2	7.0	−0.3623278059 × 10^{-1}
20	5	2	6.0	0.1327699290 × 10^{-1}
21	6	2	8.5	−0.3254111865 × 10^{-3}
22	7	2	4.0	−0.8313582932 × 10^{-2}
23	8	2	6.5	0.2124570559 × 10^{-2}
24	10	2	5.5	−0.8325206232 × 10^{-3}
25	2	4	22.0	−0.2626173276 × 10^{-4}
26	3	4	11.0	0.2599581482 × 10^{-2}
27	3	4	18.0	0.9984649663 × 10^{-2}
28	4	4	11.0	0.2199923153 × 10^{-2}
29	4	4	23.0	−0.2591350486 × 10^{-1}
30	5	4	17.0	−0.1259630848
31	5	4	18.0	0.1478355637
32	5	4	23.0	−0.1011251078 × 10^{-1}

All thermodynamic properties may be calculated from derivative functions of the fundamental equation. These derivative functions are given in Appendix A for the common thermodynamic properties. These functions were used in calculating the tables of thermodynamic properties of oxygen given in Appendix C using the coefficients and exponents given in Table 4. The vapor pressures and densities of the saturated liquid and vapor for Table 10, and saturation entries in Table 11, were calculated as functions of temperature using an iterative procedure to establish phase equilibrium values in accord with the Maxwell criteria. The derived properties for the saturation states were calculated from the fundamental equation as functions of temperature and density using the thermodynamic relations given in Appendix A.

6. Comparisons of the Fundamental Equation to Data

Comparisons of thermodynamic properties calculated with the Schmidt-Wagner[4] fundamental equation with experimental data are given in this section. The experimental data in these comparisons include P-ρ-T data, isochoric heat capacity data, saturated heat capacity data for the liquid and velocity of sound data. Comparisons are also made between values from the fundamental equation and values from equations for the saturated liquid density, saturated vapor density and vapor pressure. Separate comparisons to the P-ρ-T data in the critical region are given. Graphs illustrating the percentage differences between the calculated values and the data (see Eq. (3)) are used in most of these comparisons. The data sets included in the graphical comparisons are those that were selected for determining the fundamental equation and other modern data. There are also data points in each of the selected P-ρ-T data sets that were weighted zero and therefore were excluded from the fit of the equation. The zero-weighted data are included in the comparisons and are identified by a different symbol.

6.1. Comparisons of the Fundamental Equation to P-ρ-T Data

Comparisons of values of density calculated using the fundamental equation with experimental densities are given in Figs. 6–8. Figures 6–8 illustrate the quality of the fit in three regions: Fig. 6 – liquid states at temperatures below the critical temperature; Fig. 7 – vapor states at temperatures below the critical temperature; and Fig. 8 – states at temperatures above the critical temperature. Comparisons of pressures calculated using the fundamental equation with data are given in Fig. 9 for states in, and adjacent to, the critical region (i.e. 154 K to 160 K). Data included in Fig. 9 are also included in Fig. 6 and Fig. 8. Data reported by experimenters on isotherms are illustrated on graphs for the isotherms. Other data (e.g., data reported on isochores) are grouped for arbitrary ranges of temperature. Data with deviations from the calculated values exceeding 0.2 percent are summarized in

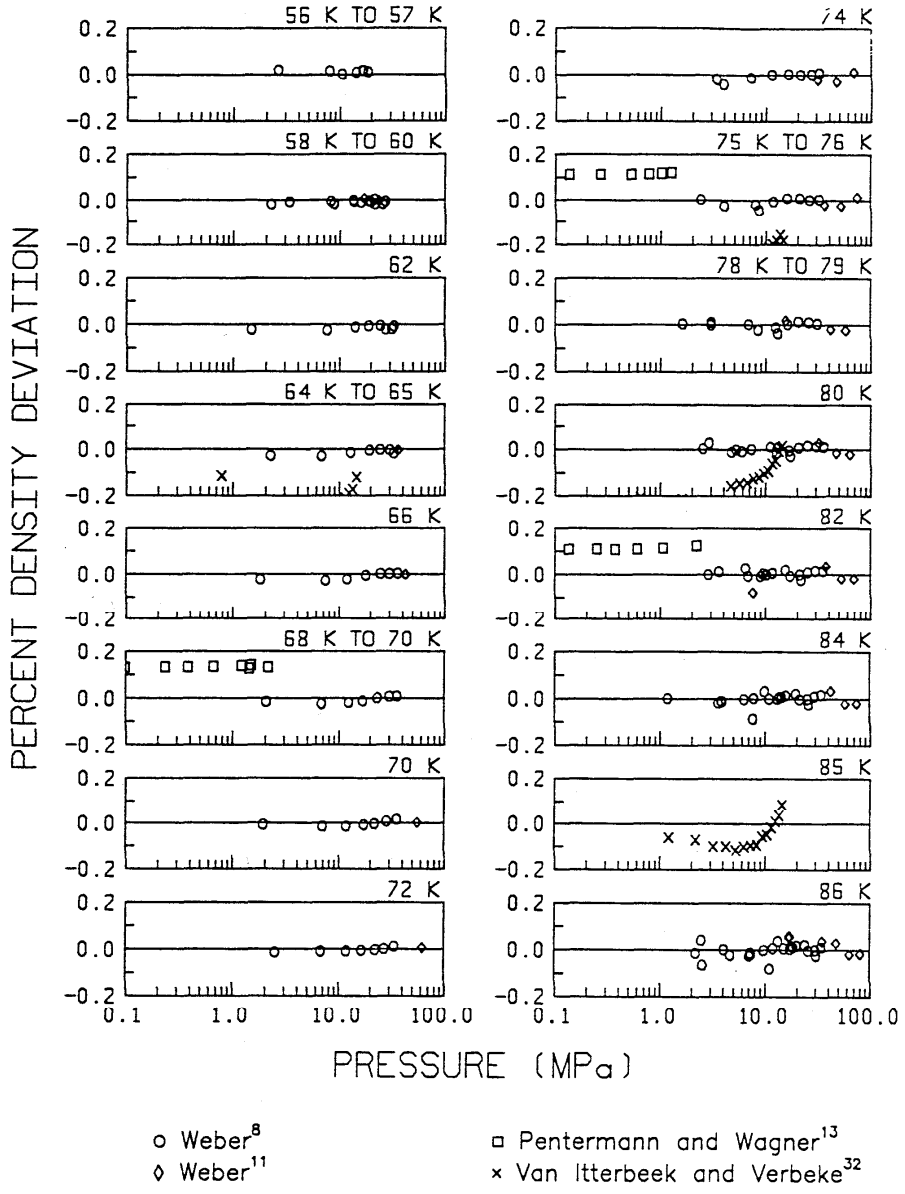

FIG. 6. Comparison of calculated values of density from the fundamental equation to experimental data for liquid states below the critical temperature. The data used in fitting Eq. 15 are ○ Weber[8], ◇ Weber[11], and □ Pentermann and Wagner[13].

Table 5. Only nine of the P-ρ-T data points listed in Table 5 were used in determining Eq. (15). The other data points had been rejected because of inconsistencies with other data or because the data set had large systematic errors.

Figure 6 compares density values calculated with the fundamental equation with P-ρ-T data of liquid oxygen at temperatures below the critical temperature. There are systematic differences between the data of Pentermann and Wagner[13] and the data of Weber[8]. These differences are approximately 0.11 percent for temperatures from 68 K to 120 K, 0.08 percent from 122 K to 135 K, and vary from 0.01 to 0.08 percent from 138 K to 150 K. No reason has been identified for these systematic differences. However, emphasis has been given to the data of Weber[8] in determining the fundamental equation. Data in the liquid region with density deviations greater than 0.2 percent are identified in Table 5.

Figure 7 compares density values calculated using the fundamental equation with P-ρ-T data of oxygen vapor at temperatures below the critical temperature. All of Weber's[8] vapor data for temperatures from 85 K to 158 K are from Series 4 of his experiments. The experimental methods in this series differed from the other series in

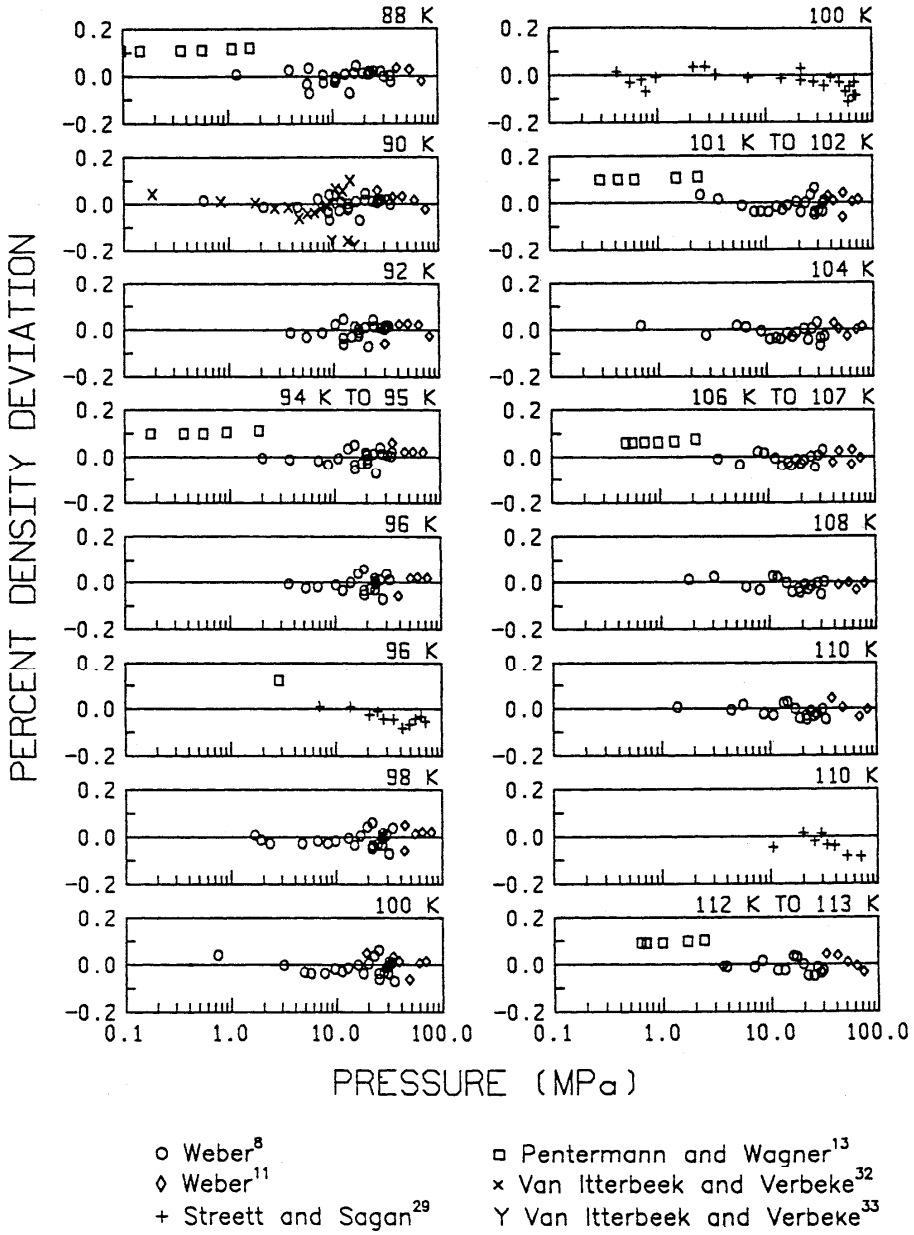

FIG. 6. Comparison of calculated values of density from the fundamental equation to experimental data for liquid states below the critical temperature. The data used in fitting Eq. 15 are ○ Weber[8], ◇ Weber[11], and □ Pentermann and Wagner[13] – Continued

the measurement of pressure and density. None of the data from Series 4 were used in fitting Eq. (15). The other three series of Weber's[8] data are for the liquid and for the fluid above 158 K. The density deviations illustrated in Fig. 7 show systematic differences between Weber's data and data from other experimenters in this low temperature vapor region.

Since there is a paucity of data in the low temperature vapor region, the second and third virial coefficients determined by Wagner *et al.*[59] were used to calculate density values to confirm the fit of the fundamental equation. These calculated density values are included in the graphical comparisons in Fig. 7 where they are identified with the symbol labeled as "virial".

In Sec. 2.4, reference was made to enthalpy of vaporization data that were used to extend the P-ρ-T data set for saturated vapor data for temperatures from 68 K to 91.3 K. The comparisons given in Fig. 7 include comparisons to the values derived from the data of Furukawa and McCoskey[62] and Suyama and Oishi[63]. The density deviations from the single values at 90.188 K derived from the measurements by Frank and Clusius[60] and Clusius and Konnertz[61] are −0.084 and 0.040 percent, respectively.

Figure 8 compares density values calculated with the

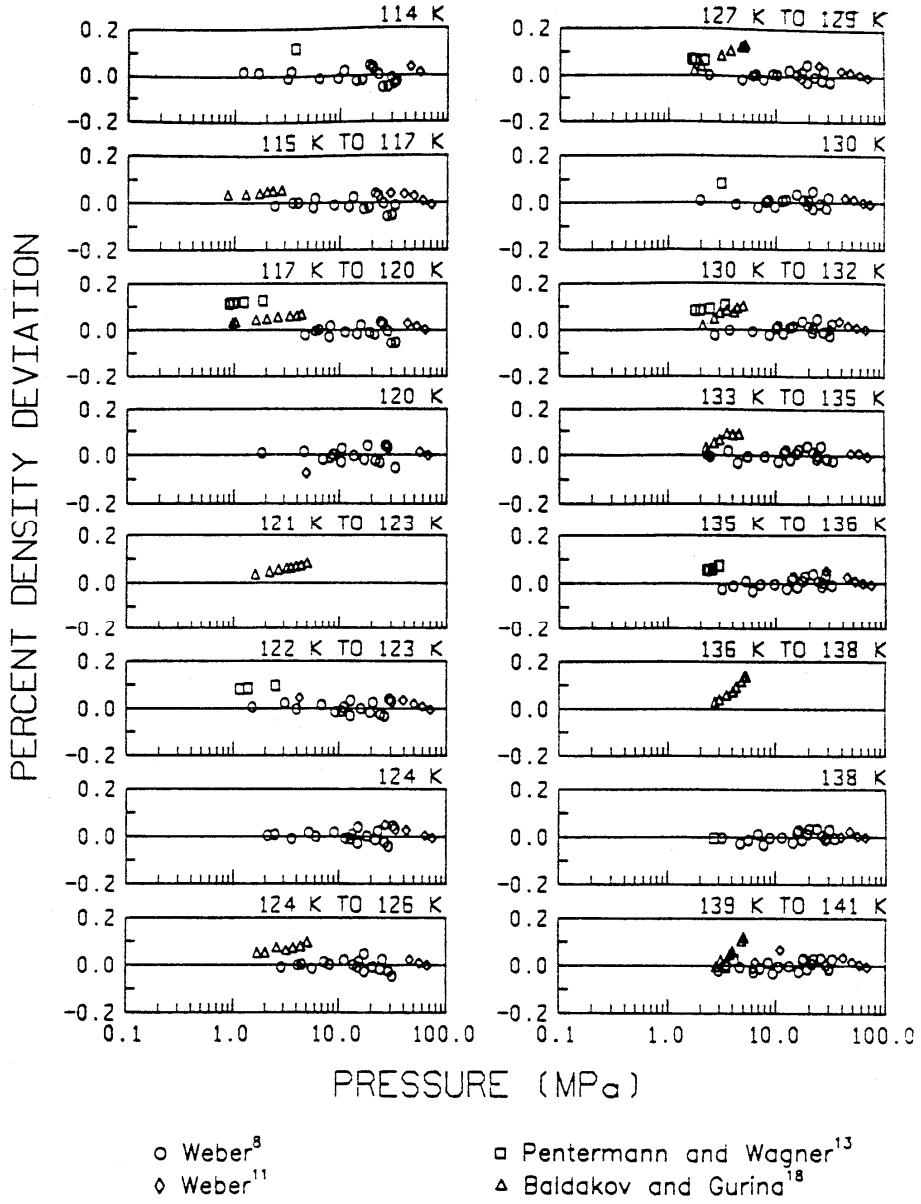

FIG. 6. Comparison of calculated values of density from the fundamental equation to experimental data for liquid states below the critical temperature. The data used in fitting Eq. 15 are ○ Weber[8], ◇ Weber[11], and □ Pentermann and Wagner[13] — Continued

fundamental equation with P-ρ-T data for oxygen at temperatures above the critical temperature. Table 5 summarizes the P-ρ-T data in this fluid region with density deviations exceeding 0.2 percent.

The P-ρ-T data by Ewers[15] for temperatures from 305 to 400 K were also used in determining Eq. (15). These data were determined by an extrapolation of experimental data to the unit compressibility ($P/\rho RT = 1$). Densities calculated with the fundamental equation differ from the unit compressibility data with a range of deviations from 0.018 to −0.059 percent.

The critical point for oxygen is at a temperature of 154.581 K and a density of 13.63 mol/dm^3. The critical region is generally described as bounded by temperatures within ±5 percent of the critical temperature and ±25 percent of the critical density. For oxygen, the critical region is the region between temperatures of 146.85 K and 162.31 K and densities of 10.22 mol/dm^3 and 17.04 mol/dm^3. Figure 9 compares pressures calculated from the fundamental equation with P-ρ-T data of oxygen at temperatures from 154 K to 160 K, which includes the P-ρ-T data in the critical region and adjacent to the critical region. Pressure deviations are less than 0.2 percent for all of the P-ρ-T data in this temperature interval for

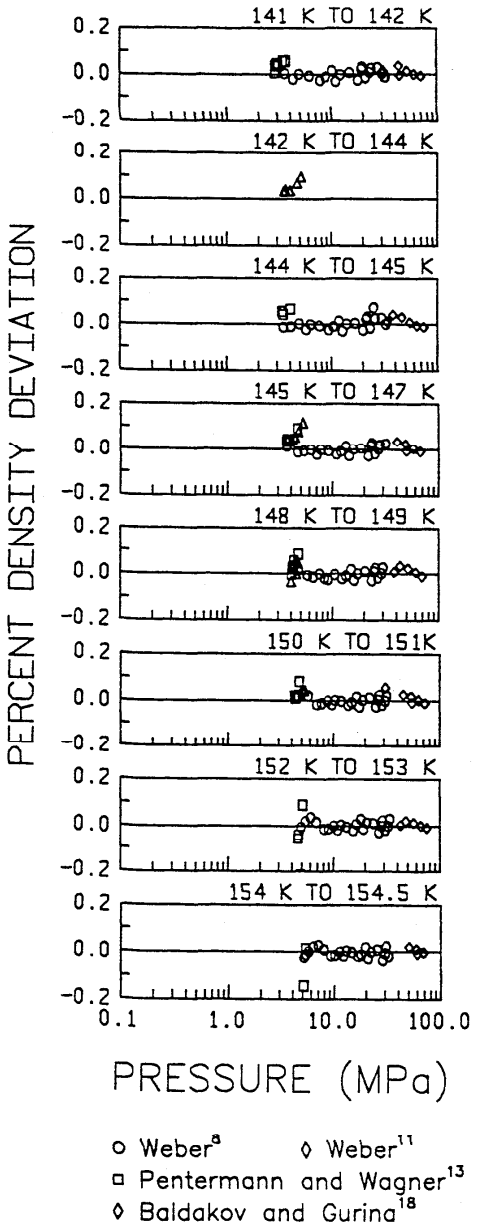

FIG. 6. Comparison of calculated values of density from the fundamental equation to experimental data for liquid states below the critical temperature. The data used in fitting Eq. 15 are ○ Weber[8], ◇ Weber[11], and □ Pentermann and Wagner[13] – Continued.

densities between 5 and 25 mol/dm^3. The data illustrated in Fig. 9 were also included in either Fig. 6 or Fig. 7 with the exception of the data at 154.581 K.

The fundamental equation of Schmidt and Wagner[4] was not constrained at the critical point in the fitting procedure. Therefore, the state where the equation has a zero slope and zero curvature varies slightly from the selected critical P-ρ-T values. The state for the zero slope and curvature of the fundamental equation from Schmidt and Wagner[4] is T = 154.599 K, P = 5.046 MPa and ρ = 13.342 mol/dm^3.

6.2. Comparisons of the Fundamental Equation to Heat Capacity Data

The principal heat capacity data are the experimental isochoric heat capacity measurements of Goodwin and Weber[37]. The experimental runs for their measurements were for a constant sample mass. The density for each run was, therefore, approximately constant. Comparisons of the measured values of C_v to heat capacity values calculated with the fundamental equation are given in Fig. 10. Each graph in Fig. 10 is for a separate experimental run. The fourteen data points with deviations exceeding ±2.0 percent are identified in Table 5.

Table 6 compares the estimated errors of the C_v data by the experimenters with the maximum deviations between the data and calculated values. The experimental data for densities of 5.2 mol/dm^3 and 6.1 mol/dm^3 have deviations from the calculated values which are larger than the estimated errors given by the experimenters. It is considered that the values of C_v calculated with the formulation are more accurate than the experimental value for these low density runs. For C_v measurements at a density of 13.1 mol/dm^3, the calculated values are within the estimated accuracy of the data, except for values at temperatures less than 156 K. (At a density of 13.1 mol/dm^3 the critical region extends to 162.3 K). The deviations of the calculated values in the critical region are indicative of the errors of the second derivatives of the fundamental equation very close to the critical point.

For densities of 20.2 mol/dm^3 to 28.6 mol/dm^3, the deviations of the calculated values of C_v are generally within the estimated errors of the measured values. At densities from 30.6 mol/dm^3 to 40.6 mol/dm^3, the calculated C_v values have deviations that exceed the estimated accuracy of the data.

Eighty-eight data points of the saturated heat capacity for the liquid, C_σ, are included in the paper by Goodwin and Weber[36]. These C_σ values were derived from experimental data for isochoric heat capacity for the two-phase region which were measured in five experimental series. Comparisons of calculated values of C_σ to the values from Goodwin and Weber[36] are illustrated in Fig. 11. The only data point exceeding the deviation scale is in Series 200 at 153.4 K with a deviation of −2.1 percent. Each of the five series of measurements are identified by separate symbols on Fig. 11. The precision of these data is about ±0.5 percent. The uncertainty of the C_σ measurements, as estimated by the experimenters, ranges from 0.4 to 2.3 percent. The maximum deviations shown in Fig. 11 are close to the uncertainties estimated by the experimenters.

The isochoric heat capacity data from Voronel *et al.*[38] are measurements made at densities within 0.5 percent of the critical density for temperatures from 153.39 K to 160.14 K. Thirty-nine of the 45 data points reported are measurements for the two-phase region. As indicated in the comparisons of the data from Goodwin and Weber[37],

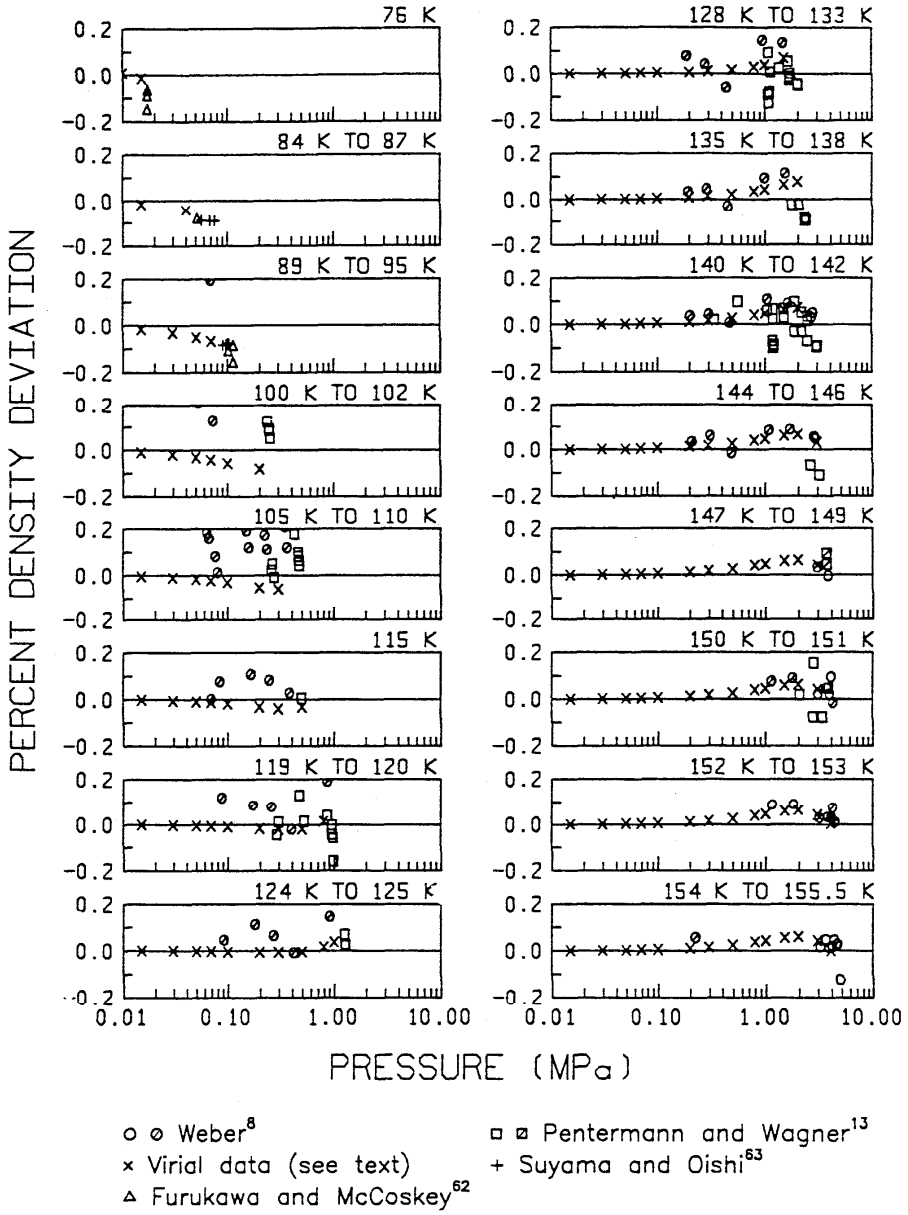

FIG. 7. Comparison of calculated values of density from the fundamental equation to experimental data for vapor states below the critical temperature. The data used to fit Eq. (15) were ○ Weber[8] and □ Pentermann and Wagner[13].

this formulation cannot be used for C_v values very close to the critical point, and no comparisons are given to these data.

The data from Workman[39] are from a flow calorimeter for temperatures from 26 to 50 °C and pressures from 10 to 130 kg/cm^2 (0.98 to 12.7 MPa). Only graphical results were published and no comparisons were made to values determined by the fundamental equation. In this low density, high temperature region the calculated values are considered to be more accurate than the measured data.

Other experimenters have reported C_v and C_p values from calorimetric measurements, values derived from velocity of sound measurements for vapor states at pressures up to 0.101325 MPa, and values for the liquid at the vapor pressure with temperatures up to 90 K. These data are summarized and compared to calculated values in the earlier work by Stewart[7].

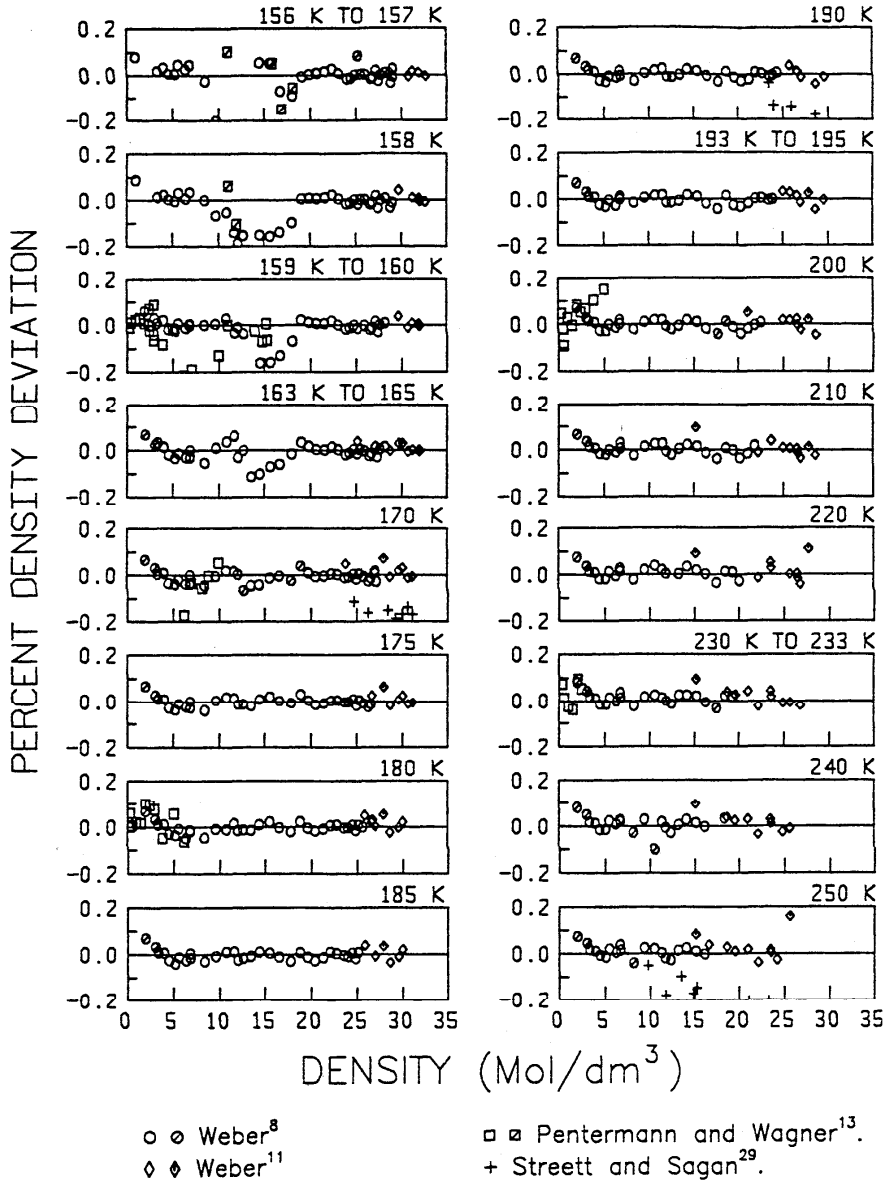

FIG. 8. Comparison of calculated values of density from the fundamental equation to experimental data for fluid states above the critical temperature. The data used in fitting Eq. 15 were ○ Weber[8], ◇ Weber[11], and □ Pentermann and Wagner[13].

6.3. Comparisons of the Fundamental Equation to Velocity of Sound Data

In comparisons of velocity of sound data to values calculated with preliminary equations of state, the velocity of sound data in the single phase, values for the saturated liquid reported by Straty and Younglove[42], and the single phase vapor data by Van Itterbeek and Van Paemel[47] were found to be concordant with the selected P-ρ-T and C_v data. These data are compared to values calculated with the fundamental equation in Figs. 12 and 13. The experimental measurements included pressure, temperature and velocity of sound. In these comparisons to single phase data, the input parameters were pressure and temperature, with the density determined from the fundamental equation for the calculation of velocity of sound.

In Fig. 12, the data of Straty and Younglove[42] for temperatures from 70 K to 140 K are for the liquid phase. The maximum deviation of the liquid data is 2.03 percent at 100 K and a pressure of 3.3 MPa. This is the only data point exceeding the deviation scale of 2 percent. The data at 160 K include eleven values at the upper boundary of

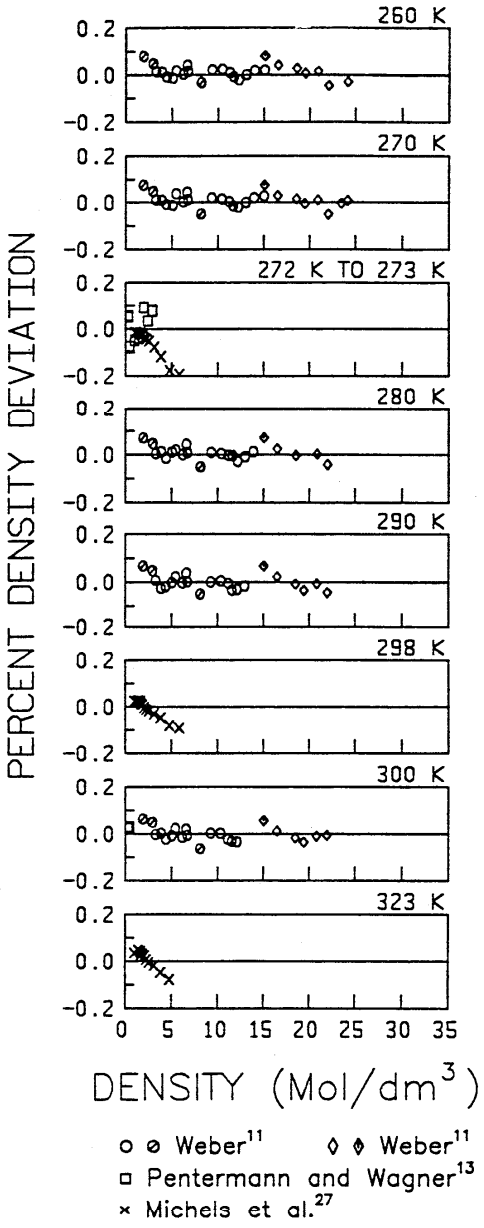

FIG. 8. Comparison of calculated values of density from the fundamental equation to experimental data for fluid states above the critical temperature. The data used in fitting Eq. 15 were ○ Weber[8], ◇ Weber[11], and □ Pentermann and Wagner[13] – Continued.

the critical region. The maximum deviation is −1.4 percent at a pressure of 6.9 MPa. For the vapor data for temperatures from 190 K to 300 K, the maximum deviation is −0.79 percent at 190 K and a pressure of 34.3 MPa.

The deviations of the data of Van Itterbeek and Van Paemel[47] from calculated values are illustrated in Fig. 13. This data set is in the vapor region at low temperatures where the only reliable P-ρ-T values were those determined from a virial equation of state. The excellent representation of these velocity of sound data by the fundamental equation supports these calculated P-ρ-T values.

The deviations of the saturated liquid velocity of sound data from calculated values are illustrated in Fig. 14. The data of Van Dael *et al.*[54] are seen to be concordant with the data of Straty and Younglove[42]. The data points exceeding ±1 percent are identified in Table 5.

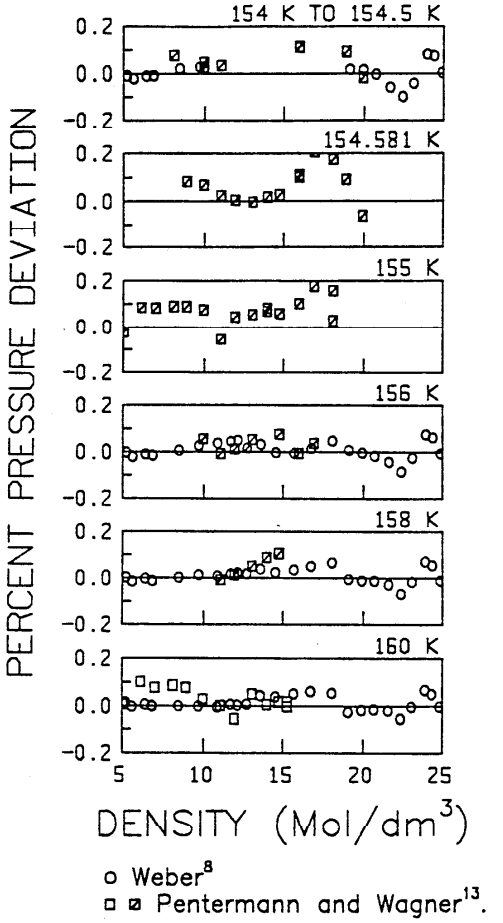

FIG. 9. Comparison of calculated values of pressure from the fundamental equation to experimental data for fluid states from 154 K to 160 K. The data used in fitting Eq. (15) are, ○ Weber[8] and □ Pentermann and Wagner[13].

6.4. Comparison of the Fundamental Equation with the Ancillary Equations for Vapor Pressure, Saturated Liquid Density and Saturated Vapor Density

The quality of the fundamental equation is further illustrated by the comparison of vapor pressure, saturated liquid density and saturated vapor density values. Vapor pressures from Eq. (7) are compared in Fig. 15 with pres

TABLE 5. Comparison of calculated properties from the fundamental equation to experimental data. Summary of deviations exceeding the scale of the percent deviation in Figs. 6, 7, 8, 10 and 14.

Figure[a]	No. data points[b]	Temperature (K)	Pressure range (MPa)	Density range (mol/dm^3)	Range of deviations (percent)	Reference
6	9	65	0.77 – 11.3	39.3 – 39.8	−0.21 – −0.32	Van Itterbeek[32]
6	8	75	3.4 – 10.5	38.0 – 38.4	−0.21 – −0.31	Van Itterbeek[32]
6	2	80	0.65 – 1.60	37.1 – 37.2	−0.21	Van Itterbeek[32]
6	6	90	22.6 – 83.5	36.9 – 39.0	−0.34 – −1.3	Van Itterbeek[33]
6	1	119	4.5	31.3	0.23	Baidakov[18]
6	9 (4)	152–154.4	4.49 – 5.04	16.0 – 19.9	−0.21 – −2.6	Pentermann[13]
6	6 (5)	154.58	5.04 – 5.17	14.0 – 18.1	−1.3 – −5.9	Pentermann[13]
7	3	85	0.04 – 0.06	0.06 – 0.09	0.9 – 9.0	Weber[8]
7	3	90	0.05 – 0.07	0.06 – 0.09	0.6 – 0.8	Weber[8]
7	3	95	0.05 – 0.14	0.06 – 0.18	0.23 – 0.46	Weber[8]
7	4	100	0.05 – 0.21	0.06 – 0.27	0.22 – 0.34	Weber[8]
7	1	105	0.34	0.43	0.21	Weber[8]
7	4	142–146	3.0 – 3.4	4.1 – 4.6	0.51 – 0.56	Weber[8]
7	3	148–150	3.3 – 3.5	4.1 – 4.6	−0.52 – 0.58	Weber[8]
7	2	152–154	3.5 – 4.9	4.1 – 9.7	−0.39 – 0.59	Weber[8]
7	5	149–151	2.4 – 4.4	2.4 – 7.0	−0.36 – 0.22	Pentermann[13]
7	5	152–153	4.5 – 4.8	8.1 – 8.9	−0.70 – −0.3	Pentermann[13]
7	4 (1)	155–155.5	4.8 – 5.0	8.1 – 11.1	−1.5 – −0.4	Pentermann[13]
7	5 (3)	154.58	4.9 – 5.0	8.9 – 13.1	−0.58 – 5.0	Pentermann[13]
8	6 (5)	156	5.2 – 5.3	9.7 – 13.6	−0.20 – 0.97	Weber[8]
8	5 (4)	156	5.2 – 5.4	10.0 – 14.8	−0.22 – −1.5	Pentermann[13]
8	1 (1)	158	5.7	13.6	0.31	Weber[8]
8	3 (3)	158	5.7 – 5.8	13.1 – 14.8	−0.44 – −0.66	Pentermann[13]
8	1 (1)	160	6.1	13.6	−0.22	Weber[8]
8	5 (2)	160	5.4 – 6.1	8.1 – 13.6	−0.21 – 0.31	Pentermann[13]
8	1	170	34.7	27.4	−0.28	Streett[29]
8	4	190	35 – 69	24.6 – 29.3	−0.24 – 0.30	Streett[29]
8	7	250	31 – 68	16.3 – 24.1	−0.21 – −0.32	Streett[29]
10	11	154–192		5.2	−2.1 – −5.2	Goodwin[37]
10	1	152		6.1	−2.01	Goodwin[37]
10	2 (2)	155–156		13.1	2.6, 13.3	Goodwin[37]
14	2	58, 60			2.2, 1.3	Straty[42]
14	4 (4)	151–164			2.1 – 7.8	Van Dael[54]
14	10	54–63			1.3 – 5.7	Clouter[51]
14	13 (13)	149–154			−2.0 – −17	Clouter[52]

[a]None of the data points listed above for Fig. 6 was used in fitting Eq. (15). Only one for Fig. 7 (at 154 K) was used in fitting Eq. (15). Eight of the data points listed for Fig. 8 were used in fitting Eq. (15); (one each at 156, 158 and 160 K for Weber[8] and five at 160 K from Pentermann[13]).
[b]The number of data points in the critical region is given in parentheses.

sures calculated using the fundamental equation at states defined by the Maxwell criteria, i.e., equal pressures and Gibbs function for saturated liquid and vapor states at the same saturation temperature. This comparison shows no differences in vapor pressure values calculated using Eq. (7) from the values determined with the fundamental equation to the number of significant figures given in the vapor pressures listed in Table 10, except for values above 136 K. The differences in the calculated vapor pressures above 136 K are: from 136 K to 140 K, +0.0001 MPa; from 147 K to 153 K, −0.0001 to −0.0002 MPa. Vapor pressure values calculated either with Eq. (7) or from the fundamental equation are within the uncertainty of the selected vapor pressure data used in determining Eq. (7).

The solid line in Fig. 16 illustrates the deviations between values from the ancillary equation for saturated liquid density, Eq. (10), and values from the fundamental equation. Data for the saturated liquid are also compared to values calculated with the fundamental equation using the Maxwell criteria in Fig. 16. Saturated vapor densities calculated with the fundamental equation using the Maxwell criteria are compared to values from Eq. (8) for saturated vapor density, in Fig. 17.

TABLE 6. The estimated experimental uncertainty and the maximum deviations of calculated values from the isochoric heat capacity data of Goodwin and Weber[37]

Nominal density (mol/dm³)	Estimated error[a] (percent)	Max. dev. C_v[b] (percent)	Temp. max.dev.[c] (K)
5.2	2.0 - 2.2	−5.2	154
6.1	1.7 - 1.9	−2.0	152
13.1	1.0 - 2.2	13.3	155
20.2	0.8 - 0.9	0.37	216
23.1	0.7 - 0.8	0.36	149
25.8	0.7 - 0.8	0.64	140
28.6	0.7 - 0.8	−0.77	155
28.6	0.7 - 0.8	0.76	130
28.6	0.6 - 1.3	−0.78	153
28.6	0.7 - 1.0	0.78	129
30.6	0.7	−0.95	139
32.5	0.7	−1.4	129
33.8	0.7	−1.3	116
34.8	0.7	−1.9	107
36.0	0.7	1.5	89
37.1	0.6 - 0.7	−1.4	95
38.1	0.7 - 0.8	−1.1	83
38.9	0.7	0.89	76
39.7	0.6 - 0.7	0.84	68
40.6	0.6 - 0.7	1.2	58

[a] Estimated errors by Goodwin and Weber[37].
[b] Comparison of data to calculated values, derived from Eq. (2).
[c] Temperature at the maximum deviation.

7. Recommended Range of the Formulation and Estimated Accuracy of Calculated Properties

The formulation presented in this paper is valid for the calculation of the thermodynamic properties of oxygen from the freezing line to 300 K at pressures up to 80 MPa. This range is consistent with the ranges of available data and extrapolation beyond estimated limits is not recommended.

It is recommended that coexistence properties be calculated by application of the Maxwell criteria, because the fundamental equation given here conforms to these requirements. The separate functions representing the vapor pressure, saturated liquid density and saturated vapor density given in this work are useful estimating equations for iterative calculations.

The accuracy of calculated values of density, isochoric heat capacity and velocity of sound has been estimated from the accuracy with which the experimental data for these properties are represented by calculated values, as illustrated in Figs. 4 to 17. The accuracy of calculated properties may also be inferred from the comparisons between properties calculated from the formulations by Schmidt and Wagner[4] and by Stewart and Jacobsen[5], as summarized in Tables 7 and 8 in Appendix B. All calculated properties from both formulations[4,5] may have substantially larger errors in the near critical region (between 10.22 and 17.04 mol/dm³ at temperatures from 146.85 to 162.31 K) than in other regions of the thermodynamic surface. Both measurement and correlation are subject to larger errors in the critical region than in other regions of the thermodynamic surface. However, the authors consider property values from the formulation by Schmidt and Wagner[4] to be more accurate for the critical region than those from the formulation by Stewart and Jacobsen[5].

The estimated accuracy of density values calculated with the formulation presented here is ±0.1 percent (see Figs. 5 to 9). Although calculated density values in the critical region are much larger (see Table 5), Fig. 10 indicates that calculated pressures in the critical region have an estimated accuracy of 0.1 percent.

The estimated accuracy of calculated isochoric heat capacity values (see Fig. 10) is ±2 percent. Tables 7 and 8 indicate that errors in calculated isobaric heat capacity values are generally of the same order of magnitude as the errors in isochoric heat capacity. Figure 11 indicates that the calculated values of the saturated heat capacity for the liquid are within 1 percent of the values derived by Goodwin and Weber[36] from their experimental data for isochoric heat capacity for the two phase region.

Calculated values of velocity of sound are estimated to be accurate to within ±1.0 percent, except near the critical point (see Figs. 12 and 13). The accuracy of the calculated values of the velocity of sound for the saturated liquid is also within ±1.0 percent (see Fig. 14), except at temperatures below 60 K and near the critical temperature.

The comparisons summarized in Tables 7 and 8 indicate the differences in calculated properties from two equivalent formulations that were fitted to the same data sets. These comparisons indicate that differences in entropy are about the same magnitude as those in density, and that differences in internal energy and enthalpy are generally about five times the magnitude of the differences in density.

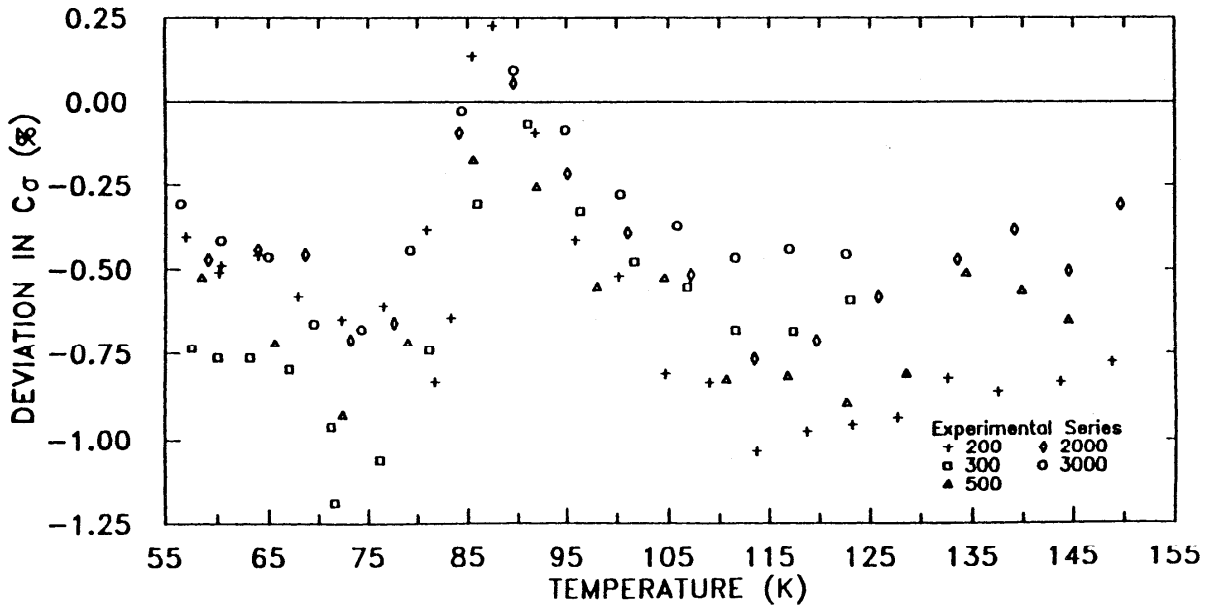

FIG. 11. Comparison of calculated values of the saturated liquid heat capacity (C_σ) from the fundamental equation to experimental values from Goodwin and Weber[36].

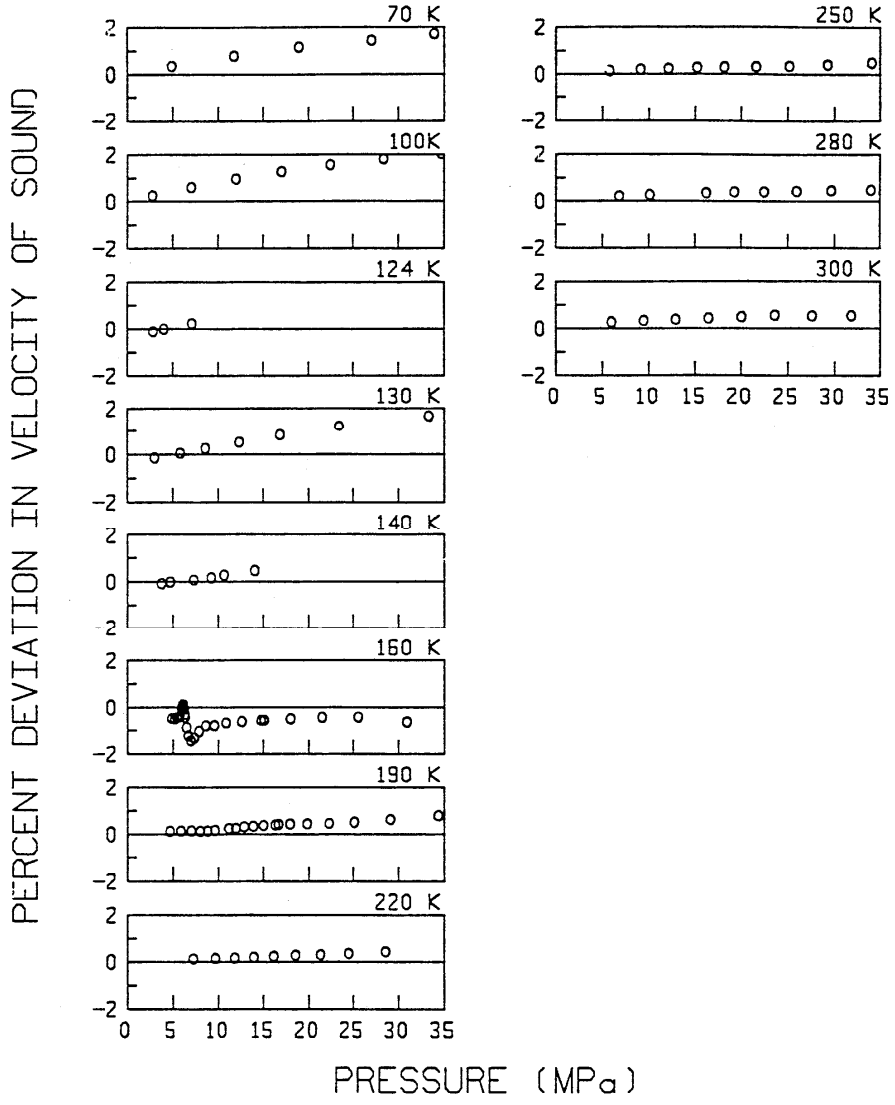

FIG. 12. Comparison of experimental data for the velocity of sound from Straty and Younglove[42] with calculated values from the fundamental equation.

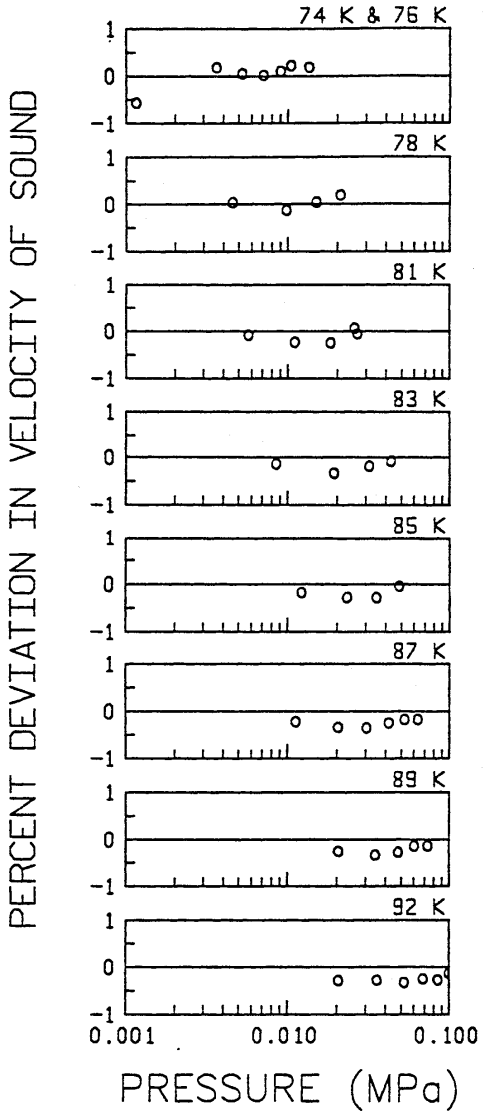

FIG. 13. Comparison of experimental data for the velocity of sound from Van Itterbeek and Van Paemel[47] with calculated values from the fundamental equation

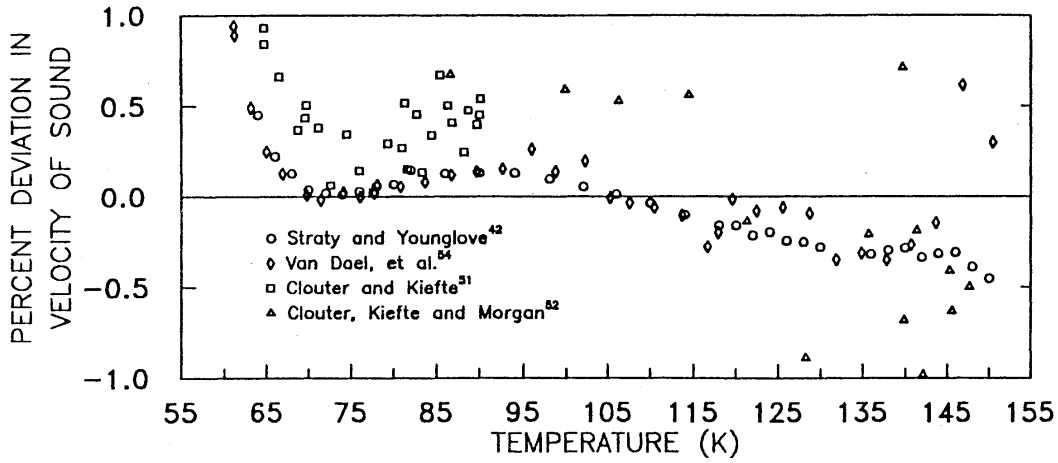

FIG. 14. Comparison of calculated values of the velocity of sound from the fundamental equation for the saturated liquid to experimental values.

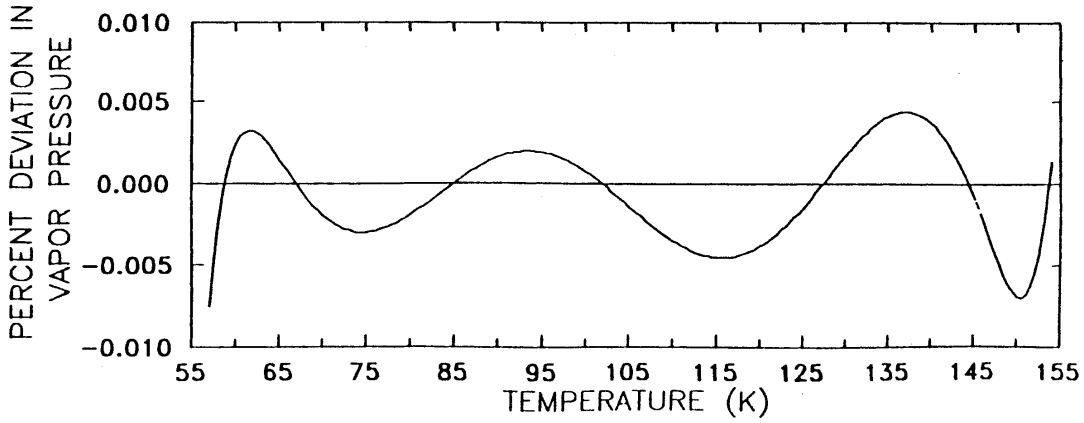

FIG. 15. Comparisons of values of the vapor pressure from Eq. (7) with values calculated from the fundamental equation using the Maxwell criteria.

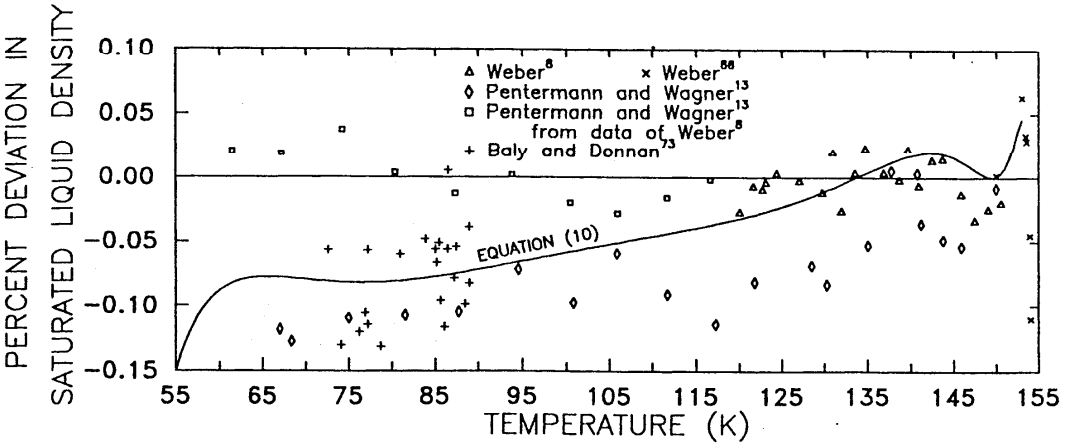

FIG. 16. Comparisons of experimental data and values from Eq. (10) with values of the saturated liquid density from the fundamental equation using the Maxwell criteria.

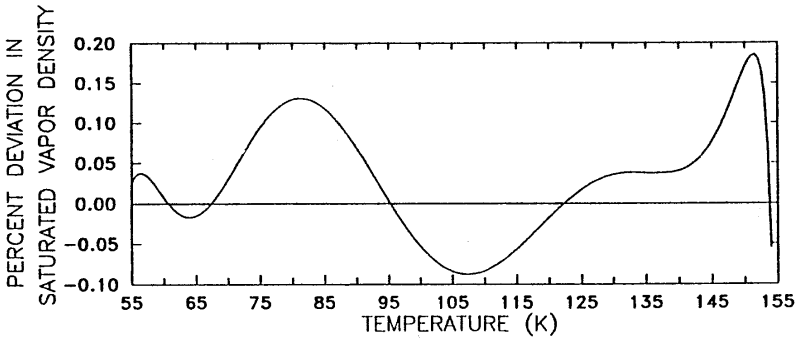

FIG. 17. Comparisons of values of the saturated vapor density from Eq. (8) with values calculated from the fundamental equation using the Maxwell criteria.

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Appendix A. Functions for the Calculation of Thermodynamic Properties

The fundamental equation used in this work is explicit in reduced Helmholtz energy. The Helmholtz energy is given by the fundamental equation, Eq. (1). The reduced aform of the fundamental equation used in this work is a nondimensional potential function, given as Eq. (2).

The ideal gas contribution to the dimensionless Helmholtz energy is given in Eq. (14) and is used in this work to develop the complete expression for α°. The ideal gas reference values of enthalpy (H°) and entropy (S°) are taken from the CODATA Bulletin No. 28[79].

The real fluid contribution to dimensionless Helmholtz energy, $\bar{\alpha}$, is given by Eq. (15). Values of the exponents and coefficients are listed in Table 4.

The following functions were used in calculating the tables of thermodynamic properties of oxygen given in Appendix C. In these expressions for derived properties, the subscripts for the properties held constant during differentiation are omitted.

$$Z = P/(\rho RT) = 1 + \delta(\partial\bar{\alpha}/\partial\delta) \tag{16}$$

$$P/P_c = [\delta/(\tau Z_c)][1 + \delta(\partial\bar{\alpha}/\partial\delta)] \tag{17}$$

$$U/(RT) = \tau[(\partial\alpha^\circ/\partial\tau) + (\partial\bar{\alpha}/\partial\tau)] \tag{18}$$

$$S/R = \tau[(\partial\alpha^\circ/\partial\tau) + (\partial\bar{\alpha}/\partial\tau)] - \alpha^\circ - \bar{\alpha} \tag{19}$$

$$H/(RT) = \tau[(\partial\alpha^\circ/\partial\tau) + (\partial\bar{\alpha}/\partial\tau)] + \delta(\partial\bar{\alpha}/\partial\delta) + 1 \tag{20}$$

$$C_v/R = -\tau^2[(\partial^2\alpha^\circ/\partial\tau^2) + (\partial^2\bar{\alpha}/\partial\tau^2)] \tag{21}$$

$$C_p/R = C_v/R + \left\{[1 + \delta(\partial\bar{\alpha}/\partial\delta) - \delta\tau(\partial^2\bar{\alpha}/\partial\delta\partial\tau)]^2 \div [1 + 2\delta(\partial\bar{\alpha}/\partial\delta) + \delta^2(\partial^2\bar{\alpha}/\partial\delta^2)]\right\} \tag{22}$$

$$W^2/(RT) = \frac{C_p}{C_v}[1 + 2\delta(\partial\bar{\alpha}/\partial\delta) + \delta^2(\partial^2\bar{\alpha}/\partial\delta^2)] \tag{23}$$

Equation (24) for the melting line from Watson[64] was used for calculating the initial state for Table 11.

$$\ln(P/P_{tp}) = N_1(T/T_{tp}-1)^{1/16} + N_2(T/T_{tp}-1)^{2/16} + N_3(T/T_{tp}-1)^{3/16} + N_4(T_{tp}-1)^{4/16} \tag{24}$$

Coefficients for Equation 24 are:

$N_1 = -32.463539$
$N_2 = 142.78011$
$N_3 = -147.02341$
$N_4 = 52.001290$

Appendix B. Summary of Comparisons of the Formulations of Schmidt and Wagner[4] and Stewart and Jacobsen[5]

Report 87–1 of the Center for Applied Thermodynamic Studies[5] includes comparisons of calculated values to the data which are similar to those given in Sec. 6, and comparisons of thermodynamic property tables calculated from the two formulations. The comparisons of the thermodynamic property tables are summarized here in Tables 7 and 8 to support the validity of this work by showing the compatibility of the two formulations. The differences between the two tables may also be used as a guide in estimating the uncertainty of calculated properties. Copies of the Report are available from the Center for Applied Thermodynamic Studies for those seeking additional information on the fundamental equation by Stewart and Jacobsen[5] or on comparisons of the two formulations to the data.

Differences given in Table 7 were taken from coexistence property tables for the two formulations tabulated at 2 K intervals with the same number of significant figures as used in Table 10. Differences given in Table 8 were taken from property tables for the two formulations similar to Table 11, tabulated for pressures of 0.1, 1.0, 5.0, 10.0, 40.0 and 80.0 MPa with temperature intervals of 5 K from 55 K to 150 K and 10 K for temperatures from 60 K to 350 K.

TABLE 7. Thermodynamic properties of oxygen for the coexistence states: Summary of comparisons between values from the Schmidt-Wagner[4] and the Stewart-Jacobsen[5] formulations

Entries are average percentage values and (maximum) percent for the stated temperature range. All entries are absolute values.

Property	Temperature range (K)						
	tp[a]-56	57–64	65–94	95–139	140–149	150–153	154
Pressure	.01	.03	.01	.02	.03	.05	.02
	(.02)	(.04)	(.02)	(.02)	(.05)	(.05)	
	Liquid properties at coexistence						
density	.07	.02	.01	.01	.02	.10	.73
	(.09)	(.03)	(.03)	(.02)	(.03)	(.21)	
enthalpy	.12	.02	.04	.16	.50	1.07	1.9
	(.15)	(.05)	(.06)	(.40)	(.62)	(1.5)	
entropy	.18	.02	.03	.02	.02	.01	.04
	(.24)	(.07)	(.04)	(.03)	(.03)	(.01)	
C_v	1.6	.48	.52	.49	1.1	1.2	7.6
	(1.9)	(.74)	(.80)	(.80)	(1.3)	(3.1)	
C_p	1.6	.48	.52	.49	1.1	1.2	13.6
	(6.1)	(3.1)	(.66)	(.48)	(.43)	(4.2)	
vel.snd.	.06	.09	.06	.22	1.1	1.5	7.9
	(.11)	(.12)	(.09)	(.89)	(1.1)	(3.8)	
	Vapor properties at coexistence						
density	.04	.05	.08	.06	.26	.48	.41
	(.06)	(.08)	(.11)	(.11)	(.41)	(.51)	
enthalpy	.18	.13	.14	.04	.39	.93	1.4
	(.18)	(.18)	(.20)	(.19)	(.64)	(1.2)	
entropy	.02	.02	.02	.00	.05	.10	.11
	(.02)	(.02)	(.03)	(.03)	(.08)	(.11)	
C_v	6.1	4.7	2.4	2.1	2.3	6.4	10.4
	(6.2)	(6.1)	(4.1)	(3.4)	(4.2)	(8.2)	
C_p	5.0	3.7	2.1	1.9	3.2	7.6	11.5
	(5.0)	(5.0)	(3.6)	(3.1)	(5.3)	(9.5)	
vel.snd.	.58	.47	.23	.22	.31	1.6	3.8
	(.59)	(.58)	(.37)	(.33)	(.76)	(2.4)	

[a]Triple point.

TABLE 8. Thermodynamic properties of oxygen: Summary of comparisons between values from the Schmidt-Wagner[4] and the Stewart-Jacobsen[5] formulations

Entries are average percentage values and (maximum) percent. All entries are absolute values

Pressure (MPa)	0.1	1.0	5.0	10.0	40.0	80.0
	T = 60 K to 150 K					
density	.02	.02	.01	.01	.01	.02
	(.06)	(.07)	(.05)	(.03)	(.04)	(.03)
int. energy	.05	.07	.13	.12	.09	.08
	(.14)	(.19)	(.38)	(.36)	(.19)	(.15)
enthalpy	.04	.06	.15	.15	.18	.51
	(.12)	(.14)	(.56)	(.58)	(.62)	(2.9)[a]
entropy	.01	.02	.02	.02	.03	.02
	(.04)	(.04)	(.03)	(.04)	(.14)	(.06)

TABLE 8. Thermodynamic properties of oxygen: Summary of comparisons between values from the Schmidt-Wagner[4] and the Stewart-Jacobsen[5] formulations – Continued

Entries are average percentage values and (maximum) percent. All entries are absolute values.

Pressure (MPa)	0.1	1.0	5.0	10.0	40.0	80.0
			T = 60 K to 150 K – Continued			
C_v	.29	.71	.40	.47	.59	.96
	(.78)	(2.8)	(.97)	(1.0)	(1.9)	(3.1)
C_p	.29	.58	.33	.31	.46	.31
	(.99)	(2.5)	(1.3)	(1.7)	(3.9)	(2.2)
vel.snd.	.03	.07	.15	.20	.29	.82
	(.10)	(.31)	(.38)	(.71)	(.81)	(1.5)
			T = 160 K to 350 K			
density	.00	.02	.03	.02	.02	.04
	(.01)	(.04)	(.06)	(.06)	(.03)	(.05)
int. energy	.00	.01	.05	.12	.33	.71
	(.01)	(.03)	(.19)	(.65)[a]	(2.6)[a]	(7.2)[a]
enthalpy	.00	.01	.03	.13	.60	.12
	(.01)	(.03)	(.13)	(1.5)[a]	(9.2)[a]	(.29)
entropy	.00	.00	.01	.01	.02	.02
	(.00)	(.00)	(.02)	(.02)	(.04)	(.06)
C_v	.01	.08	.27	.43	.62	.78
	(.04)	(.43)	(.91)	(.79)	(.90)	(1.5)
C_p	.01	.05	.14	.17	.30	.41
	(.03)	(.32)	(.52)	(.32)	(.48)	(.65)
vel.snd.	.00	.03	.09	.14	.16	.25
	(.00)	(.03)	(.20)	(.56)	(.29)	(.43)

[a]The values of internal energy and enthalpy are small in this region.

Appendix C. Thermodynamic Property Tables for Oxygen

The thermodynamic properties of the ideal gas given in Table 9 were derived from Eq. (11). Thermodynamic properties for Tables 10 and 11 were calculated using the fundamental equation [Eqs. (2, 14, 15)] with the coefficients and exponents given in Table 4 and the property functions given in Appendix A. The coexistence states were defined from the fundamental equation for calculating the liquid and vapor densities using the Maxwell criteria, i.e., equal pressures, temperatures and Gibbs energy for the liquid and vapor phases.

TABLE 9. Ideal gas properties of oxygen

T K	$S°$ J/mol·K	$H°$ J/mol	$C_v°$ J/mol·K	$C_p°$ J/mol·K	T K	$S°$ J/mol·K	$H°$ J/mol	$C_v°$ J/mol·K	$C_p°$ J/mol·K
35	142.62	1009.9	20.832	29.147	300	205.22	8736.4	21.071	29.385
40	146.51	1155.7	20.825	29.139	310	206.18	9030.5	21.123	29.437
45	149.94	1301.3	20.819	29.133	320	207.12	9325.1	21.180	29.494
50	153.01	1447.0	20.815	29.129	330	208.03	9620.4	21.242	29.556
55	155.79	1592.6	20.812	29.126	340	208.91	9916.3	21.309	29.623
60	158.32	1738.2	20.809	29.123	350	209.77	10212.8	21.380	29.694
65	160.65	1883.9	20.807	29.121	360	210.61	10510.2	21.455	29.769
70	162.81	2029.5	20.805	29.120	370	211.42	10808.2	21.534	29.849
75	164.82	2175.1	20.804	29.118	380	212.22	11107.1	21.617	29.932
80	166.70	2320.6	20.803	29.117	390	213.00	11406.9	21.703	30.018
85	168.46	2466.2	20.802	29.116	400	213.76	11707.5	21.792	30.107
90	170.13	2611.8	20.801	29.115	450	217.33	13224.6	22.271	30.585
95	171.70	2757.4	20.800	29.115	500	220.58	14766.5	22.778	31.093
100	173.19	2902.9	20.800	29.114	550	223.57	16333.9	23.287	31.602
105	174.61	3048.5	20.799	29.113	600	226.34	17926.4	23.779	32.093
110	175.97	3194.1	20.799	29.113	650	228.93	19542.7	24.242	32.556
115	177.26	3339.6	20.798	29.113	700	231.36	21181.4	24.671	32.985
120	178.50	3485.2	20.798	29.112	750	233.65	22840.7	25.065	33.379
125	179.69	3630.8	20.798	29.112	800	235.81	24518.7	25.424	33.738
130	180.83	3776.3	20.798	29.112	850	237.87	26213.9	25.750	34.065
135	181.93	3921.9	20.798	29.112	900	239.82	27924.7	26.047	34.361
140	182.99	4067.5	20.798	29.112	950	241.69	29649.6	26.317	34.631
145	184.01	4213.0	20.798	29.112	1000	243.47	31387.4	26.563	34.877
150	185.00	4358.6	20.798	29.112	1050	245.18	33137.0	26.788	35.102
155	185.95	4504.1	20.798	29.113	1100	246.82	34897.3	26.995	35.309
160	186.88	4649.7	20.799	29.113	1150	248.39	36667.7	27.187	35.501
165	187.77	4795.3	20.799	29.114	1200	249.90	38447.2	27.365	35.679
170	188.64	4940.8	20.800	29.114	1250	251.36	40235.4	27.532	35.846
175	189.49	5086.4	20.801	29.116	1300	252.77	42031.7	27.689	36.003
180	190.31	5232.0	20.803	29.117	1350	254.14	43835.6	27.839	36.153
185	191.10	5377.6	20.804	29.119	1400	255.45	45646.8	27.981	36.296
190	191.88	5523.2	20.807	29.121	1450	256.73	47465.1	28.119	36.433
195	192.64	5668.8	20.809	29.124	1500	257.97	49290.1	28.252	36.566
200	193.37	5814.4	20.812	29.127	1550	259.17	51121.7	28.381	36.696
210	194.80	6105.7	20.820	29.135	1600	260.33	52959.6	28.508	36.822
220	196.15	6397.1	20.832	29.146	1650	261.47	54803.9	28.632	36.947
230	197.45	6688.7	20.846	29.160	1700	262.57	56654.3	28.755	37.069
240	198.69	6980.3	20.864	29.178	1750	263.65	58510.8	28.876	37.191
250	199.88	7272.2	20.886	29.201	1800	264.70	60373.3	28.996	37.311
260	201.03	7564.4	20.913	29.228	1850	265.72	62241.8	29.115	37.430
270	202.13	7856.8	20.945	29.259	1900	266.72	64116.3	29.234	37.548
280	203.19	8149.6	20.982	29.296	1950	267.70	65996.6	29.352	37.666
290	204.22	8442.7	21.024	29.338	2000	268.66	67882.8	29.469	37.783

TABLE 10. Thermodynamic properties of saturated oxygen

Temp. K	Pressure MPa	Density mol/dm³	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Vel. snd. m/s
54.361[a]	.000146	40.816	−6193.4	66.94	38.25	53.54	1123
		.0003237	1573.4	209.81			140
55	.000179	40.734	−6159.2	67.57	37.65	53.49	1126
		.0003906	1591.8	208.49			141
56	.000242	40.604	−6105.8	68.53	36.86	53.46	1130
		.0005191	1620.7	206.50			142
57	.000323	40.471	−6052.3	69.47	36.21	53.46	1131
		.0006821	1649.6	204.60			143
58	.000428	40.337	−5998.8	70.40	35.67	53.48	1131
		.0008870	1678.4	202.77			144
59	.000560	40.201	−5945.3	71.32	35.22	53.51	1130
		.001142	1707.2	201.02			145
60	.000726	40.064	−5891.8	72.22	34.83	53.55	1127
		.001456	1735.9	199.35			147
61	.000932	39.926	−5838.2	73.10	34.50	53.58	1123
		.001840	1764.6	197.74			148
62	.001187	39.787	−5784.6	73.98	34.20	53.61	1119
		.002306	1793.3	196.20			149
63	.001499	39.648	−5731.0	74.83	33.93	53.63	1113
		.002866	1821.9	194.72			150
64	.001878	39.507	−5677.4	75.68	33.69	53.65	1107
		.003536	1850.5	193.30			151
65	.002335	39.367	−5623.7	76.51	33.47	53.67	1101
		.004329	1879.0	191.94			152
66	.002882	39.225	−5570.0	77.33	33.26	53.68	1095
		.005264	1907.5	190.63			153
67	.003533	39.084	−5516.3	78.14	33.07	53.69	1088
		.006359	1936.0	189.37			154
68	.004302	38.942	−5462.6	78.93	32.88	53.69	1081
		.007633	1964.3	188.15			155
69	.005206	38.799	−5408.9	79.72	32.70	53.69	1073
		.009107	1992.6	186.98			156
70	.006262	38.656	−5355.2	80.49	32.53	53.70	1066
		.010804	2020.9	185.86			158
71	.007490	38.513	−5301.5	81.25	32.37	53.70	1058
		.012748	2049.0	184.78			159
72	008910	38.369	−5247.7	82.00	32.21	53.70	1051
		.014963	2077.0	183.73			160
73	.01054	38.225	−5194.0	82.74	32.05	53.71	1043
		.017477	2105.0	182.73			161
74	.01241	38.081	−5140.3	83.47	31.90	53.71	1035
		.020316	2132.8	181.76			162
75	.01455	37.936	−5086.5	84.19	31.75	53.72	1027
		.023509	2160.4	180.82			163
76	.01697	37.790	−5032.7	84.90	31.60	53.73	1019
		.027088	2188.0	179.91			164
77	.01971	37.644	−4978.9	85.61	31.45	53.74	1011
		.031082	2215.3	179.04			165
78	.02279	37.498	−4925.1	86.30	31.31	53.76	1003
		.035524	2242.5	178.19			166
79	.02625	37.351	−4871.3	86.98	31.17	53.78	995
		.040449	2269.4	177.37			167
80	.03012	37.203	−4817.4	87.66	31.03	53.81	987
		.045891	2296.1	176.58			168
81	.03444	37.055	−4763.5	88.33	30.89	53.84	979
		.051885	2322.6	175.81			169
82	.03923	36.907	−4709.6	88.99	30.76	53.87	971
		.058468	2348.9	175.07			170
83	.04453	36.757	−4655.6	89.64	30.63	53.91	963
		.065679	2374.8	174.35			171
84	.05039	36.607	−4601.6	90.29	30.49	53.96	955
		.073555	2400.5	173.65			172
85	.05683	36.457	−4547.5	90.93	30.37	54.01	946
		.082138	2425.9	172.96			173
86	.06391	36.305	−4493.3	91.56	30.24	54.07	938
		.091467	2450.9	172.30			173

TABLE 10. Thermodynamic properties of saturated oxygen – Continued

Temp. K	Pressure MPa	Density mol/dm³	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Vel. snd. m/s
87	.07165	36.153	−4439.1	92.18	30.11	54.13	930
		.10158	2475.6	171.66			174
88	.08011	36.000	−4384.7	92.80	29.99	54.20	922
		.11253	2500.0	171.03			175
89	.08933	35.847	−4330.3	93.41	29.87	54.28	914
		.12436	2524.0	170.43			176
90	.09935	35.692	−4275.8	94.02	29.75	54.36	905
		.13710	2547.5	169.83			177
91	.1102	35.537	−4221.3	94.62	29.63	54.45	897
		.15081	2570.7	169.25			178
92	.1220	35.380	−4166.6	95.21	29.51	54.55	889
		.16554	2593.5	168.69			178
93	.1347	35.223	−4111.8	95.80	29.39	54.65	881
		.18132	2615.8	168.14			179
94	.1484	35.065	−4056.8	96.38	29.28	54.76	872
		.19821	2637.7	167.60			180
95	.1631	34.905	−4001.8	96.96	29.17	54.88	864
		.21627	2659.1	167.08			180
96	.1789	34.745	−3946.6	97.53	29.06	55.01	856
		.23553	2680.1	166.56			181
97	.1958	34.583	−3891.2	98.10	28.95	55.14	847
		.25606	2700.6	166.06			182
98	.2140	34.421	−3835.7	98.67	28.84	55.29	839
		.27791	2720.5	165.57	21.54	31.84	182
99	.2333	34.257	−3780.1	99.23	28.74	55.44	830
		.30113	2740.0	165.08	21.57	32.01	183
100	.2540	34.092	−3724.3	99.78	28.64	55.60	822
		.32579	2758.9	164.61	21.61	32.20	184
101	.2760	33.925	−3668.2	100.33	28.53	55.77	813
		.35193	2777.2	164.15	21.65	32.42	184
102	.2994	33.757	−3612.0	100.88	28.43	55.95	805
		.37963	2795.0	163.69	21.70	32.65	185
103	.3243	33.588	−3555.6	101.42	28.34	56.14	796
		.40894	2812.3	163.25	21.76	32.90	185
104	.3506	33.417	−3499.0	101.96	28.24	56.34	787
		.43993	2828.9	162.81	21.82	33.17	186
105	.3785	33.245	−3442.2	102.50	28.15	56.56	779
		.47267	2845.0	162.37	21.89	33.46	186
106	.4081	33.072	−3385.2	103.03	28.05	56.78	770
		.50722	2860.4	161.95	21.97	33.77	186
107	.4393	32.896	−3327.9	103.56	27.96	57.02	761
		.54366	2875.2	161.53	22.06	34.11	187
108	.4722	32.719	−3270.3	104.08	27.87	57.27	752
		.58206	2889.3	161.12	22.15	34.46	187
109	.5069	32.540	−3212.5	104.61	27.79	57.54	743
		.62250	2902.8	160.71	22.25	34.84	187
110	.5434	32.360	−3154.4	105.13	27.70	57.82	734
		.66506	2915.6	160.31	22.36	35.24	188
111	.5818	32.177	−3096.0	105.65	27.62	58.11	725
		.70983	2927.7	159.91	22.47	35.67	188
112	.6222	31.993	−3037.3	106.16	27.54	58.42	716
		.75690	2939.1	159.52	22.59	36.12	188
113	.6646	31.806	−2978.3	106.67	27.46	58.75	707
		.80635	2949.8	159.13	22.71	36.60	188
114	.7090	31.617	−2918.9	107.18	27.39	59.10	698
		.85829	2959.7	158.75	22.84	37.11	188
115	.7556	31.426	−2859.2	107.69	27.31	59.47	689
		.91283	2968.8	158.37	22.98	37.65	189
116	.8043	31.233	−2799.2	108.20	27.24	59.86	679
		.97006	2977.2	157.99	23.12	38.22	189
117	.8553	31.037	−2738.7	108.70	27.17	60.27	670
		1.0301	2984.7	157.62	23.26	38.82	189
118	.9086	30.839	−2677.9	109.21	27.10	60.71	660
		1.0931	2991.3	157.25	23.41	39.45	189
119	.9642	30.638	−2616.6	109.71	27.04	61.17	651
		1.1592	2997.1	156.88	23.57	40.13	189

TABLE 10. Thermodynamic properties of saturated oxygen — Continued

Temp. K	Pressure MPa	Density mol/dm³	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Vel. snd. m/s
120	1.0223	30.434	−2554.8	110.21	26.98	61.67	641
		1.2284	3002.0	156.52	23.73	40.84	189
121	1.0828	30.227	−2492.7	110.71	26.92	62.19	631
		1.3010	3006.0	156.15	23.89	41.60	189
122	1.1459	30.017	−2430.0	111.21	26.86	62.75	621
		1.3772	3008.9	155.79	24.06	42.40	189
123	1.2115	29.804	−2366.8	111.71	26.81	63.34	612
		1.4570	3010.9	155.43	24.23	43.26	189
124	1.2798	29.588	−2303.0	112.20	26.76	63.98	601
		1.5407	3011.8	155.06	24.41	44.17	189
125	1.3509	29.367	−2238.7	112.70	26.71	64.66	591
		1.6285	3011.7	154.70	24.60	45.15	188
126	1.4247	29.143	−2173.7	113.20	26.67	65.39	581
		1.7205	3010.4	154.34	24.79	46.19	188
127	1.5014	28.915	−2108.1	113.70	26.63	66.17	571
		1.8171	3007.9	153.98	24.98	47.31	188
128	1.5809	28.683	−2041.9	114.19	26.59	67.01	560
		1.9184	3004.2	153.62	25.18	48.51	188
129	1.6635	28.445	−1974.9	114.69	26.56	67.92	550
		2.0248	2999.2	153.25	25.39	49.80	188
130	1.7491	28.203	−1907.1	115.19	26.54	68.91	539
		2.1366	2992.8	152.88	25.60	51.20	187
131	1.8378	27.956	−1838.5	115.69	26.51	69.97	528
		2.2541	2985.0	152.51	25.83	52.72	187
132	1.9296	27.703	−1769.1	116.20	26.50	71.13	517
		2.3776	2975.7	152.14	26.05	54.38	187
133	2.0248	27.445	−1698.7	116.70	26.49	72.40	506
		2.5077	2964.8	151.77	26.29	56.18	186
134	2.1232	27.179	−1627.2	117.21	26.48	73.79	495
		2.6447	2952.1	151.38	26.54	58.16	186
135	2.2250	26.907	−1554.7	117.72	26.49	75.33	483
		2.7892	2937.7	151.00	26.79	60.35	185
136	2.3303	26.627	−1481.0	118.24	26.50	77.02	472
		2.9418	2921.3	150.61	27.06	62.77	185
137	2.4392	26.338	−1406.1	118.76	26.51	78.91	460
		3.1033	2902.8	150.21	27.34	65.47	184
138	2.5516	26.041	−1329.7	119.28	26.54	81.02	448
		3.2743	2882.1	149.80	27.63	68.50	184
139	2.6678	25.733	−1251.8	119.81	26.58	83.40	435
		3.4557	2858.9	149.38	27.94	71.92	183
140	2.7878	25.415	−1172.2	120.35	26.63	86.10	423
		3.6487	2833.1	148.96	28.27	75.82	182
141	2.9116	25.083	−1090.7	120.89	26.70	89.19	410
		3.8546	2804.3	148.52	28.62	80.31	182
142	3.0394	24.738	−1007.2	121.45	26.79	92.75	397
		4.0747	2772.3	148.06	28.99	85.52	181
143	3.1713	24.377	−921.2	122.01	26.89	96.92	383
		4.3109	2736.6	147.59	29.38	91.64	180
144	3.3074	23.998	−832.7	122.59	27.02	101.85	369
		4.5655	2696.9	147.10	29.81	98.95	179
145	3.4477	23.599	−741.0	123.18	27.19	107.78	355
		4.8412	2652.5	146.59	30.28	107.81	178
146	3.5925	23.174	−645.7	123.79	27.40	115.05	340
		5.1416	2602.7	146.04	30.79	118.79	177
147	3.7418	22.721	−546.3	124.43	27.66	124.18	324
		5.4715	2546.5	145.47	31.35	132.73	176
148	3.8958	22.233	−441.6	125.09	27.99	136.00	308
		5.8373	2482.7	144.85	31.99	150.99	175
149	4.0547	21.700	−330.7	125.79	28.41	151.97	291
		6.2479	2409.4	144.18	32.72	175.94	174
150	4.2186	21.110	−211.5	126.54	28.98	174.84	273
		6.7170	2323.9	143.44	33.57	212.01	172
151	4.3878	20.440	−80.9	127.35	29.76	210.56	254
		7.2666	2221.8	142.60	34.60	268.60	171
152	4.5626	19.651	66.6	128.27	30.87	274.84	232
		7.9368	2095.3	141.61	35.88	369.80	169

TABLE 10. Thermodynamic properties of saturated oxygen – Continued

Temp. K	Pressure MPa	Density mol/dm³	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Vel. snd. m/s
153	4.7434	18.650	244.0	129.37	32.64	426.37	208
		8.8165	1927.1	140.37	37.61	600.87	166
154	4.9307	17.096	500.0	130.97	36.13	1192.05	178
		10.213	1658.9	138.49	40.31	1633.93	161
154.581[b]	5.043	13.63	1039.49	134.42			

[a]Triple point.
[b]Critical point.

TABLE 11. Thermodynamic properties of oxygen

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			.02 MPa Isobar				
54.36[a]	40.817	−6193.4	−6192.9	66.94	38.25	53.54	1123
56	40.605	−6105.9	−6105.4	68.53	36.86	53.45	1130
58	40.338	−5999.0	−5998.5	70.40	35.67	53.48	1131
60	40.065	−5891.9	−5891.4	72.22	34.83	53.55	1127
62	39.788	−5784.8	−5784.3	73.97	34.20	53.61	1119
64	39.508	−5677.5	−5677.0	75.68	33.69	53.65	1108
66	39.226	−5570.2	−5569.7	77.33	33.26	53.68	1095
68	38.942	−5462.8	−5462.3	78.93	32.88	53.69	1081
70	38.657	−5355.4	−5354.9	80.49	32.53	53.70	1066
72	38.370	−5248.0	−5247.5	82.00	32.21	53.70	1051
74	38.081	−5140.6	−5140.1	83.47	31.90	53.71	1035
76	37.790	−5033.2	−5032.7	84.90	31.60	53.73	1019
77.10[a]	37.630	−4974.1	−4973.6	85.68	31.44	53.74	1010
77.10[a]	.03150	1583.2	2218.0	178.95			165
78	.03113	1603.4	2245.9	179.31			166
80	.03032	1646.9	2306.4	180.08			169
82	.02957	1689.3	2365.8	180.81			171
84	.02885	1731.3	2424.6	181.52	20.82	29.34	174
86	.02816	1773.1	2483.2	182.21	20.76	29.26	176
88	.02751	1814.8	2541.7	182.88	20.75	29.23	178
90	.02689	1856.4	2600.2	183.54	20.75	29.23	180
92	.02630	1898.1	2658.6	184.18	20.76	29.23	182
94	.02573	1939.8	2717.1	184.81	20.77	29.24	184
96	.02519	1981.5	2775.6	185.43	20.78	29.24	186
98	.02467	2023.2	2834.0	186.03	20.79	29.25	188
100	.02417	2064.9	2892.5	186.62	20.80	29.25	190
102	.02369	2106.7	2951.0	187.20	20.81	29.25	192
104	.02323	2148.4	3009.5	187.77	20.81	29.25	194
106	.02278	2190.2	3068.0	188.32	20.82	29.25	195
108	.02236	2231.9	3126.5	188.87	20.82	29.25	197
110	.02195	2273.7	3185.0	189.41	20.82	29.24	199
112	.02155	2315.4	3243.5	189.93	20.82	29.24	201
114	.02117	2357.2	3302.0	190.45	20.83	29.24	203
116	.02080	2398.9	3360.5	190.96	20.83	29.23	205
118	.02044	2440.7	3418.9	191.46	20.83	29.23	206
120	.02010	2482.4	3477.4	191.95	20.83	29.22	208
122	.01977	2524.1	3535.8	192.43	20.82	29.22	210
124	.01945	2565.9	3594.3	192.91	20.82	29.22	212
126	.01914	2607.6	3652.7	193.38	20.82	29.21	213
128	.01884	2649.3	3711.1	193.84	20.82	29.21	215

TABLE 11. Thermodynamic properties of oxygen

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			.02 MPa Isobar				
130	.01854	2691.0	3769.5	194.29	20.82	29.20	217
132	.01826	2732.7	3827.9	194.73	20.82	29.20	218
134	.01799	2774.4	3886.3	195.17	20.82	29.20	220
136	.01772	2816.1	3944.7	195.61	20.82	29.19	222
138	.01746	2857.8	4003.1	196.03	20.82	29.19	223
140	.01721	2899.5	4061.5	196.45	20.82	29.19	225
142	.01697	2941.2	4119.8	196.87	20.82	29.18	227
144	.01673	2982.9	4178.2	197.27	20.82	29.18	228
146	.01650	3024.6	4236.6	197.68	20.81	29.18	230
148	.01628	3066.3	4294.9	198.07	20.81	29.18	231
150	.01606	3107.9	4353.3	198.47	20.81	29.17	233
152	.01585	3149.6	4411.6	198.85	20.81	29.17	234
154	.01564	3191.3	4470.0	199.23	20.81	29.17	236
156	.01544	3232.9	4528.3	199.61	20.81	29.17	238
158	.01524	3274.6	4586.6	199.98	20.81	29.17	239
160	.01505	3316.3	4645.0	200.35	20.81	29.16	241
162	.01487	3357.9	4703.3	200.71	20.81	29.16	242
164	.01468	3399.6	4761.6	201.07	20.81	29.16	244
166	.01451	3441.2	4819.9	201.42	20.81	29.16	245
168	.01433	3482.9	4878.3	201.77	20.81	29.16	247
170	.01416	3524.5	4936.6	202.12	20.81	29.16	248
172	.01400	3566.2	4994.9	202.46	20.81	29.16	249
174	.01384	3607.9	5053.2	202.79	20.81	29.16	251
176	.01368	3649.5	5111.5	203.13	20.81	29.16	252
178	.01353	3691.2	5169.8	203.46	20.81	29.15	254
180	.01337	3732.8	5228.1	203.78	20.81	29.15	255
185	.01301	3836.9	5373.9	204.58	20.81	29.15	259
190	.01267	3941.1	5519.7	205.36	20.81	29.15	262
195	.01234	4045.2	5665.4	206.12	20.82	29.15	266
200	.01203	4149.3	5811.2	206.85	20.82	29.15	269
205	.01174	4253.5	5957.0	207.57	20.82	29.16	272
210	.01146	4357.6	6102.8	208.28	20.83	29.16	276
215	.01119	4461.8	6248.6	208.96	20.83	29.16	279
220	.01094	4566.0	6394.4	209.63	20.84	29.17	282
225	.01070	4670.3	6540.2	210.29	20.84	29.17	285
230	.01046	4774.5	6686.1	210.93	20.85	29.18	289
235	.01024	4878.8	6832.0	211.56	20.86	29.19	292
240	.01003	4983.2	6978.0	212.17	20.87	29.20	295
245	.00982	5087.6	7124.0	212.77	20.88	29.21	298
250	.00962	5192.0	7270.1	213.36	20.89	29.22	301
255	.00944	5296.5	7416.2	213.94	20.90	29.23	304
260	.00925	5401.1	7562.3	214.51	20.92	29.24	307
265	.00908	5505.8	7708.6	215.07	20.93	29.26	310
270	.00891	5610.5	7854.9	215.62	20.95	29.27	313
275	.00875	5715.3	8001.3	216.15	20.96	29.29	315
280	.00859	5820.2	8147.8	216.68	20.98	29.31	318
285	.00844	5925.2	8294.4	217.20	21.00	29.33	321
290	.00830	6030.3	8441.1	217.71	21.03	29.35	324
295	.00816	6135.5	8587.9	218.21	21.05	29.37	327
300	.00802	6240.8	8734.8	218.71	21.07	29.39	329

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			.04 MPa Isobar				
54.36[a]	40.817	−6193.4	−6192.4	66.94	38.24	53.54	1123
56	40.605	−6106.0	−6105.0	68.53	36.86	53.45	1130
58	40.338	−5999.0	−5998.1	70.40	35.67	53.48	1131
60	40.066	−5892.0	−5891.0	72.22	34.84	53.54	1127
62	39.789	−5784.9	−5783.9	73.97	34.20	53.61	1119
64	39.509	−5677.6	−5676.6	75.68	33.69	53.65	1108
66	39.227	−5570.3	−5569.3	77.33	33.26	53.68	1095
68	38.943	−5463.0	−5461.9	78.93	32.88	53.69	1081
70	38.658	−5355.6	−5354.5	80.49	32.53	53.69	1066
72	38.371	−5248.2	−5247.1	82.00	32.21	53.70	1051
74	38.082	−5140.8	−5139.7	83.47	31.90	53.71	1035
76	37.791	−5033.4	−5032.3	84.90	31.60	53.73	1019
78	37.499	−4925.9	−4924.8	86.30	31.31	53.76	1003
80	37.204	−4818.3	−4817.3	87.66	31.03	53.81	987
82	36.907	−4710.7	−4709.6	88.99	30.76	53.87	971
82.15[a]	36.884	−4702.5	−4701.4	89.09	30.74	53.88	970
82.15[a]	.05953	1680.9	2352.8	174.96			170
84	.05815	1721.5	2409.4	175.64			172
86	.05674	1764.4	2469.5	176.34	21.05	29.80	175
88	.05540	1806.8	2528.8	177.03	20.87	29.58	177
90	.05412	1848.8	2587.9	177.69	20.80	29.47	179
92	.05291	1890.7	2646.7	178.34	20.78	29.42	181
94	.05175	1932.6	2705.6	178.97	20.78	29.41	183
96	.05064	1974.5	2764.4	179.59	20.79	29.40	185
98	.04958	2016.3	2823.2	180.19	20.80	29.40	187
100	.04856	2058.2	2882.0	180.79	20.81	29.40	189
102	.04758	2100.1	2940.8	181.37	20.82	29.40	191
104	.04665	2142.0	2999.6	181.94	20.83	29.40	193
106	.04575	2184.0	3058.4	182.50	20.84	29.39	195
108	.04488	2225.9	3117.1	183.05	20.84	29.39	197
110	.04405	2267.8	3175.9	183.59	20.85	29.38	199
112	.04325	2309.7	3234.6	184.12	20.85	29.37	201
114	.04247	2351.6	3293.4	184.64	20.85	29.36	202
116	.04173	2393.5	3352.1	185.15	20.85	29.36	204
118	.04101	2435.4	3410.8	185.65	20.85	29.35	206
120	.04031	2477.3	3469.5	186.14	20.85	29.34	208
122	.03964	2519.2	3528.2	186.63	20.85	29.33	210
124	.03899	2561.0	3586.8	187.11	20.85	29.32	211
126	.03837	2602.9	3645.5	187.58	20.85	29.31	213
128	.03776	2644.7	3704.1	188.04	20.85	29.31	215
130	.03717	2686.6	3762.7	188.49	20.85	29.30	216
132	.03660	2728.4	3821.3	188.94	20.84	29.29	218
134	.03605	2770.2	3879.8	189.38	20.84	29.28	220
136	.03551	2812.0	3938.4	189.81	20.84	29.28	221
138	.03499	2853.8	3996.9	190.24	20.84	29.27	223
140	.03449	2895.6	4055.5	190.66	20.84	29.26	225
142	.03400	2937.4	4114.0	191.08	20.83	29.26	226
144	.03352	2979.1	4172.5	191.49	20.83	29.25	228
146	.03306	3020.9	4231.0	191.89	20.83	29.25	230
148	.03260	3062.7	4289.5	192.29	20.83	29.24	231

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			.04 MPa Isobar — Continued				
150	.03217	3104.4	4348.0	192.68	20.83	29.24	233
152	.03174	3146.2	4406.4	193.07	20.83	29.23	234
154	.03132	3187.9	4464.9	193.45	20.83	29.23	236
156	.03092	3229.7	4523.4	193.83	20.83	29.22	237
158	.03052	3271.4	4581.8	194.20	20.82	29.22	239
160	.03014	3313.1	4640.2	194.57	20.82	29.22	240
162	.02977	3354.8	4698.7	194.93	20.82	29.21	242
164	.02940	3396.6	4757.1	195.29	20.82	29.21	243
166	.02904	3438.3	4815.5	195.64	20.82	29.21	245
168	.02870	3480.0	4873.9	195.99	20.82	29.20	246
170	.02836	3521.7	4932.3	196.34	20.82	29.20	248
172	.02802	3563.4	4990.7	196.68	20.82	29.20	249
174	.02770	3605.1	5049.1	197.02	20.82	29.20	251
176	.02738	3646.8	5107.5	197.35	20.82	29.19	252
178	.02707	3688.5	5165.9	197.68	20.82	29.19	254
180	.02677	3730.2	5224.3	198.01	20.82	29.19	255
185	.02605	3834.4	5370.2	198.81	20.82	29.19	259
190	.02536	3938.7	5516.2	199.58	20.82	29.18	262
195	.02470	4042.9	5662.1	200.34	20.82	29.18	266
200	.02408	4147.1	5808.0	201.08	20.82	29.18	269
205	.02349	4251.3	5953.9	201.80	20.83	29.18	272
210	.02293	4355.6	6099.8	202.50	20.83	29.18	276
215	.02240	4459.8	6245.7	203.19	20.83	29.19	279
220	.02189	4564.1	6391.7	203.86	20.84	29.19	282
225	.02140	4668.4	6537.6	204.52	20.85	29.19	285
230	.02093	4772.7	6683.6	205.16	20.85	29.20	289
235	.02049	4877.1	6829.6	205.79	20.86	29.21	292
240	.02006	4981.5	6975.7	206.40	20.87	29.21	295
245	.01965	5085.9	7121.7	207.00	20.88	29.22	298
250	.01925	5190.4	7267.9	207.60	20.89	29.23	301
255	.01888	5295.0	7414.1	208.17	20.90	29.24	304
260	.01851	5399.6	7560.3	208.74	20.92	29.26	307
265	.01816	5504.3	7706.6	209.30	20.93	29.27	310
270	.01783	5609.0	7853.0	209.85	20.95	29.29	313
275	.01750	5713.9	7999.5	210.38	20.97	29.30	315
280	.01719	5818.8	8146.0	210.91	20.99	29.32	318
285	.01689	5923.8	8292.7	211.43	21.01	29.34	321
290	.01659	6029.0	8439.4	211.94	21.03	29.36	324
295	.01631	6134.2	8586.3	212.44	21.05	29.38	327
300	.01604	6239.5	8733.2	212.94	21.07	29.40	329
			.06 MPa Isobar				
54.37[a]	40.818	−6193.4	−6191.9	66.94	38.24	53.53	1123
56	40.606	−6106.0	−6104.6	68.52	36.86	53.45	1130
58	40.339	−5999.1	−5997.7	70.40	35.67	53.48	1131
60	40.066	−5892.1	−5890.6	72.21	34.84	53.54	1127
62	39.789	−5785.0	−5783.5	73.97	34.20	53.61	1119
64	39.510	−5677.7	−5676.2	75.67	33.69	53.65	1108
66	39.228	−5570.4	−5568.9	77.32	33.26	53.68	1095
68	38.944	−5463.1	−5461.5	78.93	32.88	53.69	1081
70	38.659	−5355.7	−5354.2	80.48	32.54	53.69	1066
72	38.372	−5248.3	−5246.8	82.00	32.21	53.70	1051

TABLE 11. Thermodynamic properties of oxygen – Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			.06 MPa Isobar – Continued				
74	38.083	−5140.9	−5139.4	83.47	31.90	53.71	1035
76	37.792	−5033.5	−5031.9	84.90	31.60	53.73	1019
78	37.500	−4926.0	−4924.4	86.30	31.31	53.76	1003
80	37.205	−4818.5	−4816.9	87.66	31.03	53.81	987
82	36.908	−4710.8	−4709.2	88.99	30.76	53.87	971
84	36.608	−4603.0	−4601.4	90.29	30.49	53.96	955
85.46[a]	36.387	−4524.2	−4522.6	91.22	30.31	54.04	943
85.46[a]	.08633	1742.4	2437.4	172.66			173
86	.08575	1754.4	2454.1	172.85			174
88	.08367	1797.9	2515.0	173.55			176
90	.08171	1840.6	2574.9	174.23	20.96	29.85	179
92	.07984	1883.0	2634.5	174.88	20.86	29.70	181
94	.07806	1925.2	2693.8	175.52	20.82	29.62	183
96	.07636	1967.3	2753.0	176.14	20.81	29.59	185
98	.07474	2009.3	2812.1	176.75	20.82	29.57	187
100	.07318	2051.4	2871.3	177.35	20.83	29.56	189
102	.07170	2093.5	2930.4	177.93	20.84	29.55	191
104	.07027	2135.6	2989.5	178.51	20.85	29.55	193
106	.06890	2177.7	3048.6	179.07	20.86	29.54	195
108	.06758	2219.8	3107.6	179.62	20.87	29.53	197
110	.06631	2261.9	3166.7	180.16	20.88	29.52	198
112	.06509	2303.9	3225.7	180.70	20.88	29.51	200
114	.06392	2346.0	3284.7	181.22	20.88	29.49	202
116	.06279	2388.1	3343.7	181.73	20.88	29.48	204
118	.06169	2430.1	3402.6	182.24	20.88	29.47	206
120	.06064	2472.1	3461.6	182.73	20.88	29.46	207
122	.05962	2514.2	3520.5	183.22	20.88	29.44	209
124	.05864	2556.2	3579.3	183.70	20.88	29.43	211
126	.05769	2598.1	3638.2	184.17	20.87	29.42	213
128	.05677	2640.1	3697.0	184.63	20.87	29.40	214
130	.05588	2682.1	3755.8	185.09	20.87	29.39	216
132	.05502	2724.0	3814.6	185.53	20.87	29.38	218
134	.05418	2765.9	3873.3	185.98	20.86	29.37	220
136	.05337	2807.8	3932.1	186.41	20.86	29.36	221
138	.05258	2849.7	3990.8	186.84	20.86	29.35	223
140	.05182	2891.6	4049.5	187.26	20.86	29.34	225
142	.05108	2933.5	4108.1	187.68	20.85	29.33	226
144	.05036	2975.4	4166.8	188.09	20.85	29.32	228
146	.04966	3017.2	4225.4	188.49	20.85	29.31	229
148	.04898	3059.1	4284.1	188.89	20.85	29.31	231
150	.04832	3100.9	4342.7	189.28	20.84	29.30	233
152	.04768	3142.7	4401.2	189.67	20.84	29.29	234
154	.04705	3184.6	4459.8	190.06	20.84	29.29	236
156	.04644	3226.4	4518.4	190.43	20.84	29.28	237
158	.04584	3268.2	4576.9	190.81	20.84	29.27	239
160	.04526	3310.0	4635.5	191.17	20.84	29.27	240
162	.04470	3351.7	4694.0	191.54	20.83	29.26	242
164	.04415	3393.5	4752.5	191.90	20.83	29.26	243
166	.04361	3435.3	4811.1	192.25	20.83	29.25	245
168	.04309	3477.1	4869.6	192.60	20.83	29.25	246

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			.06 MPa Isobar — Continued				
170	.04258	3518.8	4928.1	192.95	20.83	29.25	248
172	.04208	3560.6	4986.5	193.29	20.83	29.24	249
174	.04159	3602.3	5045.0	193.63	20.83	29.24	251
176	.04111	3644.1	5103.5	193.96	20.83	29.23	252
178	.04065	3685.8	5162.0	194.29	20.83	29.23	254
180	.04019	3727.6	5220.4	194.62	20.83	29.23	255
185	.03910	3831.9	5366.5	195.42	20.83	29.22	259
190	.03806	3936.2	5512.6	196.20	20.83	29.22	262
195	.03708	4040.6	5658.7	196.96	20.83	29.21	266
200	.03615	4144.9	5804.8	197.70	20.83	29.21	269
205	.03526	4249.2	5950.8	198.42	20.83	29.21	272
210	.03442	4353.5	6096.8	199.12	20.83	29.21	276
215	.03361	4457.8	6242.9	199.81	20.84	29.21	279
220	.03284	4562.2	6388.9	200.48	20.84	29.21	282
225	.03211	4666.5	6535.0	201.14	20.85	29.21	285
230	.03141	4770.9	6681.1	201.78	20.86	29.22	289
235	.03074	4875.3	6827.2	202.41	20.86	29.22	292
240	.03010	4979.8	6973.3	203.02	20.87	29.23	295
245	.02948	5084.3	7119.5	203.63	20.88	29.24	298
250	.02889	5188.8	7265.7	204.22	20.89	29.25	301
255	.02832	5293.4	7411.9	204.80	20.91	29.26	304
260	.02778	5398.1	7558.3	205.37	20.92	29.27	307
265	.02725	5502.8	7704.7	205.92	20.94	29.28	310
270	.02674	5607.6	7851.1	206.47	20.95	29.30	313
275	.02626	5712.5	7997.6	207.01	20.97	29.31	315
280	.02579	5817.4	8144.2	207.54	20.99	29.33	318
285	.02533	5922.5	8290.9	208.06	21.01	29.35	321
290	.02490	6027.6	8437.7	208.57	21.03	29.37	324
295	.02447	6132.9	8584.7	209.07	21.05	29.39	327
300	.02406	6238.3	8731.7	209.56	21.08	29.41	329
			.08 MPa Isobar				
54.37[a]	40.818	−6193.3	−6191.4	66.94	38.24	53.53	1123
56	40.607	−6106.1	−6104.2	68.52	36.86	53.45	1130
58	40.340	−5999.2	−5997.3	70.40	35.67	53.48	1132
60	40.067	−5892.2	−5890.2	72.21	34.84	53.54	1127
62	39.790	−5785.1	−5783.1	73.97	34.20	53.60	1119
64	39.511	−5677.9	−5675.8	75.67	33.70	53.65	1108
66	39.229	−5570.6	−5568.5	77.32	33.27	53.67	1095
68	38.945	−5463.2	−5461.2	78.93	32.88	53.69	1081
70	38.660	−5355.8	−5353.8	80.48	32.54	53.69	1066
72	38.373	−5248.5	−5246.4	81.99	32.21	53.70	1051
74	38.084	−5141.1	−5139.0	83.47	31.90	53.71	1035
76	37.793	−5033.7	−5031.6	84.90	31.60	53.72	1019
78	37.501	−4926.2	−4924.1	86.29	31.31	53.76	1003
80	37.206	−4818.7	−4816.5	87.66	31.03	53.80	987
82	36.909	−4711.0	−4708.9	88.98	30.76	53.87	971
84	36.609	−4603.2	−4601.0	90.28	30.50	53.96	955
86	36.306	−4495.2	−4493.0	91.55	30.24	54.07	938
87.99[a]	36.002	−4387.7	−4385.4	92.79	29.99	54.20	922
87.99[a]	.11239	1787.8	2499.7	171.04			175
88	.11237	1788.1	2500.1	171.05			175

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			.08 MPa Isobar — Continued				
90	.10967	1831.9	2561.4	171.74	21.23	30.37	178
92	.10712	1874.9	2621.8	172.40	21.00	30.05	180
94	.10469	1917.5	2681.7	173.04	20.89	29.89	182
96	.10237	1959.9	2741.4	173.67	20.85	29.81	184
98	.10016	2002.2	2800.9	174.29	20.85	29.76	186
100	.09805	2044.5	2860.4	174.89	20.85	29.74	188
102	.09603	2086.8	2919.9	175.48	20.87	29.72	190
104	.09409	2129.1	2979.3	176.05	20.88	29.71	192
106	.09223	2171.3	3038.7	176.62	20.89	29.69	194
108	.09045	2213.6	3098.1	177.17	20.90	29.68	196
110	.08874	2255.9	3157.4	177.72	20.90	29.66	198
112	.08709	2298.1	3216.7	178.25	20.91	29.65	200
114	.08550	2340.4	3276.0	178.78	20.91	29.63	202
116	.08398	2382.6	3335.2	179.29	20.91	29.61	204
118	.08250	2424.8	3394.4	179.80	20.91	29.59	205
120	.08108	2467.0	3453.6	180.30	20.91	29.57	207
122	.07971	2509.1	3512.7	180.78	20.91	29.56	209
124	.07839	2551.3	3571.8	181.26	20.90	29.54	211
126	.07711	2593.4	3630.9	181.74	20.90	29.52	212
128	.07587	2635.5	3689.9	182.20	20.90	29.50	214
130	.07467	2677.6	3748.9	182.66	20.89	29.49	216
132	.07351	2719.6	3807.9	183.11	20.89	29.47	218
134	.07239	2761.7	3866.8	183.55	20.89	29.46	219
136	.07130	2803.7	3925.7	183.99	20.88	29.44	221
138	.07024	2845.7	3984.6	184.42	20.88	29.43	223
140	.06922	2887.7	4043.4	184.84	20.88	29.42	224
142	.06822	2929.6	4102.3	185.26	20.87	29.41	226
144	.06726	2971.6	4161.1	185.67	20.87	29.39	228
146	.06632	3013.5	4219.8	186.08	20.87	29.38	229
148	.06541	3055.5	4278.6	186.48	20.86	29.37	231
150	.06452	3097.4	4337.3	186.87	20.86	29.36	232
152	.06366	3139.3	4396.0	187.26	20.86	29.35	234
154	.06282	3181.2	4454.7	187.64	20.85	29.35	236
156	.06200	3223.1	4513.4	188.02	20.85	29.34	237
158	.06120	3264.9	4572.1	188.39	20.85	29.33	239
160	.06043	3306.8	4630.7	188.76	20.85	29.32	240
162	.05967	3348.6	4689.4	189.13	20.85	29.31	242
164	.05893	3390.5	4748.0	189.49	20.84	29.31	243
166	.05821	3432.3	4806.6	189.84	20.84	29.30	245
168	.05751	3474.1	4865.2	190.19	20.84	29.29	246
170	.05683	3516.0	4923.8	190.54	20.84	29.29	248
172	.05616	3557.8	4982.4	190.88	20.84	29.28	249
174	.05550	3599.6	5040.9	191.22	20.84	29.28	251
176	.05487	3641.4	5099.5	191.56	20.84	29.27	252
178	.05424	3683.2	5158.0	191.89	20.83	29.27	254
180	.05363	3725.0	5216.5	192.21	20.83	29.27	255
185	.05217	3829.4	5362.9	193.01	20.83	29.26	259
190	.05078	3933.8	5509.1	193.79	20.83	29.25	262
195	.04947	4038.2	5655.3	194.55	20.83	29.24	265
200	.04822	4142.6	5801.5	195.29	20.83	29.24	269

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			.08 MPa Isobar — Continued				
205	.04704	4247.0	5947.7	196.02	20.84	29.23	272
210	.04591	4351.4	6093.9	196.72	20.84	29.23	276
215	.04484	4455.8	6240.0	197.41	20.84	29.23	279
220	.04381	4560.2	6386.2	198.08	20.85	29.23	282
225	.04283	4664.6	6532.4	198.74	20.85	29.23	285
230	.04190	4769.1	6678.5	199.38	20.86	29.24	288
235	.04100	4873.6	6824.7	200.01	20.87	29.24	292
240	.04014	4978.1	6971.0	200.63	20.88	29.25	295
245	.03932	5082.6	7117.2	201.23	20.89	29.25	298
250	.03853	5187.2	7263.5	201.82	20.90	29.26	301
255	.03777	5291.8	7409.8	202.40	20.91	29.27	304
260	.03704	5396.5	7556.2	202.97	20.92	29.28	307
265	.03634	5501.3	7702.7	203.53	20.94	29.30	310
270	.03567	5606.1	7849.2	204.07	20.95	29.31	313
275	.03501	5711.0	7995.8	204.61	20.97	29.33	315
280	.03439	5816.0	8142.5	205.14	20.99	29.34	318
285	.03378	5921.1	8289.2	205.66	21.01	29.36	321
290	.03320	6026.3	8436.1	206.17	21.03	29.38	324
295	.03263	6131.6	8583.0	206.67	21.05	29.40	327
300	.03209	6237.0	8730.1	207.17	21.08	29.42	329
			.10 MPa Isobar				
54.37[a]	40.819	−6193.3	−6190.9	66.94	38.23	53.53	1123
56	40.607	−6106.2	−6103.8	68.52	36.86	53.45	1130
58	40.341	−5999.3	−5996.9	70.40	35.67	53.47	1132
60	40.068	−5892.3	−5889.8	72.21	34.84	53.54	1127
62	39.791	−5785.2	−5782.7	73.97	34.20	53.60	1119
64	39.511	−5678.0	−5675.4	75.67	33.70	53.65	1108
66	39.230	−5570.7	−5568.1	77.32	33.27	53.67	1095
68	38.946	−5463.3	−5460.8	78.92	32.89	53.69	1081
70	38.661	−5356.0	−5353.4	80.48	32.54	53.69	1066
72	38.374	−5248.6	−5246.0	81.99	32.21	53.69	1051
74	38.085	−5141.2	−5138.6	83.46	31.90	53.70	1035
76	37.794	−5033.8	−5031.2	84.90	31.60	53.72	1019
78	37.502	−4926.4	−4923.7	86.29	31.31	53.75	1003
80	37.207	−4818.8	−4816.2	87.65	31.03	53.80	987
82	36.910	−4711.2	−4708.5	88.98	30.76	53.87	971
84	36.610	−4603.4	−4600.7	90.28	30.50	53.95	955
86	36.308	−4495.4	−4492.7	91.55	30.24	54.06	938
88	36.002	−4387.2	−4384.4	92.80	29.99	54.20	922
90	35.692	−4278.6	−4275.8	94.02	29.75	54.36	905
90.06[a]	35.682	−4275.3	−4272.5	94.05	29.74	54.37	905
90.06[a]	.13793	1824.0	2549.0	169.80			177
92	.13475	1866.5	2608.6	170.45			179
94	.13163	1909.6	2669.3	171.10	21.01	30.21	182
96	.12868	1952.4	2729.5	171.74	20.92	30.05	184
98	.12586	1995.0	2789.5	172.36	20.89	29.97	186
100	.12316	2037.5	2849.4	172.96	20.89	29.93	188
102	.12059	2080.0	2909.3	173.55	20.89	29.89	190
104	.11813	2122.5	2969.0	174.13	20.90	29.87	192
106	.11577	2164.9	3028.7	174.70	20.91	29.85	194
108	.11350	2207.4	3088.4	175.26	20.92	29.83	196

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			.10 MPa Isobar — Continued				
110	.11133	2249.8	3148.1	175.81	20.93	29.81	198
112	.10924	2292.3	3207.7	176.34	20.94	29.79	199
114	.10723	2334.7	3267.2	176.87	20.94	29.76	201
116	.10530	2377.0	3326.7	177.39	20.94	29.74	203
118	.10344	2419.4	3386.2	177.90	20.94	29.72	205
120	.10164	2461.7	3445.6	178.40	20.94	29.69	207
122	.09991	2504.0	3504.9	178.89	20.93	29.67	209
124	.09824	2546.3	3564.3	179.37	20.93	29.65	210
126	.09662	2588.6	3623.5	179.84	20.93	29.63	212
128	.09506	2630.8	3682.8	180.31	20.92	29.61	214
130	.09355	2673.0	3742.0	180.77	20.92	29.59	216
132	.09209	2715.2	3801.1	181.22	20.91	29.57	217
134	.09067	2757.4	3860.2	181.66	20.91	29.55	219
136	.08930	2799.5	3919.3	182.10	20.90	29.53	221
138	.08797	2841.6	3978.4	182.53	20.90	29.51	222
140	.08668	2883.7	4037.4	182.96	20.90	29.50	224
142	.08543	2925.8	4096.3	183.38	20.89	29.48	226
144	.08421	2967.8	4155.3	183.79	20.89	29.47	227
146	.08303	3009.8	4214.2	184.19	20.88	29.45	229
148	.08188	3051.9	4273.1	184.60	20.88	29.44	231
150	.08077	3093.9	4332.0	184.99	20.88	29.43	232
152	.07968	3135.8	4390.8	185.38	20.87	29.42	234
154	.07863	3177.8	4449.6	185.76	20.87	29.40	235
156	.07760	3219.8	4508.4	186.14	20.87	29.39	237
158	.07660	3261.7	4567.2	186.52	20.86	29.38	238
160	.07562	3303.6	4626.0	186.89	20.86	29.37	240
162	.07467	3345.5	4684.7	187.25	20.86	29.37	242
164	.07375	3387.4	4743.4	187.61	20.86	29.36	243
166	.07284	3429.3	4802.1	187.97	20.85	29.35	245
168	.07196	3471.2	4860.8	188.32	20.85	29.34	246
170	.07110	3513.1	4919.5	188.67	20.85	29.33	248
172	.07026	3555.0	4978.2	189.01	20.85	29.33	249
174	.06944	3596.8	5036.8	189.35	20.85	29.32	251
176	.06864	3638.7	5095.4	189.68	20.84	29.31	252
178	.06786	3680.5	5154.1	190.02	20.84	29.31	253
180	.06710	3722.3	5212.7	190.34	20.84	29.30	255
185	.06526	3826.9	5359.2	191.15	20.84	29.29	258
190	.06353	3931.4	5505.6	191.93	20.84	29.28	262
195	.06188	4035.9	5652.0	192.69	20.84	29.27	265
200	.06032	4140.4	5798.3	193.43	20.84	29.27	269
205	.05883	4244.9	5944.6	194.15	20.84	29.26	272
210	.05742	4349.4	6090.9	194.86	20.84	29.26	276
215	.05607	4453.8	6237.2	195.54	20.85	29.25	279
220	.05479	4558.3	6383.5	196.22	20.85	29.25	282
225	.05356	4662.8	6529.7	196.87	20.86	29.25	285
230	.05239	4767.3	6676.0	197.52	20.86	29.26	288
235	.05127	4871.8	6822.3	198.15	20.87	29.26	292
240	.05019	4976.4	6968.6	198.76	20.88	29.26	295
245	.04916	5080.9	7114.9	199.37	20.89	29.27	298
250	.04818	5185.6	7261.3	199.96	20.90	29.28	301

TABLE 11. Thermodynamic properties of oxygen – Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			.10 MPa Isobar – Continued				
255	.04723	5290.3	7407.7	200.54	20.91	29.29	304
260	.04631	5395.0	7554.2	201.11	20.92	29.30	307
265	.04544	5499.8	7700.7	201.66	20.94	29.31	310
270	.04459	5604.7	7847.3	202.21	20.96	29.32	313
275	.04378	5709.6	7994.0	202.75	20.97	29.34	315
280	.04299	5814.7	8140.7	203.28	20.99	29.35	318
285	.04223	5919.8	8287.5	203.80	21.01	29.37	321
290	.04150	6025.0	8434.4	204.31	21.03	29.39	324
295	.04080	6130.3	8581.4	204.81	21.05	29.41	327
300	.04012	6235.8	8728.5	205.31	21.08	29.43	329
			.101325 MPa Isobar				
54.37[a]	40.819	−6193.3	−6190.8	66.94	38.23	53.53	1123
56	40.608	−6106.2	−6103.7	68.52	36.86	53.45	1130
58	40.341	−5999.3	−5996.8	70.40	35.67	53.47	1132
60	40.068	−5892.3	−5889.8	72.21	34.84	53.54	1127
62	39.791	−5785.2	−5782.7	73.97	34.20	53.60	1119
64	39.511	−5678.0	−5675.4	75.67	33.70	53.65	1108
66	39.230	−5570.7	−5568.1	77.32	33.27	53.67	1095
68	38.946	−5463.3	−5460.7	78.92	32.89	53.69	1081
70	38.661	−5356.0	−5353.4	80.48	32.54	53.69	1066
72	38.374	−5248.6	−5246.0	81.99	32.21	53.69	1051
74	38.085	−5141.2	−5138.6	83.46	31.90	53.70	1035
76	37.794	−5033.8	−5031.2	84.90	31.60	53.72	1019
78	37.502	−4926.4	−4923.7	86.29	31.31	53.75	1003
80	37.207	−4818.9	−4816.1	87.65	31.03	53.80	987
82	36.910	−4711.2	−4708.5	88.98	30.76	53.87	971
84	36.610	−4603.4	−4600.6	90.28	30.50	53.95	955
86	36.308	−4495.4	−4492.6	91.55	30.24	54.06	938
88	36.002	−4387.2	−4384.4	92.80	29.99	54.20	922
90	35.692	−4278.7	−4275.8	94.02	29.75	54.36	905
90.19[a]	35.663	−4268.4	−4265.6	94.13	29.72	54.38	904
90.19[a]	.13960	1826.1	2551.9	169.72			177
92	.13659	1865.9	2607.7	170.33			179
94	.13343	1909.1	2668.4	170.99	21.02	30.23	182
96	.13043	1951.9	2728.7	171.62	20.93	30.07	184
98	.12757	1994.5	2788.8	172.24	20.89	29.99	186
100	.12484	2037.0	2848.7	172.85	20.89	29.94	188
102	.12223	2079.6	2908.5	173.44	20.89	29.91	190
104	.11973	2122.0	2968.3	174.02	20.91	29.88	192
106	.11733	2164.5	3028.1	174.59	20.92	29.86	194
108	.11504	2207.0	3087.8	175.15	20.93	29.84	196
110	.11283	2249.4	3147.4	175.69	20.93	29.82	198
112	.11072	2291.9	3207.0	176.23	20.94	29.80	199
114	.10868	2334.3	3266.6	176.76	20.94	29.77	201
116	.10672	2376.7	3326.1	177.28	20.94	29.75	203
118	.10483	2419.0	3385.6	177.78	20.94	29.73	205
120	.10301	2461.4	3445.0	178.28	20.94	29.70	207
122	.10125	2503.7	3504.4	178.77	20.94	29.68	209
124	.09956	2546.0	3563.8	179.26	20.93	29.66	210
126	.09792	2588.3	3623.1	179.73	20.93	29.63	212
128	.09634	2630.5	3682.3	180.20	20.92	29.61	214

TABLE 11. Thermodynamic properties of oxygen – Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			.101325 MPa Isobar – Continued				
130	.09480	2672.7	3741.5	180.66	20.92	29.59	216
132	.09332	2714.9	3800.7	181.11	20.91	29.57	217
134	.09189	2757.1	3859.8	181.55	20.91	29.55	219
136	.09049	2799.2	3918.9	181.99	20.91	29.54	221
138	.08915	2841.3	3977.9	182.42	20.90	29.52	222
140	.08784	2883.4	4037.0	182.85	20.90	29.50	224
142	.08657	2925.5	4096.0	183.27	20.89	29.49	226
144	.08534	2967.6	4154.9	183.68	20.89	29.47	227
146	.08414	3009.6	4213.8	184.08	20.88	29.46	229
148	.08298	3051.6	4272.7	184.48	20.88	29.44	231
150	.08185	3093.6	4331.6	184.88	20.88	29.43	232
152	.08075	3135.6	4390.5	185.27	20.87	29.42	234
154	.07968	3177.6	4449.3	185.65	20.87	29.41	235
156	.07863	3219.5	4508.1	186.03	20.87	29.40	237
158	.07762	3261.5	4566.9	186.41	20.86	29.39	238
160	.07663	3303.4	4625.7	186.78	20.86	29.38	240
162	.07567	3345.3	4684.4	187.14	20.86	29.37	242
164	.07473	3387.2	4743.1	187.50	20.86	29.36	243
166	.07381	3429.1	4801.8	187.86	20.85	29.35	245
168	.07292	3471.0	4860.5	188.21	20.85	29.34	246
170	.07205	3512.9	4919.2	188.56	20.85	29.34	248
172	.07120	3554.8	4977.9	188.90	20.85	29.33	249
174	.07037	3596.6	5036.5	189.24	20.85	29.32	250
176	.06956	3638.5	5095.2	189.57	20.85	29.32	252
178	.06877	3680.3	5153.8	189.91	20.84	29.31	253
180	.06799	3722.2	5212.4	190.23	20.84	29.31	255
185	.06613	3826.7	5358.9	191.04	20.84	29.29	258
190	.06437	3931.3	5505.4	191.82	20.84	29.28	262
195	.06270	4035.8	5651.7	192.58	20.84	29.27	265
200	.06112	4140.3	5798.1	193.32	20.84	29.27	269
205	.05961	4244.7	5944.4	194.04	20.84	29.26	272
210	.05818	4349.2	6090.7	194.75	20.84	29.26	276
215	.05682	4453.7	6237.0	195.43	20.85	29.26	279
220	.05552	4558.2	6383.3	196.11	20.85	29.26	282
225	.05427	4662.6	6529.6	196.76	20.86	29.26	285
230	.05309	4767.2	6675.8	197.41	20.86	29.26	288
235	.05195	4871.7	6822.1	198.04	20.87	29.26	292
240	.05086	4976.2	6968.5	198.65	20.88	29.27	295
245	.04982	5080.8	7114.8	199.26	20.89	29.27	298
250	.04881	5185.5	7261.2	199.85	20.90	29.28	301
255	.04785	5290.2	7407.6	200.43	20.91	29.29	304
260	.04693	5394.9	7554.1	201.00	20.93	29.30	307
265	.04604	5499.7	7700.6	201.55	20.94	29.31	310
270	.04518	5604.6	7847.2	202.10	20.96	29.32	313
275	.04436	5709.5	7993.8	202.64	20.97	29.34	315
280	.04356	5814.6	8140.6	203.17	20.99	29.36	318
285	.04279	5919.7	8287.4	203.69	21.01	29.37	321
290	.04205	6024.9	8434.3	204.20	21.03	29.39	324
295	.04134	6130.3	8581.3	204.70	21.05	29.41	327
300	.04065	6235.7	8728.4	205.20	21.08	29.44	329

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			.15 MPa Isobar				
54.38[a]	40.820	−6193.2	−6189.5	66.94	38.22	53.52	1123
56	40.609	−6106.5	−6102.8	68.52	36.85	53.44	1130
58	40.342	−5999.6	−5995.9	70.39	35.67	53.47	1132
60	40.070	−5892.6	−5888.9	72.21	34.84	53.54	1127
62	39.793	−5785.5	−5781.7	73.96	34.20	53.60	1119
64	39.513	−5678.3	−5674.5	75.67	33.70	53.64	1108
66	39.232	−5571.0	−5567.2	77.32	33.27	53.67	1095
68	38.948	−5463.7	−5459.8	78.92	32.89	53.68	1081
70	38.663	−5356.3	−5352.4	80.47	32.54	53.69	1066
72	38.376	−5249.0	−5245.1	81.99	32.21	53.69	1051
74	38.087	−5141.6	−5137.7	83.46	31.90	53.70	1035
76	37.797	−5034.2	−5030.2	84.89	31.61	53.72	1019
78	37.505	−4926.8	−4922.8	86.29	31.32	53.75	1003
80	37.210	−4819.3	−4815.2	87.65	31.04	53.80	987
82	36.913	−4711.6	−4707.6	88.98	30.77	53.86	971
84	36.613	−4603.9	−4599.8	90.28	30.50	53.95	955
86	36.311	−4495.9	−4491.8	91.55	30.24	54.06	939
88	36.005	−4387.7	−4383.5	92.79	29.99	54.19	922
90	35.696	−4279.2	−4275.0	94.01	29.75	54.35	906
92	35.382	−4170.3	−4166.1	95.21	29.51	54.54	889
94	35.065	−4061.1	−4056.8	96.38	29.28	54.76	872
94.12[a]	35.046	−4054.8	−4050.5	96.45	29.27	54.77	871
94.12[a]	.20023	1891.1	2640.2	167.54			180
96	.19579	1932.7	2698.8	168.16	21.22	30.87	182
98	.19133	1976.3	2760.2	168.79	21.06	30.61	184
100	.18708	2019.5	2821.3	169.41	21.00	30.46	187
102	.18304	2062.6	2882.1	170.01	20.98	30.38	189
104	.17918	2105.7	2942.8	170.60	20.98	30.32	191
106	.17549	2148.7	3003.4	171.18	20.99	30.27	193
108	.17196	2191.6	3063.9	171.74	21.00	30.23	195
110	.16857	2234.5	3124.3	172.30	21.01	30.19	197
112	.16533	2277.4	3184.7	172.84	21.01	30.15	199
114	.16221	2320.2	3245.0	173.37	21.01	30.12	200
116	.15922	2363.1	3305.2	173.90	21.01	30.08	202
118	.15634	2405.8	3365.3	174.41	21.01	30.04	204
120	.15357	2448.6	3425.3	174.91	21.01	30.00	206
122	.15090	2491.2	3485.3	175.41	21.01	29.97	208
124	.14832	2533.9	3545.2	175.90	21.00	29.93	210
126	.14584	2576.5	3605.0	176.38	20.99	29.90	211
128	.14344	2619.1	3664.8	176.85	20.99	29.87	213
130	.14112	2661.6	3724.5	177.31	20.98	29.84	215
132	.13888	2704.1	3784.1	177.76	20.97	29.80	217
134	.13671	2746.5	3843.7	178.21	20.97	29.78	218
136	.13461	2789.0	3903.2	178.65	20.96	29.75	220
138	.13258	2831.3	3962.7	179.09	20.95	29.72	222
140	.13061	2873.7	4022.1	179.51	20.94	29.70	224
142	.12870	2916.0	4081.5	179.94	20.94	29.67	225
144	.12685	2958.3	4140.8	180.35	20.93	29.65	227
146	.12505	3000.5	4200.1	180.76	20.93	29.63	229
148	.12330	3042.8	4259.3	181.16	20.92	29.61	230

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			.15 MPa Isobar — Continued				
150	.12160	3085.0	4318.5	181.56	20.91	29.59	232
152	.11995	3127.2	4377.7	181.95	20.91	29.57	233
154	.11834	3169.3	4436.8	182.34	20.90	29.55	235
156	.11678	3211.5	4495.9	182.72	20.90	29.54	237
158	.11526	3253.6	4555.0	183.10	20.90	29.52	238
160	.11378	3295.7	4614.0	183.47	20.89	29.51	240
162	.11234	3337.7	4673.0	183.83	20.89	29.49	241
164	.11093	3379.8	4732.0	184.20	20.88	29.48	243
166	.10956	3421.8	4790.9	184.55	20.88	29.47	244
168	.10823	3463.9	4849.9	184.91	20.88	29.46	246
170	.10692	3505.9	4908.8	185.25	20.87	29.45	247
172	.10565	3547.9	4967.6	185.60	20.87	29.43	249
174	.10441	3589.9	5026.5	185.94	20.87	29.42	250
176	.10320	3631.9	5085.3	186.27	20.87	29.42	252
178	.10202	3673.8	5144.2	186.61	20.86	29.41	253
180	.10086	3715.8	5203.0	186.94	20.86	29.40	255
185	.09808	3820.6	5349.9	187.74	20.86	29.38	258
190	.09546	3925.4	5496.8	188.52	20.86	29.36	262
195	.09297	4030.1	5643.5	189.29	20.85	29.35	265
200	.09061	4134.8	5790.2	190.03	20.85	29.34	269
205	.08837	4239.5	5936.9	190.75	20.85	29.33	272
210	.08624	4344.2	6083.5	191.46	20.85	29.32	275
215	.08421	4448.8	6230.1	192.15	20.86	29.31	279
220	.08227	4553.4	6376.6	192.82	20.86	29.31	282
225	.08043	4658.1	6523.2	193.48	20.87	29.31	285
230	.07866	4762.7	6669.7	194.13	20.87	29.30	288
235	.07697	4867.4	6816.2	194.76	20.88	29.31	292
240	.07535	4972.1	6962.7	195.37	20.89	29.31	295
245	.07380	5076.8	7109.3	195.98	20.90	29.31	298
250	.07231	5181.5	7255.9	196.57	20.91	29.32	301
255	.07088	5286.3	7402.5	197.15	20.92	29.32	304
260	.06951	5391.2	7549.1	197.72	20.93	29.33	307
265	.06819	5496.1	7695.8	198.28	20.94	29.34	310
270	.06692	5601.1	7842.5	198.83	20.96	29.36	312
275	.06570	5706.1	7989.4	199.37	20.98	29.37	315
280	.06452	5811.2	8136.2	199.90	21.00	29.38	318
285	.06338	5916.4	8283.2	200.42	21.02	29.40	321
290	.06228	6021.7	8430.3	200.93	21.04	29.42	324
295	.06122	6127.1	8577.4	201.43	21.06	29.44	327
300	.06019	6232.7	8724.6	201.93	21.08	29.46	329
			.20 MPa Isobar				
54.38[a]	40.821	−6193.1	−6188.2	66.95	38.21	53.51	1124
56	40.611	−6106.7	−6101.8	68.51	36.85	53.44	1131
58	40.344	−5999.8	−5994.9	70.39	35.67	53.47	1132
60	40.072	−5892.9	−5887.9	72.20	34.84	53.53	1127
62	39.795	−5785.8	−5780.7	73.96	34.21	53.60	1119
64	39.515	−5678.6	−5673.5	75.66	33.70	53.64	1108
66	39.234	−5571.3	−5566.2	77.31	33.27	53.67	1095
68	38.950	−5464.0	−5458.8	78.91	32.89	53.68	1081
70	38.665	−5356.6	−5351.5	80.47	32.54	53.68	1066
72	38.378	−5249.3	−5244.1	81.98	32.22	53.69	1051

TABLE 11. Thermodynamic properties of oxygen – Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			.20 MPa Isobar – Continued				
74	38.090	−5142.0	−5136.7	83.45	31.91	53.70	1035
76	37.799	−5034.6	−5029.3	84.89	31.61	53.71	1020
78	37.507	−4927.2	−4921.9	86.28	31.32	53.74	1004
80	37.213	−4819.7	−4814.3	87.64	31.04	53.79	988
82	36.916	−4712.1	−4706.7	88.97	30.77	53.86	971
84	36.616	−4604.3	−4598.9	90.27	30.50	53.94	955
86	36.314	−4496.4	−4490.9	91.54	30.25	54.05	939
88	36.008	−4388.2	−4382.7	92.79	30.00	54.18	922
90	35.699	−4279.7	−4274.1	94.00	29.75	54.34	906
92	35.386	−4170.9	−4165.3	95.20	29.51	54.53	889
94	35.069	−4061.7	−4056.0	96.38	29.28	54.75	873
96	34.747	−3952.0	−3946.2	97.53	29.06	55.00	856
97.24[a]	34.545	−3884.0	−3878.2	98.24	28.92	55.17	845
97.24[a]	.26109	1939.3	2705.3	165.94			182
98	.25871	1956.4	2729.5	166.19	21.40	31.51	183
100	.25273	2000.7	2792.1	166.82	21.20	31.15	185
102	.24706	2044.7	2854.2	167.44	21.12	30.95	187
104	.24167	2088.4	2915.9	168.04	21.08	30.82	190
106	.23654	2132.0	2977.5	168.62	21.08	30.73	192
108	.23163	2175.4	3038.9	169.20	21.08	30.66	194
110	.22694	2218.9	3100.1	169.76	21.08	30.60	196
112	.22246	2262.2	3161.3	170.31	21.09	30.54	198
114	.21816	2305.6	3222.3	170.85	21.09	30.49	200
116	.21404	2348.8	3283.2	171.38	21.09	30.43	201
118	.21008	2392.0	3344.1	171.90	21.09	30.38	203
120	.20627	2435.2	3404.8	172.41	21.08	30.33	205
122	.20261	2478.3	3465.4	172.91	21.08	30.28	207
124	.19909	2521.3	3525.9	173.40	21.07	30.23	209
126	.19569	2564.3	3586.3	173.89	21.06	30.18	211
128	.19241	2607.2	3646.6	174.36	21.05	30.14	213
130	.18925	2650.0	3706.8	174.83	21.04	30.09	214
132	.18620	2692.8	3767.0	175.29	21.03	30.05	216
134	.18324	2735.6	3827.0	175.74	21.02	30.01	218
136	.18039	2778.3	3887.0	176.18	21.01	29.97	220
138	.17763	2821.0	3946.9	176.62	21.00	29.94	221
140	.17495	2863.6	4006.8	177.05	21.00	29.90	223
142	.17236	2906.1	4066.5	177.47	20.99	29.87	225
144	.16984	2948.7	4126.2	177.89	20.98	29.84	226
146	.16740	2991.2	4185.9	178.30	20.97	29.81	228
148	.16503	3033.6	4245.5	178.71	20.96	29.78	230
150	.16274	3076.0	4305.0	179.11	20.95	29.76	231
152	.16050	3118.4	4364.5	179.50	20.95	29.73	233
154	.15833	3160.8	4423.9	179.89	20.94	29.71	235
156	.15622	3203.1	4483.3	180.27	20.93	29.68	236
158	.15417	3245.4	4542.7	180.65	20.93	29.66	238
160	.15217	3287.7	4602.0	181.02	20.92	29.64	239
162	.15022	3329.9	4661.3	181.39	20.92	29.62	241
164	.14833	3372.1	4720.5	181.76	20.91	29.61	242
166	.14648	3414.3	4779.7	182.12	20.91	29.59	244
168	.14468	3456.5	4838.9	182.47	20.90	29.57	245

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			.20 MPa Isobar — Continued				
170	.14293	3498.7	4898.0	182.82	20.90	29.56	247
172	.14121	3540.8	4957.1	183.16	20.89	29.54	248
174	.13954	3582.9	5016.2	183.51	20.89	29.53	250
176	.13791	3625.0	5075.2	183.84	20.89	29.52	251
178	.13632	3667.1	5134.2	184.18	20.88	29.50	253
180	.13477	3709.2	5193.2	184.51	20.88	29.49	254
185	.13103	3814.3	5340.6	185.31	20.88	29.47	258
190	.12750	3919.3	5487.9	186.10	20.87	29.44	262
195	.12416	4024.3	5635.1	186.86	20.87	29.42	265
200	.12100	4129.2	5782.1	187.61	20.87	29.41	269
205	.11799	4234.1	5929.1	188.34	20.87	29.39	272
210	.11513	4338.9	6076.1	189.04	20.87	29.38	275
215	.11241	4443.8	6222.9	189.73	20.87	29.37	279
220	.10982	4548.6	6369.8	190.41	20.87	29.36	282
225	.10734	4653.4	6516.6	191.07	20.87	29.36	285
230	.10498	4758.2	6663.3	191.71	20.88	29.35	288
235	.10271	4863.0	6810.1	192.35	20.89	29.35	291
240	.10055	4967.8	6956.9	192.96	20.89	29.35	295
245	.09847	5072.6	7103.6	193.57	20.90	29.35	298
250	.09648	5177.5	7250.4	194.16	20.91	29.36	301
255	.09457	5282.4	7397.2	194.74	20.92	29.36	304
260	.09274	5387.4	7544.0	195.31	20.94	29.37	307
265	.09097	5492.4	7690.9	195.87	20.95	29.38	310
270	.08927	5597.4	7837.8	196.42	20.97	29.39	312
275	.08763	5702.6	7984.8	196.96	20.98	29.40	315
280	.08606	5807.8	8131.8	197.49	21.00	29.41	318
285	.08454	5913.1	8278.9	198.01	21.02	29.43	321
290	.08307	6018.4	8426.1	198.52	21.04	29.45	324
295	.08165	6123.9	8573.4	199.03	21.06	29.46	327
300	.08028	6229.5	8720.7	199.52	21.09	29.48	329
			.25 MPa Isobar				
54.39[a]	40.822	−6193.0	−6186.9	66.95	38.20	53.51	1124
56	40.613	−6106.9	−6100.7	68.51	36.85	53.43	1131
58	40.346	−6000.1	−5993.9	70.38	35.67	53.46	1132
60	40.073	−5893.1	−5886.9	72.20	34.84	53.53	1128
62	39.797	−5786.0	−5779.7	73.95	34.21	53.59	1119
64	39.517	−5678.8	−5672.5	75.66	33.70	53.64	1108
66	39.236	−5571.6	−5565.2	77.31	33.27	53.66	1095
68	38.952	−5464.3	−5457.9	78.91	32.89	53.68	1081
70	38.667	−5357.0	−5350.5	80.47	32.55	53.68	1067
72	38.381	−5249.7	−5243.1	81.98	32.22	53.68	1051
74	38.092	−5142.3	−5135.8	83.45	31.91	53.69	1036
76	37.802	−5035.0	−5028.4	84.88	31.61	53.71	1020
78	37.510	−4927.6	−4920.9	86.28	31.32	53.74	1004
80	37.216	−4820.1	−4813.4	87.64	31.04	53.79	988
82	36.919	−4712.5	−4705.8	88.97	30.77	53.85	972
84	36.619	−4604.8	−4598.0	90.26	30.51	53.94	955
86	36.317	−4496.9	−4490.0	91.54	30.25	54.04	939
88	36.012	−4388.7	−4381.8	92.78	30.00	54.18	923
90	35.703	−4280.3	−4273.3	94.00	29.76	54.34	906
92	35.390	−4171.5	−4164.4	95.19	29.52	54.52	890

TABLE 11. Thermodynamic properties of oxygen – Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			.25 MPa Isobar – Continued				
94	35.072	−4062.3	−4055.2	96.37	29.29	54.74	873
96	34.751	−3952.6	−3945.4	97.52	29.06	54.99	856
98	34.424	−3842.4	−3835.2	98.66	28.85	55.28	839
99.81[a]	34.123	−3742.1	−3734.8	99.68	28.65	55.57	823
99.81[a]	.32102	1976.6	2755.3	164.70	21.60	32.17	183
100	.32029	1980.9	2761.4	164.76	21.57	32.11	184
102	.31281	2025.9	2825.1	165.39	21.34	31.67	186
104	.30573	2070.5	2888.2	166.00	21.23	31.42	188
106	.29901	2114.8	2950.9	166.60	21.19	31.25	190
108	.29261	2158.9	3013.3	167.18	21.17	31.13	193
110	.28652	2202.9	3075.4	167.76	21.17	31.04	195
112	.28069	2246.8	3137.4	168.31	21.17	30.96	197
114	.27513	2290.6	3199.3	168.86	21.17	30.88	199
116	.26980	2334.3	3261.0	169.40	21.17	30.81	201
118	.26469	2378.0	3322.5	169.92	21.17	30.74	202
120	.25979	2421.6	3383.9	170.44	21.16	30.67	204
122	.25508	2465.1	3445.2	170.95	21.15	30.60	206
124	.25055	2508.5	3506.3	171.44	21.14	30.54	208
126	.24620	2551.9	3567.3	171.93	21.13	30.47	210
128	.24200	2595.1	3628.2	172.41	21.12	30.41	212
130	.23795	2638.3	3689.0	172.88	21.11	30.36	214
132	.23405	2681.5	3749.6	173.34	21.10	30.30	215
134	.23028	2724.5	3810.2	173.80	21.08	30.25	217
136	.22664	2767.5	3870.6	174.25	21.07	30.20	219
138	.22311	2810.5	3931.0	174.69	21.06	30.16	221
140	.21970	2853.4	3991.3	175.12	21.05	30.11	222
142	.21640	2896.2	4051.5	175.55	21.04	30.07	224
144	.21321	2939.0	4111.6	175.97	21.02	30.03	226
146	.21011	2981.7	4171.6	176.38	21.01	29.99	228
148	.20710	3024.4	4231.5	176.79	21.00	29.96	229
150	.20418	3067.0	4291.4	177.19	20.99	29.92	231
152	.20135	3109.6	4351.2	177.59	20.99	29.89	232
154	.19860	3152.2	4411.0	177.98	20.98	29.86	234
156	.19593	3194.7	4470.7	178.36	20.97	29.83	236
158	.19333	3237.2	4530.3	178.74	20.96	29.81	237
160	.19080	3279.6	4589.9	179.12	20.95	29.78	239
162	.18833	3322.0	4649.5	179.49	20.95	29.76	240
164	.18594	3364.4	4708.9	179.85	20.94	29.73	242
166	.18360	3406.8	4768.4	180.21	20.93	29.71	244
168	.18133	3449.1	4827.8	180.57	20.93	29.69	245
170	.17911	3491.4	4887.2	180.92	20.92	29.67	247
172	.17695	3533.7	4946.5	181.27	20.92	29.65	248
174	.17484	3575.9	5005.8	181.61	20.91	29.64	250
176	.17278	3618.1	5065.0	181.95	20.91	29.62	251
178	.17078	3660.4	5124.3	182.28	20.91	29.60	253
180	.16881	3702.5	5183.5	182.61	20.90	29.59	254
185	.16411	3807.9	5331.3	183.43	20.89	29.56	258
190	.15966	3913.2	5479.0	184.21	20.89	29.53	261
195	.15546	4018.5	5626.6	184.98	20.88	29.50	265
200	.15148	4123.6	5774.0	185.73	20.88	29.48	268

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			.25 MPa Isobar — Continued				
205	.14769	4228.7	5921.4	186.45	20.88	29.46	272
210	.14410	4333.7	6068.6	187.16	20.88	29.44	275
215	.14068	4438.7	6215.8	187.86	20.88	29.43	278
220	.13742	4543.7	6362.9	188.53	20.88	29.42	282
225	.13431	4648.7	6510.0	189.19	20.88	29.41	285
230	.13134	4753.6	6657.0	189.84	20.89	29.40	288
235	.12850	4858.5	6804.0	190.47	20.89	29.40	291
240	.12579	4963.5	6951.0	191.09	20.90	29.39	294
245	.12318	5068.5	7098.0	191.70	20.91	29.39	298
250	.12069	5173.4	7244.9	192.29	20.92	29.40	301
255	.11829	5278.5	7391.9	192.87	20.93	29.40	304
260	.11599	5383.5	7538.9	193.44	20.94	29.40	307
265	.11377	5488.6	7686.0	194.00	20.96	29.41	310
270	.11164	5593.8	7833.0	194.55	20.97	29.42	312
275	.10959	5699.0	7980.2	195.09	20.99	29.43	315
280	.10762	5804.3	8127.4	195.62	21.01	29.44	318
285	.10571	5909.7	8274.6	196.15	21.02	29.46	321
290	.10387	6015.2	8421.9	196.66	21.04	29.47	324
295	.10210	6120.7	8569.3	197.16	21.07	29.49	327
300	.10038	6226.4	8716.8	197.66	21.09	29.51	329
			.30 MPa Isobar				
54.39[a]	40.823	−6192.9	−6185.6	66.95	38.20	53.50	1124
56	40.615	−6107.1	−6099.7	68.50	36.85	53.43	1131
58	40.348	−6000.3	−5992.9	70.38	35.67	53.46	1132
60	40.075	−5893.4	−5885.9	72.19	34.84	53.53	1128
62	39.799	−5786.3	−5778.8	73.95	34.21	53.59	1119
64	39.519	−5679.1	−5671.5	75.65	33.70	53.63	1108
66	39.238	−5571.9	−5564.2	77.30	33.28	53.66	1095
68	38.955	−5464.6	−5456.9	78.90	32.90	53.67	1081
70	38.670	−5357.3	−5349.6	80.46	32.55	53.68	1067
72	38.383	−5250.0	−5242.2	81.97	32.22	53.68	1051
74	38.095	−5142.7	−5134.8	83.44	31.91	53.69	1036
76	37.805	−5035.4	−5027.4	84.88	31.62	53.71	1020
78	37.513	−4928.0	−4920.0	86.27	31.33	53.73	1004
80	37.218	−4820.5	−4812.5	87.63	31.05	53.78	988
82	36.922	−4713.0	−4704.9	88.96	30.78	53.85	972
84	36.622	−4605.3	−4597.1	90.26	30.51	53.93	956
86	36.320	−4497.4	−4489.1	91.53	30.25	54.04	939
88	36.015	−4389.3	−4380.9	92.77	30.00	54.17	923
90	35.706	−4280.8	−4272.4	93.99	29.76	54.33	906
92	35.393	−4172.1	−4163.6	95.19	29.52	54.51	890
94	35.076	−4062.9	−4054.4	96.36	29.29	54.73	873
96	34.755	−3953.3	−3944.6	97.52	29.07	54.98	856
98	34.428	−3843.1	−3834.4	98.65	28.85	55.26	839
100	34.096	−3732.4	−3723.6	99.77	28.64	55.59	822
102	33.757	−3620.9	−3612.0	100.88	28.43	55.95	805
102.02[a]	33.753	−3619.6	−3610.7	100.89	28.43	55.95	804
102.02[a]	.38033	2006.7	2795.5	163.68	21.70	32.65	185
104	.37147	2051.8	2859.4	164.30	21.46	32.17	187
106	.36301	2097.0	2923.5	164.91	21.34	31.87	189
108	.35498	2141.9	2987.0	165.51	21.29	31.67	191

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			.30 MPa Isobar — Continued				
110	.34736	2186.5	3050.2	166.09	21.27	31.52	194
112	.34010	2231.0	3113.1	166.65	21.26	31.40	196
114	.33317	2275.3	3175.8	167.21	21.26	31.30	198
116	.32655	2319.6	3238.3	167.75	21.25	31.20	200
118	.32022	2363.7	3300.6	168.28	21.25	31.11	202
120	.31415	2407.7	3362.7	168.81	21.24	31.02	204
122	.30834	2451.7	3424.7	169.32	21.23	30.94	205
124	.30275	2495.5	3486.4	169.82	21.22	30.86	207
126	.29738	2539.3	3548.1	170.31	21.20	30.78	209
128	.29222	2582.9	3609.6	170.80	21.19	30.70	211
130	.28725	2626.5	3670.9	171.27	21.17	30.63	213
132	.28245	2670.0	3732.1	171.74	21.16	30.57	215
134	.27783	2713.4	3793.2	172.20	21.14	30.50	217
136	.27337	2756.7	3854.1	172.65	21.13	30.44	218
138	.26906	2799.9	3914.9	173.09	21.11	30.38	220
140	.26489	2843.1	3975.6	173.53	21.10	30.33	222
142	.26086	2886.2	4036.2	173.96	21.09	30.28	224
144	.25695	2929.2	4096.7	174.38	21.07	30.23	225
146	.25317	2972.2	4157.2	174.80	21.06	30.18	227
148	.24951	3015.1	4217.5	175.21	21.05	30.14	229
150	.24595	3058.0	4277.7	175.62	21.04	30.10	230
152	.24250	3100.8	4337.9	176.01	21.02	30.06	232
154	.23915	3143.5	4397.9	176.41	21.01	30.02	234
156	.23590	3186.2	4458.0	176.79	21.00	29.99	235
158	.23274	3228.9	4517.9	177.18	20.99	29.95	237
160	.22966	3271.5	4577.8	177.55	20.99	29.92	239
162	.22667	3314.1	4637.6	177.92	20.98	29.89	240
164	.22376	3356.7	4697.3	178.29	20.97	29.86	242
166	.22093	3399.2	4757.0	178.65	20.96	29.84	243
168	.21817	3441.6	4816.7	179.01	20.96	29.81	245
170	.21548	3484.1	4876.3	179.36	20.95	29.79	246
172	.21286	3526.5	4935.9	179.71	20.94	29.77	248
174	.21031	3568.9	4995.4	180.05	20.94	29.75	249
176	.20782	3611.3	5054.8	180.39	20.93	29.72	251
178	.20538	3653.6	5114.3	180.73	20.93	29.71	252
180	.20301	3695.9	5173.7	181.06	20.92	29.69	254
185	.19732	3801.6	5322.0	181.87	20.91	29.65	258
190	.19194	3907.1	5470.1	182.66	20.90	29.61	261
195	.18686	4012.6	5618.1	183.43	20.90	29.58	265
200	.18205	4118.0	5765.9	184.18	20.89	29.55	268
205	.17748	4223.3	5913.6	184.91	20.89	29.53	272
210	.17314	4328.5	6061.2	185.62	20.89	29.51	275
215	.16902	4433.7	6208.6	186.32	20.89	29.49	278
220	.16509	4538.8	6356.0	186.99	20.89	29.47	282
225	.16134	4643.9	6503.4	187.66	20.89	29.46	285
230	.15776	4749.0	6650.7	188.30	20.90	29.45	288
235	.15434	4854.1	6797.9	188.94	20.90	29.44	291
240	.15107	4959.2	6945.1	189.56	20.91	29.44	294
245	.14793	5064.3	7092.3	190.16	20.92	29.44	297
250	.14492	5169.4	7239.5	190.76	20.93	29.44	301

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			.30 MPa Isobar — Continued				
255	.14204	5274.5	7386.6	191.34	20.94	29.44	304
260	.13927	5379.7	7533.8	191.91	20.95	29.44	307
265	.13660	5484.9	7681.0	192.47	20.96	29.45	309
270	.13404	5590.2	7828.3	193.02	20.98	29.45	312
275	.13157	5695.5	7975.6	193.57	20.99	29.46	315
280	.12920	5800.9	8122.9	194.10	21.01	29.47	318
285	.12691	5906.3	8270.3	194.62	21.03	29.49	321
290	.12469	6011.9	8417.8	195.13	21.05	29.50	324
295	.12256	6117.5	8565.3	195.64	21.07	29.52	327
300	.12050	6223.2	8712.9	196.13	21.09	29.53	329
			.40 MPa Isobar				
54.41[a]	40.825	−6192.7	−6182.9	66.95	38.18	53.49	1124
56	40.618	−6107.6	−6097.7	68.50	36.84	53.42	1131
58	40.351	−6000.8	−5990.9	70.37	35.67	53.45	1132
60	40.079	−5893.9	−5883.9	72.18	34.84	53.52	1128
62	39.803	−5786.8	−5776.8	73.94	34.21	53.58	1120
64	39.524	−5679.7	−5669.6	75.64	33.71	53.63	1109
66	39.242	−5572.5	−5562.3	77.29	33.28	53.65	1096
68	38.959	−5465.2	−5455.0	78.90	32.90	53.67	1082
70	38.674	−5358.0	−5347.6	80.45	32.55	53.67	1067
72	38.388	−5250.7	−5240.3	81.96	32.23	53.67	1052
74	38.100	−5143.4	−5132.9	83.43	31.92	53.68	1036
76	37.810	−5036.1	−5025.6	84.87	31.62	53.70	1020
78	37.518	−4928.8	−4918.1	86.26	31.33	53.73	1004
80	37.224	−4821.4	−4810.7	87.62	31.05	53.77	988
82	36.927	−4713.9	−4703.1	88.95	30.78	53.83	972
84	36.629	−4606.2	−4595.3	90.25	30.52	53.92	956
86	36.327	−4498.4	−4487.4	91.52	30.26	54.02	940
88	36.022	−4390.3	−4379.2	92.76	30.01	54.16	923
90	35.713	−4281.9	−4270.7	93.98	29.76	54.31	907
92	35.401	−4173.2	−4161.9	95.18	29.53	54.50	890
94	35.084	−4064.1	−4052.7	96.35	29.30	54.71	874
96	34.763	−3954.6	−3943.1	97.50	29.07	54.96	857
98	34.436	−3844.5	−3832.9	98.64	28.86	55.24	840
100	34.105	−3733.8	−3722.1	99.76	28.64	55.56	823
102	33.767	−3622.5	−3610.6	100.86	28.44	55.92	805
104	33.422	−3510.3	−3498.4	101.95	28.24	56.33	788
105.73[a]	33.118	−3412.5	−3400.4	102.89	28.08	56.72	772
105.73[a]	.49780	2052.8	2856.3	162.06	21.95	33.69	186
106	.49616	2059.1	2865.3	162.15	21.91	33.59	187
108	.48435	2106.0	2931.9	162.77	21.66	33.03	189
110	.47323	2152.3	2997.6	163.37	21.54	32.68	191
112	.46271	2198.2	3062.7	163.96	21.48	32.42	193
114	.45273	2243.8	3127.3	164.53	21.45	32.23	196
116	.44325	2289.2	3191.6	165.09	21.43	32.06	198
118	.43421	2334.4	3255.6	165.64	21.42	31.91	200
120	.42559	2379.4	3319.3	166.17	21.40	31.78	202
122	.41735	2424.3	3382.7	166.70	21.39	31.65	204
124	.40946	2469.0	3445.9	167.21	21.37	31.53	206
126	.40191	2513.6	3508.8	167.71	21.35	31.42	208
128	.39466	2558.0	3571.6	168.21	21.33	31.31	210

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			.40 MPa Isobar — Continued				
130	.38769	2602.4	3634.1	168.69	21.31	31.21	212
132	.38100	2646.5	3696.4	169.17	21.29	31.11	214
134	.37456	2690.6	3758.6	169.63	21.27	31.02	215
136	.36835	2734.6	3820.5	170.09	21.25	30.94	217
138	.36236	2778.4	3882.3	170.55	21.23	30.86	219
140	.35659	2822.2	3943.9	170.99	21.21	30.78	221
142	.35101	2865.9	4005.4	171.42	21.19	30.71	223
144	.34562	2909.4	4066.8	171.85	21.17	30.64	224
146	.34040	2952.9	4128.0	172.28	21.15	30.57	226
148	.33536	2996.3	4189.1	172.69	21.13	30.51	228
150	.33047	3039.6	4250.0	173.10	21.12	30.45	230
152	.32573	3082.9	4310.9	173.50	21.10	30.40	231
154	.32113	3126.0	4371.6	173.90	21.09	30.35	233
156	.31668	3169.1	4432.3	174.29	21.08	30.30	235
158	.31235	3212.2	4492.8	174.68	21.06	30.25	236
160	.30814	3255.2	4553.3	175.06	21.05	30.21	238
162	.30406	3298.1	4613.7	175.43	21.04	30.17	239
164	.30008	3341.0	4674.0	175.80	21.03	30.13	241
166	.29622	3383.8	4734.2	176.17	21.02	30.09	243
168	.29246	3426.6	4794.3	176.53	21.01	30.06	244
170	.28880	3469.4	4854.4	176.88	21.00	30.03	246
172	.28523	3512.1	4914.4	177.23	20.99	30.00	247
174	.28176	3554.7	4974.4	177.58	20.98	29.97	249
176	.27837	3597.4	5034.3	177.92	20.98	29.94	250
178	.27507	3640.0	5094.2	178.26	20.97	29.91	252
180	.27184	3682.5	5154.0	178.60	20.96	29.89	253
185	.26412	3788.8	5303.2	179.41	20.95	29.83	257
190	.25684	3894.9	5452.3	180.21	20.94	29.78	261
195	.24997	4000.8	5601.0	180.98	20.93	29.73	264
200	.24347	4106.7	5749.6	181.73	20.92	29.70	268
205	.23730	4212.4	5898.0	182.47	20.92	29.66	271
210	.23145	4318.0	6046.2	183.18	20.91	29.63	275
215	.22589	4423.6	6194.3	183.88	20.91	29.61	278
220	.22060	4529.0	6342.3	184.56	20.91	29.58	281
225	.21556	4634.5	6490.2	185.22	20.91	29.57	285
230	.21074	4739.9	6637.9	185.87	20.91	29.55	288
235	.20614	4845.2	6785.7	186.51	20.92	29.54	291
240	.20174	4950.6	6933.3	187.13	20.92	29.53	294
245	.19753	5055.9	7080.9	187.74	20.93	29.52	297
250	.19350	5161.3	7228.5	188.33	20.94	29.51	300
255	.18962	5266.6	7376.1	188.92	20.95	29.51	303
260	.18591	5372.0	7523.6	189.49	20.96	29.51	306
265	.18234	5477.4	7671.2	190.05	20.97	29.51	309
270	.17890	5582.9	7818.8	190.61	20.99	29.52	312
275	.17559	5688.4	7966.4	191.15	21.00	29.52	315
280	.17241	5794.0	8114.0	191.68	21.02	29.53	318
285	.16934	5899.6	8261.7	192.20	21.04	29.54	321
290	.16638	6005.3	8409.4	192.72	21.06	29.55	324
295	.16352	6111.1	8557.2	193.22	21.08	29.57	327
300	.16076	6217.0	8705.1	193.72	21.10	29.58	329

TABLE 11. Thermodynamic properties of oxygen – Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			.50 MPa Isobar				
54.42[a]	40.827	−6192.5	−6180.3	66.96	38.16	53.47	1125
56	40.622	−6108.0	−6095.7	68.49	36.84	53.41	1131
58	40.355	−6001.3	−5988.9	70.36	35.67	53.44	1133
60	40.083	−5894.4	−5881.9	72.18	34.84	53.51	1128
62	39.807	−5787.4	−5774.8	73.93	34.21	53.58	1120
64	39.528	−5680.3	−5667.6	75.63	33.71	53.62	1109
66	39.246	−5573.1	−5560.4	77.28	33.28	53.65	1096
68	38.963	−5465.9	−5453.0	78.89	32.91	53.66	1082
70	38.679	−5358.6	−5345.7	80.44	32.56	53.66	1067
72	38.392	−5251.4	−5238.4	81.95	32.23	53.67	1052
74	38.104	−5144.2	−5131.1	83.42	31.93	53.67	1036
76	37.815	−5036.9	−5023.7	84.86	31.63	53.69	1021
78	37.523	−4929.6	−4916.3	86.25	31.34	53.72	1005
80	37.229	−4822.3	−4808.8	87.61	31.06	53.76	989
82	36.933	−4714.8	−4701.2	88.94	30.79	53.82	973
84	36.635	−4607.2	−4593.5	90.24	30.52	53.91	956
86	36.333	−4499.4	−4485.6	91.51	30.27	54.01	940
88	36.028	−4391.3	−4377.5	92.75	30.02	54.14	924
90	35.720	−4283.0	−4269.0	93.97	29.77	54.30	907
92	35.408	−4174.4	−4160.3	95.16	29.53	54.48	891
94	35.092	−4065.3	−4051.1	96.34	29.30	54.69	874
96	34.771	−3955.8	−3941.5	97.49	29.08	54.94	857
98	34.445	−3845.8	−3831.3	98.63	28.86	55.22	840
100	34.114	−3735.2	−3720.6	99.75	28.65	55.53	823
102	33.776	−3624.0	−3609.2	100.85	28.45	55.89	806
104	33.432	−3511.9	−3497.0	101.94	28.25	56.29	788
106	33.081	−3399.1	−3384.0	103.01	28.06	56.75	770
108	32.722	−3285.2	−3270.0	104.08	27.88	57.26	752
108.81[a]	32.575	−3239.1	−3223.7	104.51	27.80	57.48	745
108.81[a]	.61450	2086.6	2900.3	160.79	22.23	34.77	187
110	.60542	2115.6	2941.5	161.17	22.03	34.30	189
112	.59100	2163.4	3009.5	161.78	21.83	33.74	191
114	.57743	2210.6	3076.6	162.37	21.71	33.36	194
116	.56461	2257.4	3143.0	162.95	21.65	33.07	196
118	.55247	2303.8	3208.9	163.51	21.61	32.83	198
120	.54093	2350.0	3274.3	164.06	21.58	32.63	200
122	.52996	2395.9	3339.4	164.60	21.55	32.44	202
124	.51949	2441.6	3404.1	165.13	21.53	32.27	204
126	.50949	2487.1	3468.5	165.64	21.50	32.12	206
128	.49993	2532.4	3532.6	166.15	21.48	31.97	208
130	.49077	2577.6	3596.4	166.64	21.45	31.83	210
132	.48199	2622.5	3659.9	167.13	21.42	31.70	212
134	.47356	2667.4	3723.2	167.60	21.39	31.58	214
136	.46545	2712.0	3786.2	168.07	21.37	31.46	216
138	.45765	2756.5	3849.1	168.53	21.34	31.36	218
140	.45014	2800.9	3911.7	168.98	21.32	31.25	220
142	.44290	2845.1	3974.1	169.42	21.29	31.16	222
144	.43591	2889.3	4036.3	169.86	21.27	31.07	223
146	.42916	2933.3	4098.3	170.28	21.25	30.98	225
148	.42264	2977.2	4160.2	170.70	21.22	30.90	227

TABLE 11. Thermodynamic properties of oxygen – Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			.50 MPa Isobar – Continued				
150	.41633	3021.0	4221.9	171.12	21.20	30.83	229
152	.41023	3064.7	4283.5	171.53	21.18	30.75	230
154	.40432	3108.3	4345.0	171.93	21.17	30.69	232
156	.39859	3151.8	4406.3	172.32	21.15	30.62	234
158	.39303	3195.3	4467.5	172.71	21.13	30.56	235
160	.38764	3238.7	4528.5	173.10	21.12	30.51	237
162	.38240	3282.0	4589.5	173.48	21.10	30.45	239
164	.37731	3325.2	4650.4	173.85	21.09	30.40	240
166	.37237	3368.4	4711.1	174.22	21.08	30.36	242
168	.36756	3411.5	4771.8	174.58	21.06	30.31	244
170	.36289	3454.5	4832.4	174.94	21.05	30.27	245
172	.35834	3497.5	4892.9	175.29	21.04	30.23	247
174	.35391	3540.5	4953.3	175.64	21.03	30.19	248
176	.34959	3583.4	5013.6	175.99	21.02	30.16	250
178	.34538	3626.2	5073.9	176.33	21.01	30.12	251
180	.34128	3669.1	5134.1	176.66	21.00	30.09	253
185	.33146	3775.9	5284.4	177.49	20.99	30.02	257
190	.32222	3882.6	5434.3	178.29	20.97	29.95	260
195	.31350	3989.0	5583.9	179.07	20.96	29.89	264
200	.30527	4095.3	5733.2	179.82	20.95	29.84	267
205	.29746	4201.5	5882.3	180.56	20.94	29.80	271
210	.29007	4307.5	6031.2	181.28	20.93	29.76	274
215	.28304	4413.4	6179.9	181.98	20.93	29.73	278
220	.27636	4519.2	6328.5	182.66	20.93	29.70	281
225	.26999	4625.0	6476.9	183.33	20.93	29.67	284
230	.26392	4730.7	6625.2	183.98	20.93	29.65	288
235	.25812	4836.3	6773.4	184.61	20.93	29.63	291
240	.25258	4942.0	6921.5	185.24	20.94	29.62	294
245	.24728	5047.6	7069.6	185.85	20.94	29.60	297
250	.24220	5153.1	7217.5	186.45	20.95	29.59	300
255	.23733	5258.7	7365.5	187.03	20.96	29.59	303
260	.23266	5364.3	7513.4	187.61	20.97	29.58	306
265	.22817	5470.0	7661.3	188.17	20.98	29.58	309
270	.22385	5575.6	7809.2	188.72	21.00	29.58	312
275	.21970	5681.3	7957.2	189.27	21.01	29.59	315
280	.21570	5787.0	8105.1	189.80	21.03	29.59	318
285	.21184	5892.8	8253.1	190.32	21.05	29.60	321
290	.20812	5998.7	8401.1	190.84	21.07	29.61	324
295	.20454	6104.7	8549.2	191.34	21.09	29.62	327
300	.20107	6210.7	8697.3	191.84	21.11	29.63	329
			.60 MPa Isobar				
54.43[a]	40.829	−6192.4	−6177.7	66.96	38.14	53.46	1125
56	40.625	−6108.5	−6093.7	68.48	36.83	53.40	1132
58	40.359	−6001.7	−5986.9	70.36	35.67	53.43	1133
60	40.087	−5894.9	−5879.9	72.17	34.84	53.50	1129
62	39.811	−5787.9	−5772.9	73.92	34.22	53.57	1120
64	39.532	−5680.8	−5665.7	75.62	33.71	53.62	1109
66	39.251	−5573.7	−5558.4	77.28	33.29	53.64	1096
68	38.968	−5466.5	−5451.1	78.88	32.91	53.65	1082
70	38.683	−5359.3	−5343.8	80.43	32.57	53.66	1068
72	38.397	−5252.1	−5236.5	81.94	32.24	53.66	1052

TABLE 11. Thermodynamic properties of oxygen – Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			.60 MPa Isobar – Continued				
74	38.109	−5144.9	−5129.2	83.41	31.93	53.66	1037
76	37.820	−5037.7	−5021.8	84.85	31.63	53.68	1021
78	37.528	−4930.4	−4914.4	86.24	31.35	53.71	1005
80	37.235	−4823.1	−4807.0	87.60	31.07	53.75	989
82	36.939	−4715.7	−4699.4	88.93	30.79	53.81	973
84	36.641	−4608.1	−4591.7	90.23	30.53	53.89	957
86	36.339	−4500.3	−4483.8	91.50	30.27	54.00	941
88	36.035	−4392.4	−4375.7	92.74	30.02	54.13	924
90	35.727	−4284.1	−4267.3	93.96	29.78	54.28	908
92	35.415	−4175.5	−4158.6	95.15	29.54	54.46	891
94	35.099	−4066.5	−4049.5	96.32	29.31	54.67	875
96	34.779	−3957.1	−3939.9	97.48	29.09	54.91	858
98	34.453	−3847.2	−3829.8	98.61	28.87	55.19	841
100	34.122	−3736.7	−3719.1	99.73	28.66	55.51	824
102	33.786	−3625.5	−3607.7	100.83	28.45	55.86	807
104	33.442	−3513.6	−3495.6	101.92	28.26	56.26	789
106	33.092	−3400.8	−3382.7	103.00	28.07	56.71	771
108	32.734	−3287.1	−3268.7	104.06	27.88	57.22	753
110	32.367	−3172.3	−3153.7	105.12	27.71	57.79	735
111.46[a]	32.093	−3088.0	−3069.3	105.88	27.58	58.25	721
111.46[a]	.73102	2112.3	2933.0	159.73	22.53	35.88	188
112	.72592	2125.9	2952.5	159.91	22.41	35.60	189
114	.70801	2175.4	3022.8	160.53	22.11	34.83	191
116	.69126	2224.0	3091.9	161.13	21.95	34.30	194
118	.67549	2271.9	3160.1	161.71	21.85	33.91	196
120	.66061	2319.4	3227.6	162.28	21.79	33.59	198
122	.64652	2366.5	3294.5	162.83	21.74	33.33	200
124	.63313	2413.3	3361.0	163.37	21.70	33.09	203
126	.62040	2459.8	3426.9	163.90	21.67	32.88	205
128	.60827	2506.1	3492.5	164.42	21.63	32.68	207
130	.59668	2552.1	3557.7	164.92	21.59	32.50	209
132	.58560	2597.9	3622.5	165.42	21.56	32.33	211
134	.57498	2643.5	3687.0	165.90	21.53	32.17	213
136	.56481	2688.9	3751.2	166.38	21.49	32.02	215
138	.55504	2734.1	3815.1	166.85	21.46	31.89	217
140	.54565	2779.2	3878.8	167.30	21.43	31.76	219
142	.53662	2824.0	3942.1	167.75	21.40	31.63	220
144	.52792	2868.8	4005.3	168.19	21.37	31.52	222
146	.51953	2913.3	4068.2	168.63	21.34	31.41	224
148	.51143	2957.8	4130.9	169.06	21.32	31.31	226
150	.50361	3002.1	4193.5	169.48	21.29	31.21	228
152	.49606	3046.3	4255.8	169.89	21.27	31.12	229
154	.48875	3090.3	4318.0	170.29	21.24	31.04	231
156	.48167	3134.3	4380.0	170.69	21.22	30.96	233
158	.47482	3178.2	4441.8	171.09	21.20	30.89	235
160	.46817	3221.9	4503.5	171.48	21.18	30.82	236
162	.46173	3265.6	4565.1	171.86	21.17	30.75	238
164	.45548	3309.2	4626.5	172.24	21.15	30.69	240
166	.44941	3352.7	4687.8	172.61	21.13	30.63	241
168	.44351	3396.2	4749.0	172.97	21.12	30.57	243

TABLE 11. Thermodynamic properties of oxygen – Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			.60 MPa Isobar – Continued				
170	.43777	3439.5	4810.1	173.34	21.10	30.52	245
172	.43220	3482.9	4871.1	173.69	21.09	30.47	246
174	.42677	3526.1	4932.0	174.04	21.08	30.42	248
176	.42149	3569.3	4992.8	174.39	21.07	30.38	249
178	.41635	3612.4	5053.5	174.73	21.06	30.34	251
180	.41133	3655.5	5114.2	175.07	21.05	30.30	252
185	.39935	3763.0	5265.4	175.90	21.02	30.21	256
190	.38808	3870.2	5416.2	176.71	21.00	30.13	260
195	.37747	3977.1	5566.7	177.49	20.99	30.05	264
200	.36745	4083.9	5716.8	178.25	20.98	29.99	267
205	.35797	4190.5	5866.6	178.99	20.97	29.94	271
210	.34899	4296.9	6016.2	179.71	20.96	29.89	274
215	.34046	4403.2	6165.5	180.41	20.95	29.85	278
220	.33236	4509.4	6314.7	181.10	20.95	29.81	281
225	.32465	4615.5	6463.6	181.77	20.95	29.78	284
230	.31730	4721.5	6612.4	182.42	20.95	29.75	288
235	.31029	4827.4	6761.1	183.06	20.95	29.73	291
240	.30359	4933.3	6909.7	183.69	20.95	29.70	294
245	.29718	5039.2	7058.2	184.30	20.96	29.69	297
250	.29104	5145.0	7206.6	184.90	20.96	29.67	300
255	.28516	5250.8	7354.9	185.49	20.97	29.66	303
260	.27951	5356.6	7503.2	186.06	20.98	29.66	306
265	.27410	5462.5	7651.5	186.63	20.99	29.65	309
270	.26889	5568.3	7799.7	187.18	21.01	29.65	312
275	.26388	5674.2	7948.0	187.72	21.02	29.65	315
280	.25905	5780.1	8096.2	188.26	21.04	29.65	318
285	.25441	5886.1	8244.5	188.78	21.06	29.66	321
290	.24993	5992.1	8392.8	189.30	21.07	29.66	324
295	.24561	6098.2	8541.1	189.81	21.10	29.67	327
300	.24144	6204.4	8689.5	190.31	21.12	29.68	329
			.70 MPa Isobar				
54.44[a]	40.831	−6192.2	−6175.0	66.96	38.12	53.45	1126
56	40.629	−6108.9	−6091.7	68.47	36.83	53.39	1132
58	40.362	−6002.2	−5984.9	70.35	35.67	53.42	1133
60	40.090	−5895.4	−5878.0	72.16	34.84	53.50	1129
62	39.814	−5788.5	−5770.9	73.91	34.22	53.56	1120
64	39.536	−5681.4	−5663.7	75.62	33.72	53.61	1109
66	39.255	−5574.3	−5556.5	77.27	33.29	53.64	1097
68	38.972	−5467.1	−5449.2	78.87	32.92	53.65	1083
70	38.688	−5360.0	−5341.9	80.42	32.57	53.65	1068
72	38.402	−5252.8	−5234.6	81.93	32.25	53.65	1053
74	38.114	−5145.6	−5127.3	83.40	31.94	53.66	1037
76	37.825	−5038.5	−5020.0	84.84	31.64	53.67	1021
78	37.534	−4931.2	−4912.6	86.23	31.35	53.70	1005
80	37.240	−4823.9	−4805.1	87.59	31.07	53.74	989
82	36.945	−4716.6	−4697.6	88.92	30.80	53.80	973
84	36.647	−4609.0	−4589.9	90.21	30.54	53.88	957
86	36.346	−4501.3	−4482.1	91.48	30.28	53.98	941
88	36.041	−4393.4	−4374.0	92.73	30.03	54.11	925
90	35.734	−4285.2	−4265.6	93.94	29.78	54.26	908
92	35.422	−4176.7	−4156.9	95.14	29.55	54.44	892

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			.70 MPa Isobar — Continued				
94	35.107	−4067.8	−4047.8	96.31	29.32	54.65	875
96	34.787	−3958.4	−3938.3	97.46	29.09	54.89	858
98	34.462	−3848.5	−3828.2	98.60	28.87	55.17	842
100	34.131	−3738.1	−3717.6	99.72	28.66	55.48	824
102	33.795	−3627.0	−3606.3	100.82	28.46	55.83	807
104	33.452	−3515.2	−3494.2	101.91	28.26	56.23	790
106	33.103	−3402.5	−3381.3	102.98	28.07	56.67	772
108	32.745	−3288.9	−3267.5	104.05	27.89	57.18	754
110	32.379	−3174.2	−3152.6	105.10	27.71	57.74	736
112	32.003	−3058.4	−3036.5	106.15	27.54	58.38	717
113.80[a]	31.655	−2952.9	−2930.8	107.08	27.40	59.03	700
113.80[a]	.84774	2132.1	2957.8	158.83	22.82	37.01	188
114	.84550	2137.3	2965.2	158.89	22.77	36.88	189
116	.82397	2188.3	3037.9	159.52	22.39	35.90	191
118	.80392	2238.2	3109.0	160.13	22.18	35.23	194
120	.78514	2287.4	3178.9	160.72	22.05	34.73	196
122	.76746	2335.9	3248.0	161.29	21.96	34.34	199
124	.75076	2383.9	3316.3	161.85	21.89	34.01	201
126	.73495	2431.6	3384.0	162.39	21.84	33.72	203
128	.71993	2478.9	3451.2	162.92	21.79	33.46	205
130	.70564	2525.9	3517.9	163.43	21.75	33.23	207
132	.69202	2572.6	3584.2	163.94	21.71	33.01	209
134	.67901	2619.1	3650.0	164.43	21.66	32.81	211
136	.66657	2665.3	3715.4	164.92	21.62	32.62	213
138	.65466	2711.2	3780.5	165.39	21.58	32.45	215
140	.64324	2757.0	3845.2	165.86	21.55	32.29	217
142	.63227	2802.5	3909.6	166.32	21.51	32.13	219
144	.62172	2847.8	3973.8	166.76	21.47	31.99	221
146	.61157	2893.0	4037.6	167.21	21.44	31.86	223
148	.60179	2938.0	4101.2	167.64	21.41	31.74	225
150	.59236	2982.8	4164.6	168.06	21.38	31.62	227
152	.58326	3027.5	4227.7	168.48	21.35	31.51	229
154	.57447	3072.1	4290.6	168.89	21.32	31.41	230
156	.56598	3116.5	4353.3	169.30	21.30	31.31	232
158	.55775	3160.8	4415.8	169.70	21.27	31.22	234
160	.54979	3205.0	4478.2	170.09	21.25	31.14	236
162	.54208	3249.1	4540.4	170.47	21.23	31.06	237
164	.53461	3293.0	4602.4	170.85	21.21	30.98	239
166	.52735	3336.9	4664.3	171.23	21.19	30.91	241
168	.52031	3380.7	4726.1	171.60	21.17	30.84	242
170	.51347	3424.4	4787.7	171.96	21.16	30.78	244
172	.50683	3468.0	4849.2	172.32	21.14	30.72	246
174	.50037	3511.6	4910.6	172.68	21.13	30.66	247
176	.49408	3555.1	4971.8	173.03	21.11	30.61	249
178	.48797	3598.5	5033.0	173.37	21.10	30.56	250
180	.48201	3641.8	5094.1	173.71	21.09	30.51	252
185	.46779	3749.9	5246.3	174.55	21.06	30.40	256
190	.45443	3857.7	5398.1	175.36	21.04	30.30	259
195	.44187	3965.2	5549.4	176.14	21.02	30.22	263
200	.43001	4072.4	5700.3	176.91	21.00	30.14	267

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			.70 MPa Isobar — Continued				
205	.41881	4179.5	5850.8	177.65	20.99	30.08	270
210	.40821	4286.3	6001.1	178.38	20.98	30.02	274
215	.39816	4393.0	6151.1	179.08	20.97	29.97	277
220	.38861	4499.5	6300.8	179.77	20.97	29.92	281
225	.37953	4605.9	6450.3	180.44	20.96	29.88	284
230	.37088	4712.2	6599.6	181.10	20.96	29.85	287
235	.36263	4818.5	6748.8	181.74	20.96	29.82	291
240	.35475	4924.6	6897.9	182.37	20.97	29.79	294
245	.34722	5030.8	7046.8	182.98	20.97	29.77	297
250	.34001	5136.8	7195.6	183.58	20.98	29.75	300
255	.33310	5242.9	7344.3	184.17	20.98	29.74	303
260	.32648	5348.9	7493.0	184.75	20.99	29.73	306
265	.32012	5455.0	7641.6	185.32	21.00	29.72	309
270	.31401	5561.0	7790.2	185.87	21.02	29.71	312
275	.30814	5667.1	7938.8	186.42	21.03	29.71	315
280	.30249	5773.2	8087.3	186.95	21.05	29.71	318
285	.29704	5879.3	8235.9	187.48	21.06	29.71	321
290	.29179	5985.5	8384.5	188.00	21.08	29.72	324
295	.28673	6091.8	8533.1	188.50	21.10	29.73	327
300	.28185	6198.1	8681.7	189.00	21.13	29.74	329
			.80 MPa Isobar				
54.45[a]	40.833	−6192.0	−6172.4	66.97	38.10	53.43	1126
56	40.632	−6109.3	−6089.7	68.47	36.83	53.38	1132
58	40.366	−6002.7	−5982.9	70.34	35.67	53.42	1134
60	40.094	−5895.9	−5876.0	72.15	34.84	53.49	1129
62	39.818	−5789.0	−5768.9	73.91	34.22	53.56	1121
64	39.540	−5682.0	−5661.8	75.61	33.72	53.60	1110
66	39.259	−5574.9	−5554.5	77.26	33.30	53.63	1097
68	38.976	−5467.8	−5447.3	78.86	32.92	53.64	1083
70	38.692	−5360.6	−5340.0	80.41	32.58	53.64	1068
72	38.406	−5253.5	−5232.7	81.92	32.25	53.64	1053
74	38.119	−5146.4	−5125.4	83.39	31.94	53.65	1037
76	37.830	−5039.2	−5018.1	84.82	31.65	53.66	1022
78	37.539	−4932.0	−4910.7	86.22	31.36	53.69	1006
80	37.246	−4824.8	−4803.3	87.58	31.08	53.73	990
82	36.951	−4717.4	−4695.8	88.91	30.81	53.79	974
84	36.653	−4610.0	−4588.1	90.20	30.54	53.87	958
86	36.352	−4502.3	−4480.3	91.47	30.29	53.97	941
88	36.048	−4394.4	−4372.2	92.71	30.03	54.10	925
90	35.741	−4286.3	−4263.9	93.93	29.79	54.25	909
92	35.430	−4177.8	−4155.2	95.13	29.55	54.43	892
94	35.114	−4069.0	−4046.2	96.30	29.32	54.63	876
96	34.795	−3959.7	−3936.7	97.45	29.10	54.87	859
98	34.470	−3849.9	−3826.7	98.59	28.88	55.14	842
100	34.140	−3739.5	−3716.1	99.70	28.67	55.45	825
102	33.804	−3628.5	−3604.8	100.80	28.47	55.80	808
104	33.462	−3516.8	−3492.9	101.89	28.27	56.19	790
106	33.113	−3404.2	−3380.0	102.97	28.08	56.64	773
108	32.756	−3290.7	−3266.3	104.03	27.89	57.13	755
110	32.391	−3176.2	−3151.5	105.08	27.72	57.69	736
112	32.016	−3060.4	−3035.4	106.13	27.55	58.33	718

TABLE 11. Thermodynamic properties of oxygen – Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			.80 MPa Isobar – Continued				
114	31.630	−2943.4	−2918.1	107.17	27.39	59.04	699
115.91[a]	31.250	−2830.0	−2804.4	108.15	27.25	59.82	680
115.91[a]	.96497	2147.4	2976.5	158.03	23.11	38.16	189
116	.96382	2149.8	2979.8	158.06	23.08	38.10	189
118	.93856	2202.4	3054.8	158.70	22.64	36.93	192
120	.91516	2253.6	3127.8	159.31	22.38	36.12	194
122	.89331	2303.8	3199.4	159.90	22.23	35.53	197
124	.87280	2353.4	3270.0	160.48	22.12	35.06	199
126	.85348	2402.3	3339.7	161.03	22.04	34.67	201
128	.83522	2450.8	3408.7	161.58	21.97	34.32	204
130	.81791	2498.9	3477.0	162.11	21.91	34.02	206
132	.80147	2546.6	3544.8	162.62	21.86	33.75	208
134	.78583	2594.0	3612.0	163.13	21.81	33.50	210
136	.77090	2641.0	3678.8	163.62	21.76	33.26	212
138	.75665	2687.8	3745.1	164.11	21.71	33.05	214
140	.74302	2734.3	3811.0	164.58	21.67	32.85	216
142	.72995	2780.5	3876.5	165.05	21.62	32.67	218
144	.71742	2826.5	3941.6	165.50	21.58	32.49	220
146	.70538	2872.3	4006.5	165.95	21.54	32.33	222
148	.69380	2917.9	4071.0	166.39	21.51	32.18	224
150	.68265	2963.3	4135.2	166.82	21.47	32.04	226
152	.67191	3008.5	4199.2	167.24	21.44	31.91	228
154	.66155	3053.6	4262.9	167.66	21.41	31.79	229
156	.65155	3098.5	4326.3	168.07	21.38	31.68	231
158	.64188	3143.2	4389.6	168.47	21.35	31.57	233
160	.63253	3187.8	4452.6	168.87	21.32	31.47	235
162	.62349	3232.3	4515.4	169.26	21.30	31.37	237
164	.61473	3276.7	4578.1	169.64	21.27	31.28	238
166	.60624	3320.9	4640.6	170.02	21.25	31.20	240
168	.59800	3365.1	4702.9	170.39	21.23	31.12	242
170	.59001	3409.1	4765.0	170.76	21.21	31.04	243
172	.58225	3453.1	4827.1	171.13	21.19	30.97	245
174	.57471	3496.9	4888.9	171.48	21.18	30.91	247
176	.56739	3540.7	4950.7	171.84	21.16	30.84	248
178	.56026	3584.4	5012.3	172.18	21.15	30.78	250
180	.55333	3628.0	5073.8	172.53	21.13	30.73	251
185	.53679	3736.8	5227.1	173.37	21.10	30.60	255
190	.52128	3845.1	5379.8	174.18	21.07	30.49	259
195	.50670	3953.2	5532.0	174.97	21.05	30.39	263
200	.49297	4060.9	5683.7	175.74	21.03	30.30	266
205	.48001	4168.4	5835.0	176.49	21.02	30.22	270
210	.46775	4275.6	5985.9	177.22	21.00	30.15	274
215	.45614	4382.7	6136.5	177.92	21.00	30.09	277
220	.44511	4489.6	6286.9	178.62	20.99	30.04	281
225	.43464	4596.4	6437.0	179.29	20.98	29.99	284
230	.42466	4703.0	6586.8	179.95	20.98	29.95	287
235	.41516	4809.5	6736.5	180.59	20.98	29.92	291
240	.40608	4916.0	6886.0	181.22	20.98	29.89	294
245	.39741	5022.3	7035.4	181.84	20.98	29.86	297
250	.38912	5128.7	7184.6	182.44	20.99	29.84	300

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			.80 MPa Isobar — Continued				
255	.38117	5234.9	7333.7	183.03	21.00	29.82	303
260	.37356	5341.2	7482.8	183.61	21.01	29.80	306
265	.36625	5447.4	7631.7	184.18	21.02	29.79	309
270	.35923	5553.7	7780.7	184.73	21.03	29.78	312
275	.35248	5660.0	7929.6	185.28	21.04	29.77	315
280	.34599	5766.2	8078.4	185.82	21.06	29.77	318
285	.33974	5872.5	8227.3	186.34	21.07	29.77	321
290	.33372	5978.9	8376.1	186.86	21.09	29.77	324
295	.32791	6085.3	8525.0	187.37	21.11	29.78	327
300	.32231	6191.8	8673.9	187.87	21.13	29.79	329
			.90 MPa Isobar				
54.46[a]	40.835	−6191.8	−6169.7	66.97	38.08	53.42	1126
56	40.636	−6109.8	−6087.6	68.46	36.82	53.37	1133
58	40.370	−6003.2	−5980.9	70.33	35.67	53.41	1134
60	40.098	−5896.4	−5874.0	72.14	34.85	53.48	1129
62	39.822	−5789.6	−5767.0	73.90	34.22	53.55	1121
64	39.544	−5682.6	−5659.8	75.60	33.73	53.60	1110
66	39.263	−5575.5	−5552.6	77.25	33.30	53.62	1097
68	38.981	−5468.4	−5445.3	78.85	32.93	53.63	1083
70	38.697	−5361.3	−5338.0	80.40	32.58	53.64	1069
72	38.411	−5254.2	−5230.8	81.91	32.26	53.64	1053
74	38.124	−5147.1	−5123.5	83.38	31.95	53.64	1038
76	37.835	−5040.0	−5016.2	84.81	31.65	53.65	1022
78	37.544	−4932.8	−4908.9	86.21	31.36	53.68	1006
80	37.251	−4825.6	−4801.5	87.57	31.09	53.72	990
82	36.956	−4718.3	−4694.0	88.90	30.81	53.78	974
84	36.659	−4610.9	−4586.3	90.19	30.55	53.86	958
86	36.358	−4503.3	−4478.5	91.46	30.29	53.96	942
88	36.054	−4395.5	−4370.5	92.70	30.04	54.08	926
90	35.747	−4287.4	−4262.2	93.92	29.80	54.23	909
92	35.437	−4179.0	−4153.6	95.11	29.56	54.41	893
94	35.122	−4070.2	−4044.5	96.29	29.33	54.61	876
96	34.803	−3960.9	−3935.1	97.44	29.11	54.85	860
98	34.479	−3851.2	−3825.1	98.57	28.89	55.12	843
100	34.149	−3740.9	−3714.6	99.69	28.68	55.43	826
102	33.814	−3630.0	−3603.4	100.79	28.47	55.77	809
104	33.472	−3518.4	−3491.5	101.88	28.28	56.16	791
106	33.124	−3405.9	−3378.7	102.95	28.08	56.60	773
108	32.767	−3292.5	−3265.0	104.01	27.90	57.09	756
110	32.403	−3178.1	−3150.3	105.06	27.72	57.65	737
112	32.028	−3062.5	−3034.4	106.11	27.56	58.27	719
114	31.644	−2945.6	−2917.2	107.15	27.40	58.98	700
116	31.247	−2827.2	−2798.4	108.18	27.24	59.79	680
117.84[a]	30.871	−2716.7	−2687.5	109.13	27.11	60.64	662
117.84[a]	1.0829	2159.3	2990.3	157.31	23.39	39.35	189
118	1.0805	2163.6	2996.6	157.36	23.34	39.22	189
120	1.0515	2217.7	3073.6	158.01	22.86	37.89	192
122	1.0247	2270.1	3148.4	158.63	22.57	36.97	195
124	.99977	2321.4	3221.6	159.22	22.39	36.28	197
126	.97643	2371.9	3293.6	159.80	22.26	35.74	200
128	.95449	2421.7	3364.6	160.36	22.17	35.29	202

TABLE 11. Thermodynamic properties of oxygen – Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			.90 MPa Isobar – Continued				
130	.93380	2471.0	3434.8	160.90	22.09	34.90	204
132	.91422	2519.8	3504.2	161.43	22.02	34.55	206
134	.89564	2568.2	3573.0	161.95	21.96	34.24	209
136	.87799	2616.1	3641.2	162.45	21.90	33.95	211
138	.86118	2663.8	3708.8	162.95	21.84	33.69	213
140	.84513	2711.1	3776.0	163.43	21.79	33.45	215
142	.82980	2758.1	3842.7	163.90	21.74	33.23	217
144	.81512	2804.8	3908.9	164.37	21.69	33.02	219
146	.80104	2851.2	3974.8	164.82	21.65	32.83	221
148	.78754	2897.5	4040.3	165.27	21.61	32.65	223
150	.77455	2943.4	4105.4	165.70	21.56	32.49	225
152	.76206	2989.2	4170.2	166.13	21.53	32.33	227
154	.75003	3034.8	4234.7	166.56	21.49	32.19	229
156	.73844	3080.2	4299.0	166.97	21.46	32.05	230
158	.72724	3125.4	4363.0	167.38	21.42	31.93	232
160	.71643	3170.5	4426.7	167.78	21.39	31.81	234
162	.70598	3215.4	4490.2	168.17	21.36	31.70	236
164	.69587	3260.2	4553.5	168.56	21.34	31.59	238
166	.68608	3304.8	4616.6	168.94	21.31	31.50	239
168	.67660	3349.3	4679.5	169.32	21.29	31.40	241
170	.66741	3393.7	4742.2	169.69	21.27	31.32	243
172	.65849	3438.0	4804.7	170.06	21.25	31.23	244
174	.64983	3482.2	4867.1	170.42	21.23	31.16	246
176	.64142	3526.2	4929.4	170.77	21.21	31.08	248
178	.63325	3570.2	4991.5	171.12	21.19	31.01	249
180	.62530	3614.1	5053.4	171.47	21.17	30.95	251
185	.60636	3723.5	5207.8	172.32	21.14	30.80	255
190	.58863	3832.5	5361.5	173.14	21.11	30.67	259
195	.57199	3941.1	5514.5	173.93	21.08	30.56	262
200	.55633	4049.3	5667.0	174.70	21.06	30.46	266
205	.54156	4157.2	5819.1	175.45	21.04	30.37	270
210	.52761	4264.9	5970.7	176.19	21.03	30.29	273
215	.51439	4372.4	6122.0	176.90	21.02	30.22	277
220	.50187	4479.6	6272.9	177.59	21.01	30.16	280
225	.48997	4586.7	6423.6	178.27	21.00	30.10	284
230	.47865	4693.7	6574.0	178.93	21.00	30.06	287
235	.46786	4800.5	6724.2	179.58	21.00	30.01	290
240	.45758	4907.3	6874.1	180.21	21.00	29.98	294
245	.44775	5013.9	7023.9	180.82	21.00	29.94	297
250	.43836	5120.5	7173.6	181.43	21.00	29.92	300
255	.42936	5227.0	7323.1	182.02	21.01	29.89	303
260	.42074	5333.5	7472.5	182.60	21.02	29.87	306
265	.41248	5439.9	7621.9	183.17	21.03	29.86	309
270	.40454	5546.4	7771.1	183.73	21.04	29.85	312
275	.39691	5652.8	7920.3	184.28	21.05	29.84	315
280	.38957	5759.3	8069.5	184.81	21.07	29.83	318
285	.38251	5865.8	8218.7	185.34	21.08	29.83	321
290	.37570	5972.3	8367.8	185.86	21.10	29.83	324
295	.36914	6078.9	8517.0	186.37	21.12	29.83	327
300	.36281	6185.5	8666.1	186.87	21.14	29.84	329

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			1.0 MPa Isobar				
54.47[a]	40.837	−6191.6	−6167.1	66.97	38.06	53.41	1127
56	40.639	−6110.2	−6085.6	68.45	36.82	53.36	1133
58	40.373	−6003.6	−5978.9	70.32	35.66	53.40	1134
60	40.102	−5896.9	−5872.0	72.13	34.85	53.48	1130
62	39.826	−5790.1	−5765.0	73.89	34.23	53.54	1121
64	39.548	−5683.1	−5657.8	75.59	33.73	53.59	1110
66	39.267	−5576.1	−5550.6	77.24	33.31	53.62	1097
68	38.985	−5469.0	−5443.4	78.84	32.93	53.63	1084
70	38.701	−5362.0	−5336.1	80.39	32.59	53.63	1069
72	38.416	−5254.9	−5228.9	81.90	32.26	53.63	1054
74	38.129	−5147.8	−5121.6	83.37	31.96	53.63	1038
76	37.840	−5040.8	−5014.3	84.80	31.66	53.65	1022
78	37.550	−4933.6	−4907.0	86.20	31.37	53.67	1007
80	37.257	−4826.5	−4799.6	87.56	31.09	53.71	991
82	36.962	−4719.2	−4692.2	88.88	30.82	53.77	975
84	36.665	−4611.8	−4584.6	90.18	30.56	53.85	958
86	36.364	−4504.3	−4476.8	91.45	30.30	53.94	942
88	36.061	−4396.5	−4368.8	92.69	30.05	54.07	926
90	35.754	−4288.5	−4260.5	93.91	29.80	54.22	910
92	35.444	−4180.1	−4151.9	95.10	29.57	54.39	893
94	35.129	−4071.4	−4042.9	96.27	29.34	54.59	877
96	34.811	−3962.2	−3933.5	97.42	29.11	54.83	860
98	34.487	−3852.6	−3823.6	98.56	28.89	55.10	843
100	34.158	−3742.4	−3713.1	99.67	28.68	55.40	826
102	33.823	−3631.5	−3601.9	100.77	28.48	55.74	809
104	33.482	−3519.9	−3490.1	101.86	28.28	56.13	792
106	33.134	−3407.6	−3377.4	102.93	28.09	56.56	774
108	32.778	−3294.3	−3263.8	104.00	27.91	57.05	756
110	32.414	−3180.0	−3149.2	105.05	27.73	57.60	738
112	32.041	−3064.6	−3033.3	106.09	27.56	58.22	720
114	31.657	−2947.8	−2916.2	107.13	27.40	58.92	701
116	31.262	−2829.6	−2797.6	108.16	27.25	59.72	681
118	30.854	−2709.7	−2677.3	109.19	27.11	60.63	661
119.62[a]	30.512	−2611.1	−2578.3	110.02	27.00	61.48	645
119.62[a]	1.2018	2168.2	3000.3	156.66	23.67	40.56	189
120	1.1952	2178.9	3015.6	156.78	23.54	40.22	189
122	1.1625	2234.2	3094.5	157.43	23.03	38.76	192
124	1.1323	2287.8	3170.9	158.06	22.73	37.75	195
126	1.1043	2340.1	3245.6	158.65	22.53	36.98	198
128	1.0782	2391.4	3318.9	159.23	22.39	36.38	200
130	1.0536	2442.1	3391.2	159.79	22.28	35.87	203
132	1.0305	2492.1	3462.5	160.34	22.20	35.43	205
134	1.0087	2541.6	3532.9	160.87	22.12	35.05	207
136	.98804	2590.6	3602.7	161.38	22.05	34.70	209
138	.96841	2639.1	3671.8	161.89	21.98	34.38	212
140	.94974	2687.3	3740.2	162.38	21.92	34.09	214
142	.93193	2735.1	3808.1	162.86	21.86	33.83	216
144	.91493	2782.6	3875.6	163.33	21.81	33.59	218
146	.89867	2829.7	3942.5	163.79	21.76	33.36	220
148	.88309	2876.6	4009.0	164.25	21.71	33.15	222

TABLE 11. Thermodynamic properties of oxygen – Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			1.0 MPa Isobar – Continued				
150	.86814	2923.2	4075.1	164.69	21.66	32.96	224
152	.85379	2969.6	4140.8	165.13	21.62	32.77	226
154	.83998	3015.7	4206.2	165.55	21.58	32.61	228
156	.82669	3061.6	4271.3	165.97	21.54	32.45	230
158	.81389	3107.4	4336.0	166.38	21.50	32.30	231
160	.80153	3152.9	4400.5	166.79	21.47	32.16	233
162	.78960	3198.2	4464.7	167.19	21.43	32.04	235
164	.77808	3243.4	4528.6	167.58	21.40	31.92	237
166	.76693	3288.5	4592.4	167.97	21.37	31.80	239
168	.75614	3333.3	4655.9	168.35	21.35	31.70	240
170	.74569	3378.1	4719.1	168.72	21.32	31.60	242
172	.73556	3422.7	4782.2	169.09	21.30	31.50	244
174	.72573	3467.2	4845.2	169.45	21.28	31.41	245
176	.71620	3511.6	4907.9	169.81	21.26	31.33	247
178	.70694	3555.9	4970.5	170.17	21.24	31.25	249
180	.69794	3600.1	5032.9	170.52	21.22	31.18	250
185	.67652	3710.2	5188.4	171.37	21.18	31.01	254
190	.65650	3819.8	5343.0	172.19	21.14	30.86	258
195	.63773	3928.9	5497.0	172.99	21.11	30.73	262
200	.62009	4037.6	5650.3	173.77	21.09	30.61	266
205	.60347	4146.1	5803.1	174.52	21.07	30.51	270
210	.58778	4254.2	5955.5	175.26	21.05	30.43	273
215	.57294	4362.0	6107.4	175.97	21.04	30.35	277
220	.55887	4469.7	6259.0	176.67	21.03	30.28	280
225	.54553	4577.1	6410.2	177.35	21.02	30.21	284
230	.53284	4684.4	6561.1	178.01	21.01	30.16	287
235	.52076	4791.5	6711.8	178.66	21.01	30.11	290
240	.50924	4898.5	6862.2	179.29	21.01	30.07	293
245	.49824	5005.4	7012.5	179.91	21.01	30.03	297
250	.48773	5112.3	7162.6	180.52	21.02	30.00	300
255	.47767	5219.0	7312.5	181.11	21.02	29.97	303
260	.46804	5325.7	7462.3	181.70	21.03	29.95	306
265	.45880	5432.4	7612.0	182.27	21.04	29.93	309
270	.44993	5539.0	7761.6	182.83	21.05	29.91	312
275	.44141	5645.7	7911.1	183.37	21.06	29.90	315
280	.43322	5752.3	8060.6	183.91	21.07	29.89	318
285	.42534	5859.0	8210.1	184.44	21.09	29.89	321
290	.41775	5965.7	8359.5	184.96	21.11	29.88	324
295	.41043	6072.4	8508.9	185.47	21.13	29.88	327
300	.40337	6179.2	8658.3	185.97	21.15	29.89	329
			1.5 MPa Isobar				
54.53[a]	40.847	−6190.6	−6153.9	66.99	37.97	53.34	1129
56	40.657	−6112.4	−6075.5	68.41	36.80	53.31	1134
58	40.391	−6006.0	−5968.9	70.28	35.66	53.36	1136
60	40.120	−5899.5	−5862.1	72.09	34.85	53.44	1131
62	39.845	−5792.8	−5755.1	73.84	34.24	53.51	1123
64	39.568	−5686.0	−5648.1	75.54	33.75	53.56	1112
66	39.288	−5579.1	−5540.9	77.19	33.33	53.59	1099
68	39.007	−5472.2	−5433.7	78.79	32.96	53.60	1085
70	38.724	−5365.3	−5326.5	80.35	32.61	53.60	1070
72	38.439	−5258.4	−5219.3	81.86	32.29	53.59	1055

TABLE 11. Thermodynamic properties of oxygen – Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			1.5 MPa Isobar – Continued				
74	38.153	−5151.5	−5112.2	83.32	31.98	53.60	1040
76	37.865	−5044.6	−5005.0	84.75	31.69	53.60	1024
78	37.576	−4937.6	−4897.7	86.15	31.40	53.63	1008
80	37.284	−4830.7	−4790.4	87.50	31.12	53.66	992
82	36.991	−4723.6	−4683.1	88.83	30.85	53.71	977
84	36.694	−4616.5	−4575.6	90.13	30.59	53.79	961
86	36.396	−4509.1	−4467.9	91.39	30.33	53.88	944
88	36.094	−4401.6	−4360.0	92.63	30.08	54.00	928
90	35.789	−4293.8	−4251.9	93.85	29.84	54.14	912
92	35.480	−4185.8	−4143.5	95.04	29.60	54.30	896
94	35.167	−4077.3	−4034.7	96.21	29.37	54.50	879
96	34.850	−3968.5	−3925.5	97.36	29.14	54.72	863
98	34.529	−3859.2	−3815.8	98.49	28.93	54.98	846
100	34.202	−3749.4	−3705.5	99.60	28.72	55.27	829
102	33.870	−3638.9	−3594.7	100.70	28.51	55.60	812
104	33.531	−3527.8	−3483.1	101.78	28.31	55.97	795
106	33.186	−3416.0	−3370.8	102.85	28.12	56.38	778
108	32.834	−3303.2	−3257.5	103.91	27.94	56.85	760
110	32.473	−3189.5	−3143.3	104.96	27.76	57.37	742
112	32.104	−3074.7	−3028.0	106.00	27.59	57.96	724
114	31.725	−2958.7	−2911.4	107.03	27.43	58.63	705
116	31.335	−2841.3	−2793.4	108.06	27.27	59.38	686
118	30.932	−2722.3	−2673.8	109.08	27.13	60.24	667
120	30.516	−2601.5	−2552.4	110.10	27.00	61.23	647
122	30.084	−2478.7	−2428.8	111.12	26.87	62.37	626
124	29.633	−2353.4	−2302.8	112.15	26.76	63.70	604
126	29.160	−2225.3	−2173.9	113.18	26.67	65.27	582
126.98[a]	28.919	−2161.2	−2109.3	113.69	26.63	66.16	571
126.98[a]	1.8154	2181.7	3008.0	153.99	24.98	47.29	188
128	1.7848	2214.8	3055.2	154.36	24.51	45.74	190
130	1.7296	2277.1	3144.3	155.05	23.87	43.47	193
132	1.6798	2336.6	3229.6	155.70	23.46	41.86	196
134	1.6342	2394.1	3312.0	156.32	23.18	40.63	199
136	1.5922	2450.1	3392.3	156.91	22.97	39.65	202
138	1.5532	2504.9	3470.7	157.49	22.81	38.83	205
140	1.5168	2558.7	3547.7	158.04	22.67	38.14	207
142	1.4827	2611.6	3623.3	158.58	22.55	37.53	210
144	1.4506	2663.7	3697.8	159.10	22.45	36.99	212
146	1.4203	2715.2	3771.3	159.60	22.35	36.51	214
148	1.3917	2766.1	3843.9	160.10	22.26	36.08	217
150	1.3645	2816.4	3915.7	160.58	22.18	35.69	219
152	1.3387	2866.2	3986.7	161.05	22.10	35.33	221
154	1.3141	2915.5	4057.0	161.51	22.03	35.00	223
156	1.2906	2964.4	4126.7	161.96	21.97	34.70	225
158	1.2681	3013.0	4195.8	162.40	21.91	34.42	227
160	1.2466	3061.2	4264.4	162.83	21.85	34.17	229
162	1.2260	3109.0	4332.5	163.25	21.79	33.93	231
164	1.2062	3156.6	4400.1	163.67	21.74	33.71	233
166	1.1872	3203.9	4467.3	164.08	21.70	33.50	235
168	1.1689	3250.9	4534.1	164.48	21.65	33.31	237

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			1.5 MPa Isobar — Continued				
170	1.1512	3297.6	4600.6	164.87	21.61	33.13	239
172	1.1342	3344.2	4666.7	165.25	21.57	32.97	241
174	1.1178	3390.5	4732.5	165.64	21.54	32.81	243
176	1.1019	3436.6	4797.9	166.01	21.50	32.66	244
178	1.0865	3482.6	4863.1	166.38	21.47	32.53	246
180	1.0717	3528.3	4928.1	166.74	21.44	32.40	248
185	1.0365	3642.1	5089.3	167.62	21.38	32.11	252
190	1.0038	3754.9	5249.2	168.48	21.32	31.86	256
195	.97345	3867.0	5407.9	169.30	21.27	31.64	260
200	.94507	3978.5	5565.6	170.10	21.23	31.45	264
205	.91849	4089.3	5722.5	170.87	21.20	31.28	268
210	.89351	4199.7	5878.5	171.63	21.17	31.13	272
215	.86999	4309.7	6033.8	172.36	21.15	31.00	276
220	.84779	4419.2	6188.6	173.07	21.13	30.89	279
225	.82679	4528.5	6342.7	173.76	21.11	30.78	283
230	.80689	4637.4	6496.4	174.44	21.10	30.69	286
235	.78800	4746.1	6649.7	175.10	21.09	30.61	290
240	.77003	4854.6	6802.6	175.74	21.09	30.54	293
245	.75292	4962.9	6955.1	176.37	21.08	30.47	296
250	.73661	5071.0	7107.3	176.98	21.08	30.42	299
255	.72104	5179.0	7259.3	177.59	21.08	30.37	303
260	.70615	5286.8	7411.0	178.18	21.09	30.32	306
265	.69189	5394.6	7562.5	178.75	21.09	30.29	309
270	.67824	5502.3	7713.9	179.32	21.10	30.25	312
275	.66514	5609.9	7865.0	179.87	21.11	30.22	315
280	.65256	5717.5	8016.1	180.42	21.12	30.20	318
285	.64047	5825.0	8167.0	180.95	21.14	30.18	321
290	.62884	5932.6	8317.9	181.48	21.15	30.16	324
295	.61764	6040.1	8468.7	181.99	21.17	30.15	327
300	.60685	6147.7	8619.4	182.50	21.19	30.14	330
			2.0 MPa Isobar				
54.59[a]	40.856	−6189.6	−6140.6	67.01	37.88	53.28	1130
56	40.674	−6114.6	−6065.5	68.37	36.78	53.26	1136
58	40.410	−6008.4	−5958.9	70.24	35.65	53.32	1137
60	40.139	−5902.0	−5852.2	72.05	34.86	53.41	1132
62	39.865	−5795.5	−5745.3	73.80	34.25	53.48	1124
64	39.588	−5688.8	−5638.3	75.50	33.77	53.53	1113
66	39.309	−5582.1	−5531.2	77.15	33.35	53.56	1100
68	39.028	−5475.3	−5424.1	78.75	32.98	53.56	1086
70	38.746	−5368.5	−5316.9	80.30	32.64	53.56	1072
72	38.462	−5261.8	−5209.8	81.81	32.32	53.56	1057
74	38.177	−5155.1	−5102.7	83.28	32.01	53.56	1041
76	37.890	−5048.4	−4995.6	84.70	31.72	53.56	1026
78	37.602	−4941.6	−4888.4	86.10	31.43	53.58	1010
80	37.312	−4834.8	−4781.2	87.45	31.15	53.61	994
82	37.019	−4728.0	−4674.0	88.78	30.88	53.66	978
84	36.724	−4621.0	−4566.6	90.07	30.62	53.73	963
86	36.427	−4513.9	−4459.0	91.34	30.36	53.82	947
88	36.126	−4406.7	−4351.3	92.57	30.11	53.93	931
90	35.822	−4299.2	−4243.3	93.79	29.87	54.06	914
92	35.515	−4191.4	−4135.0	94.98	29.63	54.22	898

TABLE 11. Thermodynamic properties of oxygen – Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			2.0 MPa Isobar – Continued				
94	35.204	−4083.2	−4026.4	96.15	29.40	54.41	882
96	34.889	−3974.7	−3917.4	97.29	29.18	54.62	866
98	34.570	−3865.8	−3807.9	98.42	28.96	54.87	849
100	34.245	−3756.3	−3697.9	99.53	28.75	55.14	832
102	33.915	−3646.3	−3587.3	100.63	28.54	55.46	816
104	33.580	−3535.6	−3476.1	101.71	28.34	55.81	799
106	33.238	−3424.2	−3364.0	102.78	28.15	56.21	781
108	32.888	−3312.0	−3251.2	103.83	27.97	56.66	764
110	32.532	−3198.9	−3137.4	104.87	27.79	57.16	746
112	32.166	−3084.7	−3022.5	105.91	27.62	57.72	728
114	31.792	−2969.4	−2906.5	106.94	27.46	58.35	710
116	31.406	−2852.8	−2789.1	107.96	27.30	59.06	691
118	31.010	−2734.7	−2670.2	108.97	27.15	59.87	672
120	30.600	−2614.9	−2549.5	109.99	27.02	60.79	652
122	30.175	−2493.2	−2426.9	111.00	26.89	61.86	632
124	29.733	−2369.3	−2302.0	112.02	26.78	63.09	611
126	29.271	−2242.7	−2174.4	113.04	26.68	64.53	590
128	28.786	−2113.1	−2043.7	114.07	26.59	66.25	567
130	28.273	−1979.9	−1909.1	115.11	26.53	68.34	543
132	27.725	−1842.1	−1770.0	116.17	26.50	70.93	519
132.74[a]	27.512	−1789.6	−1716.9	116.57	26.49	72.07	509
132.74[a]	2.4736	2159.2	2967.7	151.86	26.23	55.70	186
134	2.4129	2206.8	3035.7	152.37	25.47	52.57	189
136	2.3270	2277.6	3137.0	153.12	24.65	49.02	193
138	2.2513	2344.1	3232.5	153.82	24.12	46.53	196
140	2.1833	2407.5	3323.6	154.48	23.75	44.66	200
142	2.1216	2468.7	3411.4	155.10	23.48	43.19	203
144	2.0650	2528.0	3496.5	155.69	23.26	41.99	205
146	2.0127	2585.8	3579.5	156.27	23.08	40.98	208
148	1.9642	2642.3	3660.6	156.82	22.93	40.11	211
150	1.9189	2697.7	3740.0	157.35	22.79	39.36	213
152	1.8764	2752.2	3818.0	157.87	22.67	38.69	216
154	1.8366	2805.8	3894.8	158.37	22.56	38.09	218
156	1.7989	2858.7	3970.4	158.86	22.45	37.56	221
158	1.7633	2910.8	4045.1	159.33	22.36	37.07	223
160	1.7295	2962.4	4118.8	159.80	22.27	36.63	225
162	1.6974	3013.4	4191.6	160.25	22.19	36.23	227
164	1.6668	3063.8	4263.7	160.69	22.12	35.87	230
166	1.6376	3113.8	4335.1	161.12	22.05	35.53	232
168	1.6097	3163.4	4405.8	161.55	21.98	35.22	234
170	1.5830	3212.6	4476.0	161.96	21.92	34.93	236
172	1.5574	3261.4	4545.6	162.37	21.87	34.67	238
174	1.5328	3309.8	4614.7	162.77	21.82	34.42	240
176	1.5091	3358.0	4683.3	163.16	21.77	34.19	242
178	1.4863	3405.9	4751.5	163.55	21.72	33.98	243
180	1.4644	3453.4	4819.2	163.92	21.68	33.78	245
185	1.4128	3571.3	4987.0	164.84	21.59	33.34	250
190	1.3653	3687.9	5152.7	165.73	21.51	32.96	254
195	1.3215	3803.3	5316.7	166.58	21.44	32.63	259
200	1.2809	3917.7	5479.1	167.40	21.38	32.35	263

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			2.0 MPa Isobar — Continued				
205	1.2430	4031.3	5640.2	168.20	21.33	32.11	267
210	1.2076	4144.1	5800.2	168.97	21.29	31.89	271
215	1.1745	4256.3	5959.2	169.72	21.26	31.70	274
220	1.1433	4367.9	6117.3	170.44	21.23	31.53	278
225	1.1139	4479.1	6274.5	171.15	21.21	31.38	282
230	1.0862	4589.8	6431.1	171.84	21.19	31.25	285
235	1.0599	4700.1	6587.1	172.51	21.17	31.13	289
240	1.0350	4810.2	6742.5	173.16	21.16	31.03	292
245	1.0114	4919.9	6897.4	173.80	21.15	30.93	296
250	.98888	5029.3	7051.8	174.43	21.15	30.85	299
255	.96745	5138.6	7205.9	175.04	21.14	30.77	302
260	.94699	5247.6	7359.6	175.63	21.14	30.71	306
265	.92744	5356.5	7513.0	176.22	21.15	30.65	309
270	.90875	5465.3	7666.1	176.79	21.15	30.60	312
275	.89084	5573.9	7818.9	177.35	21.16	30.55	315
280	.87368	5682.4	7971.6	177.90	21.17	30.51	318
285	.85720	5790.9	8124.1	178.44	21.18	30.48	321
290	.84137	5899.3	8276.4	178.97	21.19	30.45	324
295	.82615	6007.7	8428.5	179.49	21.21	30.42	327
300	.81150	6116.0	8580.6	180.00	21.22	30.40	330
			2.5 MPa Isobar				
54.65[a]	40.866	−6188.6	−6127.4	67.03	37.80	53.22	1132
56	40.692	−6116.8	−6055.4	68.33	36.76	53.21	1137
58	40.428	−6010.7	−5948.9	70.20	35.65	53.28	1138
60	40.158	−5904.5	−5842.3	72.01	34.86	53.37	1134
62	39.884	−5798.1	−5735.4	73.76	34.27	53.45	1125
64	39.608	−5691.6	−5628.5	75.46	33.79	53.50	1114
66	39.329	−5585.0	−5521.4	77.10	33.38	53.53	1102
68	39.050	−5478.4	−5414.4	78.70	33.01	53.53	1088
70	38.768	−5371.8	−5307.3	80.25	32.67	53.53	1073
72	38.485	−5265.2	−5200.3	81.76	32.35	53.53	1058
74	38.201	−5158.7	−5093.2	83.23	32.04	53.52	1043
76	37.915	−5052.1	−4986.2	84.65	31.75	53.52	1028
78	37.628	−4945.6	−4879.1	86.04	31.46	53.54	1012
80	37.339	−4839.0	−4772.0	87.40	31.19	53.56	996
82	37.047	−4732.3	−4664.8	88.72	30.91	53.61	980
84	36.754	−4625.6	−4557.6	90.02	30.65	53.67	965
86	36.457	−4518.7	−4450.2	91.28	30.39	53.75	949
88	36.158	−4411.7	−4342.5	92.52	30.14	53.86	933
90	35.856	−4304.4	−4234.7	93.73	29.90	53.98	917
92	35.551	−4196.9	−4126.6	94.92	29.66	54.14	901
94	35.241	−4089.1	−4018.1	96.08	29.43	54.31	885
96	34.928	−3980.9	−3909.3	97.23	29.21	54.52	868
98	34.611	−3872.3	−3800.0	98.35	28.99	54.76	852
100	34.288	−3763.2	−3690.3	99.46	28.78	55.02	835
102	33.961	−3653.5	−3579.9	100.56	28.57	55.32	819
104	33.628	−3543.3	−3468.9	101.63	28.38	55.66	802
106	33.288	−3432.4	−3357.2	102.70	28.18	56.04	785
108	32.942	−3320.6	−3244.7	103.75	28.00	56.47	768
110	32.589	−3208.1	−3131.3	104.79	27.82	56.95	750
112	32.227	−3094.5	−3016.9	105.82	27.65	57.48	732

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			2.5 MPa Isobar — Continued				
114	31.857	−2979.9	−2901.4	106.84	27.48	58.08	714
116	31.476	−2864.0	−2784.6	107.86	27.33	58.75	696
118	31.085	−2746.7	−2666.3	108.87	27.18	59.52	677
120	30.681	−2627.9	−2546.4	109.88	27.04	60.38	658
122	30.263	−2507.3	−2424.7	110.88	26.91	61.38	638
124	29.830	−2384.6	−2300.8	111.89	26.79	62.52	618
126	29.378	−2259.6	−2174.5	112.90	26.69	63.85	597
128	28.904	−2131.7	−2045.2	113.92	26.60	65.42	575
130	28.405	−2000.6	−1912.6	114.95	26.53	67.31	552
132	27.876	−1865.4	−1775.7	115.99	26.48	69.60	528
134	27.310	−1725.3	−1633.8	117.06	26.46	72.49	503
136	26.695	−1578.9	−1485.2	118.16	26.48	76.24	476
137.54[a]	26.177	−1460.1	−1364.6	119.04	26.53	80.03	453
137.54[a]	3.1952	2109.4	2891.8	149.99	27.50	67.08	184
138	3.1592	2130.5	2921.9	150.20	27.10	64.93	185
140	3.0194	2216.2	3044.2	151.08	25.81	58.00	190
142	2.9015	2293.8	3155.5	151.87	25.01	53.53	194
144	2.7992	2366.1	3259.2	152.60	24.47	50.38	198
146	2.7085	2434.5	3357.5	153.28	24.08	48.01	201
148	2.6269	2499.9	3451.6	153.92	23.79	46.14	204
150	2.5529	2563.0	3542.3	154.53	23.55	44.62	208
152	2.4850	2624.2	3630.2	155.11	23.35	43.35	210
154	2.4223	2683.8	3715.8	155.67	23.17	42.26	213
156	2.3642	2742.0	3799.4	156.21	23.02	41.32	216
158	2.3100	2798.9	3881.2	156.73	22.88	40.49	218
160	2.2592	2854.9	3961.4	157.23	22.75	39.76	221
162	2.2115	2909.9	4040.3	157.72	22.64	39.11	223
164	2.1666	2964.0	4117.9	158.20	22.53	38.52	226
166	2.1240	3017.4	4194.4	158.66	22.43	37.99	228
168	2.0837	3070.1	4269.9	159.11	22.35	37.51	230
170	2.0454	3122.2	4344.5	159.56	22.26	37.07	232
172	2.0089	3173.7	4418.2	159.99	22.19	36.67	235
174	1.9741	3224.7	4491.2	160.41	22.11	36.30	237
176	1.9408	3275.3	4563.4	160.82	22.05	35.96	239
178	1.9089	3325.4	4635.0	161.23	21.99	35.65	241
180	1.8784	3375.1	4706.0	161.62	21.93	35.36	243
185	1.8071	3497.7	4881.1	162.58	21.80	34.72	248
190	1.7423	3618.5	5053.3	163.50	21.70	34.18	252
195	1.6829	3737.5	5223.1	164.38	21.61	33.72	257
200	1.6282	3855.3	5390.7	165.23	21.53	33.33	261
205	1.5776	3971.8	5556.5	166.05	21.47	32.99	265
210	1.5306	4087.3	5720.7	166.84	21.42	32.70	269
215	1.4867	4201.9	5883.5	167.61	21.37	32.44	273
220	1.4456	4315.8	6045.1	168.35	21.33	32.21	277
225	1.4071	4428.9	6205.6	169.07	21.30	32.01	281
230	1.3708	4541.5	6365.2	169.77	21.27	31.83	285
235	1.3366	4653.6	6524.0	170.46	21.25	31.67	288
240	1.3043	4765.2	6682.0	171.12	21.23	31.53	292
245	1.2736	4876.4	6839.3	171.77	21.22	31.41	295
250	1.2445	4987.3	6996.1	172.40	21.21	31.29	299

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			2.5 MPa Isobar — Continued				
255	1.2169	5097.9	7152.3	173.02	21.20	31.19	302
260	1.1906	5208.1	7308.0	173.63	21.20	31.10	305
265	1.1654	5318.2	7463.3	174.22	21.20	31.02	309
270	1.1415	5428.0	7618.2	174.80	21.20	30.95	312
275	1.1185	5537.7	7772.8	175.37	21.21	30.88	315
280	1.0966	5647.2	7927.1	175.92	21.21	30.83	318
285	1.0755	5756.6	8081.1	176.47	21.22	30.78	321
290	1.0553	5865.9	8234.9	177.00	21.23	30.73	324
295	1.0359	5975.1	8388.4	177.53	21.25	30.70	327
300	1.0173	6084.3	8541.8	178.04	21.26	30.66	330
			3.0 MPa Isobar				
54.70[a]	40.876	−6187.6	−6114.2	67.05	37.71	53.16	1134
56	40.709	−6119.0	−6045.3	68.29	36.74	53.16	1139
58	40.446	−6013.1	−5938.9	70.16	35.65	53.24	1140
60	40.176	−5907.0	−5832.3	71.96	34.87	53.34	1135
62	39.903	−5800.8	−5725.6	73.71	34.28	53.42	1127
64	39.628	−5694.4	−5618.7	75.41	33.81	53.47	1116
66	39.350	−5587.9	−5511.7	77.06	33.40	53.50	1103
68	39.071	−5481.5	−5404.7	78.65	33.03	53.50	1089
70	38.790	−5375.0	−5297.7	80.21	32.70	53.50	1075
72	38.508	−5268.6	−5190.7	81.71	32.38	53.49	1060
74	38.225	−5162.2	−5083.7	83.18	32.07	53.48	1045
76	37.940	−5055.8	−4976.8	84.60	31.78	53.48	1029
78	37.654	−4949.5	−4869.8	85.99	31.49	53.49	1014
80	37.366	−4843.1	−4762.8	87.35	31.22	53.52	998
82	37.075	−4736.6	−4655.7	88.67	30.95	53.56	982
84	36.783	−4630.1	−4548.5	89.96	30.68	53.61	967
86	36.488	−4523.5	−4441.2	91.22	30.43	53.69	951
88	36.190	−4416.7	−4333.8	92.46	30.18	53.79	935
90	35.889	−4309.7	−4226.1	93.67	29.93	53.91	919
92	35.586	−4202.4	−4118.1	94.86	29.69	54.06	903
94	35.278	−4094.9	−4009.8	96.02	29.46	54.23	887
96	34.967	−3987.0	−3901.2	97.16	29.24	54.42	871
98	34.651	−3878.7	−3792.1	98.29	29.02	54.65	855
100	34.331	−3770.0	−3682.6	99.39	28.81	54.90	838
102	34.006	−3660.7	−3572.5	100.48	28.60	55.19	822
104	33.675	−3550.9	−3461.8	101.56	28.41	55.52	805
106	33.338	−3440.4	−3350.4	102.62	28.21	55.88	788
108	32.995	−3329.1	−3238.2	103.67	28.03	56.29	771
110	32.645	−3217.1	−3125.2	104.71	27.85	56.74	754
112	32.287	−3104.1	−3011.2	105.73	27.68	57.25	736
114	31.921	−2990.1	−2896.2	106.75	27.51	57.82	719
116	31.545	−2875.0	−2779.9	107.76	27.35	58.46	701
118	31.159	−2758.5	−2662.3	108.77	27.20	59.18	682
120	30.761	−2640.6	−2543.1	109.77	27.06	60.00	663
122	30.350	−2521.0	−2422.2	110.77	26.93	60.93	644
124	29.924	−2399.6	−2299.3	111.77	26.81	61.99	624
126	29.481	−2275.9	−2174.1	112.77	26.70	63.22	603
128	29.018	−2149.6	−2046.3	113.78	26.61	64.66	582
130	28.533	−2020.4	−1915.3	114.79	26.53	66.37	560
132	28.020	−1887.6	−1780.6	115.82	26.47	68.43	537

TABLE 11. Thermodynamic properties of oxygen – Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			3.0 MPa Isobar – Continued				
134	27.474	−1750.5	−1641.3	116.87	26.43	70.96	513
136	26.886	−1607.8	−1496.3	117.94	26.43	74.17	487
138	26.245	−1458.2	−1343.9	119.05	26.47	78.40	460
140	25.531	−1299.1	−1181.6	120.22	26.58	84.30	429
141.69[a]	24.845	−1153.7	−1032.9	121.28	26.76	91.61	401
141.69[a]	4.0059	2033.5	2782.4	148.20	28.87	83.84	181
142	3.9669	2051.3	2807.6	148.38	28.50	81.08	182
144	3.7491	2155.8	2956.0	149.42	26.76	68.61	188
146	3.5756	2246.3	3085.3	150.31	25.73	61.33	193
148	3.4302	2328.3	3202.9	151.11	25.05	56.51	197
150	3.3048	2404.5	3312.3	151.84	24.58	53.03	201
152	3.1941	2476.4	3415.6	152.53	24.21	50.38	204
154	3.0952	2544.9	3514.2	153.17	23.93	48.28	208
156	3.0056	2610.8	3608.9	153.78	23.69	46.55	211
158	2.9239	2674.5	3700.5	154.37	23.48	45.10	214
160	2.8487	2736.4	3789.5	154.93	23.30	43.87	216
162	2.7792	2796.7	3876.1	155.46	23.14	42.80	219
164	2.7144	2855.6	3960.8	155.98	22.99	41.87	222
166	2.6539	2913.3	4043.7	156.49	22.86	41.04	224
168	2.5972	2969.9	4125.0	156.97	22.74	40.30	227
170	2.5438	3025.6	4205.0	157.45	22.63	39.64	229
172	2.4934	3080.5	4283.6	157.91	22.53	39.05	232
174	2.4457	3134.6	4361.2	158.36	22.44	38.51	234
176	2.4004	3187.9	4437.7	158.79	22.35	38.02	236
178	2.3573	3240.7	4513.3	159.22	22.27	37.57	238
180	2.3163	3292.8	4588.0	159.64	22.20	37.16	240
185	2.2214	3421.0	4771.5	160.64	22.03	36.27	246
190	2.1360	3546.5	4950.9	161.60	21.90	35.53	250
195	2.0586	3669.7	5127.0	162.51	21.79	34.91	255
200	1.9878	3791.1	5300.2	163.39	21.69	34.39	260
205	1.9228	3910.8	5471.0	164.23	21.61	33.94	264
210	1.8627	4029.2	5639.8	165.05	21.54	33.56	268
215	1.8069	4146.4	5806.7	165.83	21.48	33.22	272
220	1.7550	4262.7	5972.1	166.59	21.44	32.93	276
225	1.7065	4378.0	6136.0	167.33	21.39	32.67	280
230	1.6610	4492.6	6298.8	168.05	21.36	32.44	284
235	1.6182	4606.5	6460.5	168.74	21.33	32.24	288
240	1.5778	4719.8	6621.2	169.42	21.31	32.05	291
245	1.5397	4832.6	6781.0	170.08	21.29	31.89	295
250	1.5036	4944.9	6940.1	170.72	21.28	31.75	299
255	1.4694	5056.8	7098.5	171.35	21.26	31.62	302
260	1.4368	5168.4	7256.4	171.96	21.26	31.50	305
265	1.4058	5279.6	7413.6	172.56	21.25	31.40	309
270	1.3763	5390.6	7570.4	173.15	21.25	31.31	312
275	1.3481	5501.4	7726.7	173.72	21.25	31.22	315
280	1.3212	5611.9	7882.6	174.28	21.26	31.15	318
285	1.2954	5722.2	8038.2	174.83	21.27	31.08	321
290	1.2706	5832.4	8193.5	175.37	21.28	31.02	324
295	1.2469	5942.5	8348.5	175.90	21.29	30.97	327
300	1.2241	6052.5	8503.2	176.42	21.30	30.93	330

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			4.0 MPa Isobar				
54.82[a]	40.896	−6185.7	−6087.9	67.08	37.55	53.04	1138
56	40.744	−6123.3	−6025.1	68.21	36.70	53.06	1142
58	40.481	−6017.7	−5918.9	70.08	35.64	53.16	1143
60	40.213	−5911.9	−5812.5	71.88	34.88	53.27	1138
62	39.941	−5806.0	−5705.8	73.63	34.31	53.36	1130
64	39.667	−5699.9	−5599.1	75.32	33.84	53.41	1119
66	39.391	−5593.8	−5492.2	76.97	33.44	53.44	1106
68	39.113	−5487.6	−5385.3	78.56	33.08	53.44	1092
70	38.834	−5381.5	−5278.5	80.11	32.75	53.44	1078
72	38.554	−5275.3	−5171.6	81.62	32.43	53.43	1063
74	38.273	−5169.3	−5064.8	83.08	32.13	53.41	1048
76	37.990	−5063.2	−4957.9	84.51	31.84	53.41	1033
78	37.705	−4957.2	−4851.1	85.89	31.55	53.41	1017
80	37.419	−4851.2	−4744.3	87.25	31.28	53.43	1002
82	37.131	−4745.1	−4637.4	88.56	31.01	53.46	986
84	36.841	−4639.0	−4530.4	89.85	30.74	53.51	971
86	36.548	−4532.8	−4423.4	91.11	30.49	53.57	955
88	36.253	−4426.5	−4316.1	92.35	30.24	53.66	939
90	35.956	−4320.0	−4208.7	93.55	29.99	53.77	924
92	35.655	−4213.2	−4101.1	94.74	29.76	53.90	908
94	35.350	−4106.3	−3993.1	95.90	29.53	54.05	892
96	35.043	−3999.0	−3884.8	97.04	29.30	54.23	876
98	34.731	−3891.3	−3776.2	98.16	29.08	54.44	860
100	34.415	−3783.3	−3667.0	99.26	28.87	54.68	844
102	34.094	−3674.8	−3557.4	100.34	28.67	54.94	828
104	33.768	−3565.7	−3447.3	101.41	28.47	55.24	812
106	33.437	−3456.1	−3336.5	102.47	28.27	55.57	795
108	33.099	−3345.8	−3224.9	103.51	28.09	55.94	778
110	32.755	−3234.8	−3112.7	104.54	27.91	56.36	762
112	32.404	−3122.9	−2999.5	105.56	27.73	56.82	745
114	32.046	−3010.2	−2885.3	106.57	27.57	57.34	727
116	31.678	−2896.4	−2770.1	107.57	27.41	57.91	710
118	31.302	−2781.4	−2653.6	108.57	27.25	58.56	692
120	30.915	−2665.2	−2535.8	109.56	27.11	59.28	673
122	30.516	−2547.5	−2416.4	110.55	26.97	60.10	655
124	30.104	−2428.2	−2295.3	111.53	26.85	61.03	636
126	29.677	−2307.0	−2172.2	112.52	26.73	62.09	616
128	29.234	−2183.7	−2046.8	113.50	26.63	63.32	596
130	28.772	−2057.8	−1918.8	114.50	26.53	64.74	575
132	28.287	−1929.1	−1787.7	115.50	26.46	66.42	554
134	27.775	−1796.9	−1652.9	116.51	26.40	68.43	531
136	27.232	−1660.6	−1513.7	117.54	26.37	70.88	508
138	26.649	−1519.1	−1369.0	118.60	26.36	73.94	483
140	26.016	−1371.1	−1217.3	119.69	26.40	77.91	457
142	25.317	−1214.4	−1056.4	120.83	26.49	83.28	428
144	24.525	−1045.7	−882.6	122.04	26.68	91.07	397
146	23.589	−858.6	−689.0	123.38	27.04	103.70	361
148	22.391	−638.3	−459.6	124.94	27.79	129.38	316
148.66[a]	21.887	−552.1	−369.3	125.55	28.26	145.93	297
148.66[a]	6.1022	1780.1	2435.6	144.42	32.46	166.47	174

TABLE 11. Thermodynamic properties of oxygen – Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			4.0 MPa Isobar – Continued				
150	5.6598	1914.2	2620.9	145.66	29.73	118.09	181
152	5.2279	2059.7	2824.8	147.01	27.63	89.83	189
154	4.9177	2176.0	2989.4	148.08	26.45	76.06	194
156	4.6731	2276.6	3132.6	149.01	25.68	67.72	199
158	4.4705	2367.2	3262.0	149.83	25.14	62.04	203
160	4.2972	2450.9	3381.7	150.59	24.72	57.87	207
162	4.1457	2529.3	3494.1	151.28	24.39	54.67	210
164	4.0113	2603.6	3600.8	151.94	24.11	52.11	214
166	3.8904	2674.7	3702.9	152.56	23.87	50.01	217
168	3.7806	2743.0	3801.1	153.14	23.66	48.25	220
170	3.6802	2809.1	3896.0	153.71	23.47	46.75	223
172	3.5876	2873.3	3988.2	154.25	23.30	45.46	225
174	3.5019	2935.7	4078.0	154.76	23.15	44.33	228
176	3.4220	2996.7	4165.6	155.27	23.02	43.34	231
178	3.3473	3056.4	4251.4	155.75	22.89	42.46	233
180	3.2772	3115.0	4335.5	156.22	22.78	41.67	236
185	3.1188	3257.0	4539.6	157.34	22.53	40.02	241
190	2.9802	3394.1	4736.3	158.39	22.32	38.71	247
195	2.8572	3527.2	4927.1	159.38	22.16	37.66	252
200	2.7469	3657.0	5113.2	160.32	22.02	36.79	257
205	2.6471	3784.2	5295.3	161.22	21.90	36.07	262
210	2.5561	3909.2	5474.1	162.08	21.80	35.45	266
215	2.4726	4032.2	5650.0	162.91	21.72	34.93	271
220	2.3956	4153.7	5823.4	163.71	21.65	34.47	275
225	2.3243	4273.8	5994.8	164.48	21.59	34.08	279
230	2.2579	4392.7	6164.3	165.22	21.54	33.73	283
235	2.1959	4510.6	6332.1	165.95	21.49	33.42	287
240	2.1378	4627.5	6498.6	166.65	21.46	33.15	291
245	2.0832	4743.6	6663.7	167.33	21.43	32.91	295
250	2.0318	4859.1	6827.7	167.99	21.41	32.70	298
255	1.9833	4973.9	6990.7	168.64	21.39	32.51	302
260	1.9373	5088.1	7152.8	169.26	21.37	32.34	305
265	1.8937	5201.9	7314.1	169.88	21.36	32.18	309
270	1.8523	5315.2	7474.7	170.48	21.35	32.04	312
275	1.8129	5428.2	7634.6	171.07	21.35	31.92	315
280	1.7754	5540.8	7793.9	171.64	21.35	31.81	319
285	1.7395	5653.1	7952.6	172.20	21.35	31.71	322
290	1.7052	5765.2	8110.9	172.75	21.36	31.61	325
295	1.6724	5877.1	8268.8	173.29	21.36	31.53	328
300	1.6410	5988.7	8426.3	173.82	21.37	31.46	331
			5.0 MPa Isobar				
54.93[a]	40.915	−6183.8	−6061.6	67.11	37.40	52.93	1141
56	40.779	−6127.6	−6005.0	68.14	36.66	52.97	1145
58	40.517	−6022.3	−5898.9	70.00	35.63	53.08	1145
60	40.250	−5916.8	−5792.6	71.80	34.89	53.20	1141
62	39.979	−5811.2	−5686.1	73.54	34.33	53.30	1132
64	39.706	−5705.4	−5579.5	75.24	33.88	53.35	1121
66	39.432	−5599.5	−5472.7	76.88	33.49	53.38	1109
68	39.155	−5493.6	−5365.9	78.47	33.13	53.39	1095
70	38.878	−5387.8	−5259.2	80.02	32.80	53.38	1081
72	38.599	−5282.0	−5152.4	81.52	32.49	53.36	1066

TABLE 11. Thermodynamic properties of oxygen – Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			5.0 MPa Isobar – Continued				
74	38.320	−5176.2	−5045.7	82.99	32.19	53.34	1051
76	38.039	−5070.5	−4939.1	84.41	31.90	53.33	1036
78	37.756	−4964.8	−4832.4	85.79	31.61	53.33	1021
80	37.472	−4859.2	−4725.7	87.14	31.34	53.34	1005
82	37.186	−4753.5	−4619.0	88.46	31.07	53.36	990
84	36.898	−4647.8	−4512.3	89.75	30.81	53.40	975
86	36.608	−4542.0	−4405.4	91.00	30.55	53.46	959
88	36.316	−4436.1	−4298.4	92.23	30.30	53.53	944
90	36.021	−4330.1	−4191.3	93.44	30.06	53.63	928
92	35.723	−4223.9	−4083.9	94.62	29.82	53.75	913
94	35.422	−4117.4	−3976.3	95.78	29.59	53.89	897
96	35.117	−4010.7	−3868.3	96.91	29.36	54.05	881
98	34.809	3903.7	3760.0	98.03	29.15	54.24	866
100	34.497	−3796.3	−3651.3	99.13	28.93	54.46	850
102	34.180	−3688.5	−3542.2	100.21	28.73	54.70	834
104	33.859	−3580.2	−3432.5	101.27	28.53	54.97	818
106	33.532	−3471.4	−3322.3	102.32	28.34	55.28	802
108	33.200	−3362.0	−3211.4	103.36	28.15	55.62	785
110	32.863	−3251.9	−3099.8	104.38	27.97	56.00	769
112	32.518	−3141.1	−2987.3	105.39	27.79	56.42	752
114	32.166	−3029.5	−2874.0	106.40	27.62	56.89	735
116	31.807	−2917.0	−2759.8	107.39	27.46	57.41	718
118	31.439	−2803.4	−2644.4	108.38	27.31	57.99	701
120	31.062	−2688.7	−2527.7	109.36	27.16	58.64	683
122	30.674	−2572.8	−2409.8	110.33	27.02	59.37	665
124	30.275	−2455.4	−2290.2	111.30	26.89	60.18	647
126	29.863	−2336.4	−2168.9	112.27	26.77	61.11	628
128	29.437	−2215.6	−2045.7	113.25	26.65	62.16	609
130	28.994	−2092.7	−1920.2	114.22	26.55	63.37	589
132	28.532	−1967.3	−1792.1	115.20	26.47	64.77	569
134	28.049	−1839.2	−1661.0	116.18	26.39	66.40	548
136	27.540	−1707.8	−1526.3	117.18	26.34	68.35	526
138	27.000	−1572.5	−1387.3	118.19	26.30	70.69	504
140	26.424	−1432.4	−1243.2	119.23	26.30	73.59	480
142	25.801	−1286.3	−1092.5	120.30	26.32	77.26	455
144	25.119	−1132.4	−933.4	121.41	26.40	82.08	428
146	24.357	−968.2	−762.9	122.59	26.55	88.76	399
148	23.478	−789.1	−576.2	123.86	26.82	98.74	367
150	22.415	−586.5	−363.4	125.29	27.32	115.72	330
152	20.992	−338.5	−100.4	127.03	28.39	153.64	284
154	18.207	76.8	351.4	129.98	32.80	432.47	205
154.36[a]	16.011	355.7	668.0	132.03	38.88	163	
154.36[a]	11.159	1031.4	1479.4	137.29	41.91	158	
156	7.9655	1648.9	2276.6	142.43	31.51	205.61	180
158	7.0373	1879.2	2589.7	144.43	28.62	125.43	189
160	6.4804	2037.4	2809.0	145.81	27.19	97.42	196
162	6.0773	2165.1	2987.8	146.92	26.30	82.66	201
164	5.7605	2275.3	3143.2	147.87	25.67	73.39	205
166	5.4992	2374.0	3283.2	148.72	25.20	66.95	209
168	5.2771	2464.6	3412.1	149.49	24.82	62.19	213

TABLE 11. Thermodynamic properties of oxygen – Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			5.0 MPa Isobar – Continued				
170	5.0839	2549.2	3532.7	150.21	24.50	58.49	216
172	4.9131	2628.9	3646.6	150.87	24.23	55.54	220
174	4.7603	2704.8	3755.2	151.50	23.99	53.11	223
176	4.6220	2777.5	3859.3	152.10	23.78	51.08	226
178	4.4959	2847.6	3959.7	152.66	23.59	49.35	229
180	4.3800	2915.4	4056.9	153.21	23.42	47.86	231
185	4.1263	3076.7	4288.4	154.47	23.07	44.90	238
190	3.9119	3229.0	4507.2	155.64	22.78	42.70	244
195	3.7270	3374.6	4716.2	156.73	22.55	40.99	250
200	3.5647	3515.0	4917.6	157.75	22.36	39.63	255
205	3.4204	3651.1	5112.9	158.71	22.20	38.52	260
210	3.2909	3783.8	5303.1	159.63	22.07	37.60	265
215	3.1735	3913.6	5489.1	160.50	21.95	36.83	270
220	3.0665	4041.1	5671.6	161.34	21.86	36.17	274
225	2.9682	4166.5	5851.0	162.15	21.78	35.61	278
230	2.8775	4290.2	6027.8	162.93	21.71	35.12	283
235	2.7934	4412.4	6202.4	163.68	21.66	34.70	287
240	2.7151	4533.3	6374.9	164.40	21.61	34.32	291
245	2.6419	4653.1	6545.6	165.11	21.57	33.99	294
250	2.5734	4771.9	6714.8	165.79	21.53	33.70	298
255	2.5089	4889.7	6882.7	166.46	21.51	33.43	302
260	2.4481	5006.9	7049.2	167.10	21.48	33.20	305
265	2.3908	5123.3	7214.7	167.73	21.47	32.99	309
270	2.3364	5239.1	7379.2	168.35	21.45	32.80	312
275	2.2849	5354.4	7542.7	168.95	21.44	32.63	316
280	2.2359	5469.2	7705.5	169.54	21.44	32.48	319
285	2.1892	5583.6	7867.6	170.11	21.44	32.34	322
290	2.1447	5697.6	8028.9	170.67	21.44	32.22	326
295	2.1022	5811.3	8189.7	171.22	21.44	32.10	329
300	2.0616	5924.7	8350.0	171.76	21.45	32.00	332
			6.0 MPa Isobar				
55.04[a]	40.935	−6181.8	−6035.3	67.15	37.26	52.83	1145
56	40.813	−6131.8	−5984.8	68.06	36.62	52.87	1148
58	40.552	−6026.9	−5878.9	69.92	35.62	53.01	1148
60	40.286	−5921.7	−5772.8	71.71	34.91	53.14	1143
62	40.017	−5816.3	−5666.4	73.46	34.36	53.24	1135
64	39.745	−5710.8	−5559.8	75.15	33.92	53.30	1124
66	39.472	−5605.2	−5453.2	76.79	33.53	53.33	1111
68	39.197	−5499.6	−5346.5	78.38	33.18	53.33	1098
70	38.921	−5394.0	−5239.9	79.93	32.86	53.32	1084
72	38.644	−5288.5	−5133.3	81.43	32.55	53.30	1069
74	38.366	−5183.1	−5026.7	82.89	32.25	53.28	1054
76	38.087	−5077.7	−4920.2	84.31	31.96	53.26	1039
78	37.806	−4972.4	−4813.6	85.69	31.67	53.25	1024
80	37.524	−4867.0	−4707.1	87.04	31.40	53.25	1009
82	37.240	−4761.7	−4600.6	88.36	31.13	53.27	994
84	36.955	−4656.4	−4494.1	89.64	30.87	53.30	978
86	36.667	−4551.1	−4387.4	90.90	30.61	53.35	963
88	36.377	−4445.6	−4280.7	92.12	30.36	53.41	948
90	36.085	−4340.0	−4173.8	93.32	30.12	53.50	933
92	35.790	−4234.3	−4066.7	94.50	29.88	53.60	917

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			6.0 MPa Isobar — Continued				
94	35.492	−4128.4	−3959.3	95.66	29.65	53.73	902
96	35.190	−4022.2	−3851.7	96.79	29.43	53.88	887
98	34.886	−3915.8	−3743.8	97.90	29.21	54.05	871
100	34.577	−3809.0	−3635.5	99.00	29.00	54.25	855
102	34.265	−3701.9	−3526.8	100.07	28.79	54.47	840
104	33.948	−3594.3	−3417.6	101.13	28.59	54.73	824
106	33.626	−3486.3	−3307.8	102.18	28.40	55.01	808
108	33.299	−3377.7	−3197.5	103.21	28.21	55.32	792
110	32.967	−3268.5	−3086.5	104.23	28.03	55.66	776
112	32.628	−3158.7	−2974.8	105.23	27.85	56.05	760
114	32.283	−3048.2	−2862.3	106.23	27.68	56.47	743
116	31.931	−2936.8	−2748.9	107.21	27.52	56.95	727
118	31.572	−2824.5	−2634.5	108.19	27.36	57.47	710
120	31.203	−2711.3	−2519.0	109.16	27.21	58.05	693
122	30.826	−2596.9	−2402.2	110.13	27.07	58.70	675
124	30.438	−2481.3	−2284.1	111.09	26.93	59.42	657
126	30.039	−2364.2	−2164.5	112.05	26.81	60.24	639
128	29.627	−2245.6	−2043.1	113.00	26.69	61.15	621
130	29.201	−2125.3	−1919.8	113.96	26.58	62.19	602
132	28.759	−2002.9	−1794.3	114.91	26.48	63.37	583
134	28.299	−1878.2	−1666.2	115.88	26.40	64.74	563
136	27.818	−1750.9	−1535.2	116.85	26.33	66.32	543
138	27.313	−1620.4	−1400.7	117.83	26.27	68.18	522
140	26.779	−1486.3	−1262.2	118.83	26.24	70.41	500
142	26.211	−1347.7	−1118.8	119.84	26.23	73.11	478
144	25.601	−1203.7	−969.3	120.89	26.25	76.46	454
146	24.937	−1052.9	−812.3	121.97	26.31	80.75	429
148	24.205	−893.3	−645.4	123.11	26.43	86.44	402
150	23.380	−721.7	−465.1	124.32	26.63	94.38	374
152	22.420	−532.9	−265.3	125.64	26.96	106.33	343
154	21.246	−316.8	−34.3	127.15	27.53	126.64	307
156	19.670	−49.4	255.6	129.02	28.64	169.74	266
158	17.036	353.0	705.2	131.88	31.40	314.32	213
160	12.160	1085.3	1578.7	137.37	33.35	415.79	184
162	9.7039	1533.4	2151.8	140.94	30.03	201.45	191
164	8.5740	1779.3	2479.1	142.94	28.18	136.22	198
166	7.8591	1955.9	2719.3	144.40	27.08	107.19	203
168	7.3393	2098.5	2916.0	145.58	26.33	90.78	207
170	6.9327	2220.8	3086.3	146.59	25.77	80.17	211
172	6.5995	2329.6	3238.7	147.48	25.33	72.72	215
174	6.3181	2428.7	3378.4	148.28	24.96	67.17	219
176	6.0748	2520.6	3508.2	149.03	24.65	62.86	222
178	5.8610	2606.7	3630.4	149.72	24.38	59.42	225
180	5.6705	2688.2	3746.3	150.36	24.14	56.59	228
185	5.2703	2876.8	4015.2	151.84	23.64	51.33	235
190	4.9474	3049.5	4262.3	153.16	23.26	47.69	242
195	4.6780	3211.1	4493.7	154.36	22.96	45.01	248
200	4.4475	3364.3	4713.4	155.47	22.71	42.95	253
205	4.2468	3511.1	4923.9	156.51	22.50	41.33	259
210	4.0696	3652.9	5127.2	157.49	22.33	40.02	264

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			6.0 MPa Isobar — Continued				
215	3.9112	3790.5	5324.5	158.42	22.19	38.94	269
220	3.7684	3924.8	5516.9	159.30	22.07	38.04	273
225	3.6386	4056.2	5705.2	160.15	21.97	37.27	278
230	3.5197	4185.2	5889.9	160.96	21.89	36.62	282
235	3.4104	4312.2	6071.5	161.74	21.82	36.05	287
240	3.3093	4437.4	6250.5	162.50	21.76	35.55	291
245	3.2153	4561.1	6427.1	163.23	21.70	35.12	295
250	3.1277	4683.4	6601.8	163.93	21.66	34.74	299
255	3.0457	4804.6	6774.6	164.62	21.62	34.40	302
260	2.9688	4924.8	6945.8	165.28	21.59	34.09	306
265	2.8964	5044.0	7115.6	165.93	21.57	33.82	310
270	2.8281	5162.5	7284.1	166.56	21.55	33.58	313
275	2.7634	5280.2	7451.4	167.17	21.54	33.36	317
280	2.7022	5397.3	7617.7	167.77	21.53	33.16	320
285	2.6440	5513.8	7783.1	168.36	21.52	32.99	323
290	2.5887	5629.8	7947.6	168.93	21.52	32.83	326
295	2.5360	5745.4	8111.4	169.49	21.52	32.68	330
300	2.4857	5860.6	8274.4	170.04	21.52	32.55	333
			7.0 MPa Isobar				
55.16[a]	40.954	−6179.9	−6009.0	67.18	37.12	52.73	1148
56	40.847	−6136.0	−5964.6	67.98	36.58	52.78	1150
58	40.587	−6031.4	−5858.9	69.84	35.61	52.93	1151
60	40.323	−5926.5	−5752.9	71.63	34.92	53.07	1146
62	40.055	−5821.4	−5646.6	73.37	34.39	53.18	1138
64	39.784	−5716.1	−5540.2	75.06	33.95	53.24	1127
66	39.512	−5610.8	−5433.7	76.70	33.57	53.27	1114
68	39.239	−5505.5	−5327.1	78.29	33.23	53.28	1101
70	38.964	−5400.2	−5220.6	79.84	32.91	53.26	1087
72	38.689	−5295.0	−5114.1	81.34	32.60	53.24	1072
74	38.412	−5189.9	−5007.6	82.80	32.30	53.21	1057
76	38.135	−5084.8	−4901.2	84.21	32.01	53.19	1042
78	37.856	−4979.8	−4794.9	85.60	31.73	53.17	1027
80	37.576	−4874.8	−4688.5	86.94	31.46	53.17	1012
82	37.294	−4769.9	−4582.2	88.26	31.19	53.18	997
84	37.011	−4664.9	−4475.8	89.54	30.93	53.20	982
86	36.725	−4560.0	−4369.4	90.79	30.67	53.24	967
88	36.438	−4454.9	−4262.8	92.01	30.42	53.30	952
90	36.148	−4349.8	−4156.2	93.21	30.18	53.37	937
92	35.856	−4244.5	−4049.3	94.39	29.94	53.47	922
94	35.561	−4139.1	−3942.3	95.54	29.71	53.58	907
96	35.263	−4033.5	−3835.0	96.67	29.49	53.72	891
98	34.961	−3927.6	−3727.4	97.78	29.27	53.87	876
100	34.656	−3821.5	−3619.5	98.87	29.06	54.05	861
102	34.348	−3715.0	−3511.2	99.94	28.85	54.26	845
104	34.035	−3608.1	−3402.4	100.99	28.65	54.49	830
106	33.718	−3500.8	−3293.2	102.03	28.46	54.75	814
108	33.396	−3393.0	−3183.4	103.06	28.27	55.03	799
110	33.068	−3284.7	−3073.0	104.07	28.09	55.35	783
112	32.736	−3175.8	−2962.0	105.07	27.91	55.70	767

TABLE 11. Thermodynamic properties of oxygen – Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			7.0 MPa Isobar – Continued				
114	32.397	−3066.3	−2850.2	106.06	27.74	56.09	751
116	32.052	−2956.0	−2737.6	107.04	27.57	56.52	735
118	31.700	−2844.9	−2624.1	108.01	27.42	56.99	718
120	31.340	−2733.0	−2509.6	108.97	27.26	57.52	702
122	30.971	−2620.0	−2394.0	109.93	27.12	58.10	685
124	30.594	−2506.0	−2277.2	110.88	26.98	58.74	668
126	30.206	−2390.7	−2159.0	111.83	26.85	59.46	650
128	29.808	−2274.1	−2039.3	112.77	26.73	60.26	633
130	29.397	−2156.0	−1917.9	113.71	26.61	61.16	615
132	28.972	−2036.2	−1794.6	114.65	26.51	62.18	596
134	28.532	−1914.4	−1669.1	115.59	26.41	63.33	578
136	28.074	−1790.5	−1541.1	116.54	26.33	64.65	558
138	27.597	−1664.0	−1410.4	117.50	26.26	66.17	539
140	27.096	−1534.6	−1276.3	118.46	26.21	67.94	519
142	26.569	−1401.9	−1138.4	119.44	26.17	70.03	498
144	26.010	−1265.0	−995.9	120.43	26.15	72.53	476
146	25.413	−1123.4	−847.9	121.46	26.17	75.56	454
148	24.770	−975.8	−693.2	122.51	26.21	79.34	430
150	24.068	−820.7	−529.9	123.60	26.30	84.16	406
152	23.292	−656.1	−355.5	124.76	26.44	90.51	380
154	22.415	−478.5	−166.3	126.00	26.67	99.26	353
156	21.397	−283.0	44.1	127.35	27.00	112.01	324
158	20.170	−60.5	286.5	128.90	27.51	131.97	294
160	18.614	204.9	581.0	130.75	28.29	165.46	261
162	16.545	539.0	962.1	133.11	29.37	218.31	230
164	14.031	942.1	1440.9	136.05	29.93	247.73	209
166	11.911	1308.0	1895.7	138.81	29.14	200.35	205
168	10.511	1578.6	2244.5	140.90	28.06	151.88	207
170	9.5613	1783.5	2515.7	142.50	27.20	121.72	210
172	8.8655	1949.2	2738.8	143.81	26.53	102.74	214
174	8.3250	2089.9	2930.8	144.92	26.00	89.99	217
176	7.8868	2213.6	3101.2	145.89	25.57	80.90	220
178	7.5203	2325.1	3255.9	146.77	25.20	74.11	223
180	7.2066	2427.3	3398.6	147.56	24.88	68.84	226
185	6.5808	2654.4	3718.1	149.31	24.24	59.71	234
190	6.1030	2854.1	4001.1	150.82	23.76	53.87	240
195	5.7195	3035.8	4259.7	152.17	23.37	49.80	247
200	5.4008	3204.8	4500.9	153.39	23.06	46.81	253
205	5.1293	3364.3	4729.0	154.52	22.81	44.52	258
210	4.8938	3516.6	4946.9	155.57	22.60	42.72	264
215	4.6864	3663.1	5156.7	156.55	22.43	41.26	269
220	4.5015	3804.9	5360.0	157.49	22.29	40.06	273
225	4.3352	3943.0	5557.7	158.38	22.17	39.06	278
230	4.1843	4077.8	5750.8	159.23	22.06	38.21	283
235	4.0464	4210.0	5939.9	160.04	21.98	37.48	287
240	3.9197	4339.9	6125.7	160.82	21.90	36.85	291
245	3.8027	4467.8	6308.5	161.58	21.84	36.30	295
250	3.6942	4593.9	6488.8	162.30	21.79	35.81	299
255	3.5931	4718.6	6666.8	163.01	21.74	35.39	303
260	3.4986	4841.9	6842.8	163.69	21.70	35.01	307

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			7.0 MPa Isobar — Continued				
265	3.4100	4964.1	7017.0	164.36	21.67	34.67	310
270	3.3266	5085.3	7189.6	165.00	21.65	34.37	314
275	3.2480	5205.6	7360.7	165.63	21.63	34.10	317
280	3.1737	5325.0	7530.6	166.24	21.61	33.86	321
285	3.1034	5443.8	7699.4	166.84	21.60	33.64	324
290	3.0366	5561.9	7867.1	167.42	21.59	33.44	328
295	2.9731	5679.4	8033.8	167.99	21.59	33.26	331
300	2.9127	5796.5	8199.8	168.55	21.59	33.10	334
			8.0 MPa Isobar				
55.27[a]	40.974	−6178.0	−5982.8	67.21	36.99	52.64	1151
56	40.881	−6140.1	−5944.4	67.90	36.55	52.69	1153
58	40.622	−6035.8	−5838.9	69.76	35.60	52.86	1154
60	40.359	−5931.2	−5733.0	71.55	34.93	53.01	1149
62	40.092	−5826.4	−5626.8	73.29	34.41	53.12	1140
64	39.823	−5721.4	−5520.5	74.98	33.99	53.19	1129
66	39.552	−5616.4	−5414.1	76.62	33.62	53.22	1117
68	39.280	−5511.3	−5307.7	78.20	33.28	53.22	1104
70	39.007	−5406.3	−5201.2	79.75	32.96	53.21	1090
72	38.733	−5301.4	−5094.8	81.25	32.65	53.18	1075
74	38.458	−5196.5	−4988.5	82.70	32.36	53.15	1060
76	38.182	−5091.8	−4882.2	84.12	32.07	53.12	1046
78	37.905	−4987.1	−4776.0	85.50	31.79	53.10	1031
80	37.627	−4882.5	−4669.8	86.84	31.52	53.09	1016
82	37.347	−4777.9	−4563.7	88.15	31.25	53.09	1001
84	37.066	−4673.3	−4457.5	89.43	30.99	53.11	986
86	36.783	−4568.7	−4351.2	90.68	30.73	53.14	971
88	36.498	−4464.1	−4244.9	91.91	30.48	53.18	956
90	36.211	−4359.4	−4138.5	93.10	30.24	53.25	941
92	35.921	−4254.6	−4031.9	94.27	30.00	53.33	926
94	35.629	−4149.7	−3925.1	95.42	29.77	53.44	911
96	35.334	−4044.6	−3818.1	96.55	29.55	53.56	896
98	35.035	−3939.2	−3710.9	97.65	29.33	53.70	881
100	34.734	−3833.6	−3603.3	98.74	29.12	53.87	866
102	34.429	−3727.8	−3495.4	99.81	28.91	54.05	851
104	34.120	−3621.6	−3387.1	100.86	28.71	54.26	836
106	33.807	−3515.0	−3278.3	101.90	28.52	54.50	821
108	33.490	−3407.9	−3169.1	102.92	28.33	54.76	805
110	33.168	−3300.5	−3059.3	103.92	28.14	55.05	790
112	32.840	−3192.4	−2948.8	104.92	27.97	55.37	774
114	32.507	−3083.8	−2837.7	105.90	27.80	55.73	758
116	32.169	−2974.6	−2725.9	106.87	27.63	56.12	742
118	31.823	−2864.6	−2613.2	107.84	27.47	56.55	726
120	31.471	−2753.9	−2499.7	108.79	27.32	57.02	710
122	31.111	−2642.2	−2385.1	109.74	27.17	57.54	694
124	30.743	−2529.7	−2269.4	110.68	27.03	58.12	677
126	30.366	−2416.0	−2152.6	111.61	26.89	58.76	660
128	29.979	−2301.2	−2034.4	112.54	26.77	59.47	643
130	29.581	−2185.1	−1914.7	113.47	26.65	60.26	626
132	29.172	−2067.5	−1793.3	114.40	26.54	61.14	609

TABLE 11. Thermodynamic properties of oxygen – Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			8.0 MPa Isobar – Continued				
134	28.749	−1948.3	−1670.0	115.33	26.44	62.12	591
136	28.311	−1827.3	−1544.7	116.25	26.34	63.24	572
138	27.857	−1704.2	−1417.0	117.19	26.26	64.51	554
140	27.383	−1578.7	−1286.6	118.13	26.19	65.95	535
142	26.889	−1450.6	−1153.0	119.07	26.14	67.62	515
144	26.369	−1319.3	−1015.9	120.03	26.10	69.57	496
146	25.821	−1184.4	−874.5	121.01	26.08	71.86	475
148	25.239	−1045.2	−728.2	122.00	26.08	74.58	454
150	24.616	−900.8	−575.8	123.02	26.11	77.88	432
152	23.944	−750.2	−416.1	124.08	26.17	81.95	410
154	23.212	−592.0	−247.3	125.18	26.28	87.06	386
156	22.404	−424.0	−66.9	126.35	26.42	93.64	362
158	21.499	−243.5	128.6	127.59	26.63	102.30	338
160	20.466	−46.6	344.3	128.95	26.90	113.93	313
162	19.269	171.8	586.9	130.46	27.25	129.46	288
164	17.870	417.0	864.7	132.16	27.64	148.73	264
166	16.275	690.0	1181.6	134.08	27.99	167.24	244
168	14.604	977.4	1525.1	136.14	28.08	173.12	230
170	13.086	1249.4	1860.7	138.12	27.81	159.89	223
172	11.857	1484.8	2159.5	139.87	27.33	138.67	222
174	10.900	1683.1	2417.0	141.36	26.82	119.51	222
176	10.147	1852.0	2640.4	142.64	26.36	104.59	224
178	9.5391	1999.1	2837.8	143.75	25.94	93.27	226
180	9.0365	2130.0	3015.3	144.74	25.57	84.59	228
185	8.0808	2408.5	3398.5	146.85	24.81	70.05	235
190	7.3902	2642.6	3725.1	148.59	24.23	61.22	241
195	6.8571	2849.0	4015.6	150.10	23.78	55.35	247
200	6.4270	3036.6	4281.4	151.44	23.41	51.17	253
205	6.0688	3210.9	4529.1	152.67	23.11	48.06	259
210	5.7634	3375.1	4763.2	153.80	22.87	45.67	264
215	5.4983	3531.6	4986.6	154.85	22.66	43.76	269
220	5.2649	3681.9	5201.4	155.83	22.50	42.22	274
225	5.0569	3827.2	5409.2	156.77	22.35	40.94	279
230	4.8699	3968.4	5611.2	157.66	22.23	39.87	283
235	4.7002	4106.2	5808.2	158.50	22.13	38.96	288
240	4.5453	4241.0	6001.0	159.32	22.04	38.19	292
245	4.4031	4373.3	6190.2	160.10	21.97	37.51	296
250	4.2718	4503.5	6376.3	160.85	21.91	36.92	300
255	4.1500	4631.9	6559.6	161.57	21.85	36.40	304
260	4.0366	4758.6	6740.4	162.28	21.81	35.95	308
265	3.9306	4883.8	6919.1	162.96	21.77	35.54	312
270	3.8312	5007.8	7095.9	163.62	21.74	35.18	315
275	3.7378	5130.7	7271.0	164.26	21.71	34.85	319
280	3.6498	5252.6	7444.5	164.89	21.69	34.56	322
285	3.5666	5373.6	7616.7	165.49	21.68	34.30	326
290	3.4878	5493.9	7787.5	166.09	21.67	34.06	329
295	3.4131	5613.4	7957.3	166.67	21.66	33.85	332
300	3.3420	5732.3	8126.1	167.24	21.66	33.65	335

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			9.0 MPa Isobar				
55.38[a]	40.993	−6176.1	−5956.6	67.25	36.87	52.55	1155
56	40.915	−6144.2	−5924.2	67.83	36.51	52.60	1156
58	40.657	−6040.2	−5818.8	69.68	35.60	52.79	1156
60	40.394	−5935.9	−5713.1	71.47	34.94	52.95	1151
62	40.129	−5831.4	−5607.1	73.21	34.44	53.07	1143
64	39.861	−5726.6	−5500.9	74.89	34.02	53.14	1132
66	39.591	−5621.9	−5394.5	76.53	33.66	53.17	1120
68	39.321	−5517.1	−5288.2	78.12	33.32	53.17	1106
70	39.049	−5412.4	−5181.9	79.66	33.01	53.15	1092
72	38.777	−5307.7	−5075.6	81.15	32.71	53.12	1078
74	38.504	−5203.1	−4969.4	82.61	32.41	53.09	1064
76	38.230	−5098.7	−4863.2	84.03	32.13	53.06	1049
78	37.954	−4994.3	−4757.2	85.40	31.85	53.03	1034
80	37.678	−4890.0	−4651.1	86.75	31.57	53.01	1019
82	37.400	−4785.7	−4545.1	88.05	31.31	53.01	1005
84	37.121	−4681.5	−4439.1	89.33	31.04	53.01	990
86	36.840	−4577.3	−4333.0	90.58	30.79	53.04	975
88	36.557	−4473.1	−4226.9	91.80	30.54	53.08	960
90	36.272	−4368.8	−4120.7	92.99	30.30	53.13	946
92	35.985	−4264.5	−4014.4	94.16	30.06	53.21	931
94	35.696	−4160.0	−3907.9	95.31	29.83	53.30	916
96	35.403	−4055.4	−3801.2	96.43	29.61	53.41	901
98	35.108	−3950.6	−3694.2	97.53	29.39	53.54	886
100	34.810	−3845.6	−3587.0	98.61	29.18	53.69	871
102	34.509	−3740.3	−3479.5	99.68	28.97	53.86	857
104	34.204	−3634.7	−3371.6	100.73	28.77	54.05	842
106	33.895	−3528.8	−3263.3	101.76	28.58	54.27	826
108	33.582	−3422.5	−3154.5	102.78	28.39	54.51	811
110	33.264	−3315.8	−3045.2	103.78	28.20	54.77	796
112	32.942	−3208.6	−2935.4	104.77	28.02	55.07	781
114	32.615	−3100.9	−2824.9	105.75	27.85	55.39	765
116	32.282	−2992.6	−2713.8	106.71	27.69	55.75	750
118	31.943	−2883.6	−2601.9	107.67	27.53	56.14	734
120	31.598	−2774.0	−2489.2	108.62	27.37	56.57	718
122	31.246	−2663.6	−2375.6	109.55	27.22	57.04	703
124	30.887	−2552.4	−2261.0	110.49	27.08	57.56	686
126	30.519	−2440.2	−2145.3	111.41	26.94	58.13	670
128	30.143	−2327.0	−2028.5	112.33	26.81	58.75	654
130	29.757	−2212.7	−1910.3	113.25	26.69	59.45	637
132	29.361	−2097.2	−1790.6	114.16	26.57	60.22	620
134	28.953	−1980.2	−1669.3	115.07	26.47	61.07	603
136	28.532	−1861.7	−1546.3	115.98	26.37	62.03	586
138	28.097	−1741.5	−1421.1	116.90	26.28	63.10	568
140	27.647	−1619.3	−1293.8	117.81	26.20	64.31	550
142	27.179	−1494.9	−1163.8	118.74	26.13	65.68	532
144	26.690	−1368.1	−1030.9	119.66	26.07	67.24	513
146	26.180	−1238.5	−894.7	120.60	26.03	69.03	494
148	25.643	−1105.6	−754.6	121.56	26.01	71.11	475
150	25.076	−968.9	−610.0	122.53	26.00	73.54	455
152	24.475	−827.9	−460.1	123.52	26.02	76.41	434

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			9.0 MPa Isobar — Continued				
154	23.832	−681.6	−304.0	124.54	26.05	79.84	414
156	23.141	−529.2	−140.3	125.60	26.12	83.97	393
158	22.391	−369.5	32.5	126.70	26.22	89.00	371
160	21.571	−200.8	216.5	127.85	26.34	95.18	350
162	20.669	−21.3	414.1	129.08	26.50	102.70	328
164	19.669	170.7	628.2	130.40	26.68	111.63	307
166	18.565	376.5	861.3	131.81	26.86	121.49	288
168	17.364	595.6	1113.9	133.32	27.02	130.83	270
170	16.105	823.7	1382.5	134.91	27.11	137.02	256
172	14.857	1052.1	1657.9	136.52	27.07	137.19	246
174	13.702	1270.0	1926.8	138.07	26.91	130.80	240
176	12.693	1469.5	2178.5	139.51	26.65	120.57	236
178	11.838	1648.4	2408.6	140.81	26.34	109.63	235
180	11.119	1808.3	2617.7	141.98	26.02	99.69	236
185	9.7596	2143.9	3066.1	144.44	25.28	81.07	239
190	8.8040	2417.4	3439.7	146.43	24.65	69.23	244
195	8.0874	2652.1	3765.0	148.12	24.15	61.38	249
200	7.5230	2861.1	4057.4	149.60	23.74	55.88	255
205	7.0623	3051.9	4326.2	150.93	23.40	51.86	260
210	6.6757	3229.4	4577.6	152.14	23.12	48.79	266
215	6.3446	3396.8	4815.3	153.26	22.89	46.40	271
220	6.0563	3556.3	5042.3	154.31	22.70	44.48	275
225	5.8018	3709.4	5260.6	155.29	22.53	42.90	280
230	5.5747	3857.3	5471.8	156.22	22.40	41.60	285
235	5.3701	4001.0	5676.9	157.10	22.28	40.50	289
240	5.1845	4141.1	5877.0	157.94	22.18	39.56	293
245	5.0149	4278.1	6072.7	158.75	22.10	38.75	298
250	4.8591	4412.5	6264.7	159.52	22.02	38.05	302
255	4.7151	4544.6	6453.4	160.27	21.96	37.43	305
260	4.5816	4674.8	6639.1	160.99	21.91	36.89	309
265	4.4573	4803.2	6822.4	161.69	21.87	36.41	313
270	4.3410	4930.1	7003.4	162.37	21.83	35.99	317
275	4.2321	5055.7	7182.3	163.02	21.80	35.61	320
280	4.1296	5180.1	7359.5	163.66	21.78	35.27	324
285	4.0330	5303.5	7535.1	164.28	21.76	34.96	327
290	3.9417	5425.9	7709.1	164.89	21.74	34.68	331
295	3.8553	5547.4	7881.9	165.48	21.73	34.43	334
300	3.7732	5668.3	8053.5	166.06	21.72	34.20	337
			10.0 MPa Isobar				
55.50[a]	41.012	−6174.3	−5930.4	67.28	36.76	52.46	1158
56	40.948	−6148.3	−5904.0	67.75	36.47	52.51	1159
58	40.692	−6044.6	−5798.8	69.60	35.59	52.72	1159
60	40.430	−5940.5	−5693.2	71.39	34.95	52.89	1154
62	40.165	−5836.3	−5587.3	73.13	34.47	53.02	1145
64	39.899	−5731.8	−5481.2	74.81	34.06	53.09	1135
66	39.630	−5627.3	−5375.0	76.44	33.70	53.12	1122
68	39.361	−5522.8	−5268.7	78.03	33.37	53.12	1109
70	39.091	−5418.3	−5162.5	79.57	33.06	53.10	1095
72	38.820	−5313.9	−5056.3	81.06	32.76	53.07	1081

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			10.0 MPa Isobar — Continued				
74	38.549	−5209.6	−4950.2	82.52	32.47	53.03	1067
76	38.276	−5105.5	−4844.2	83.93	32.18	52.99	1052
78	38.003	−5001.4	−4738.3	85.31	31.90	52.96	1037
80	37.728	−4897.4	−4632.4	86.65	31.63	52.94	1023
82	37.452	−4793.5	−4526.5	87.96	31.36	52.92	1008
84	37.175	−4689.7	−4420.7	89.23	31.10	52.93	994
86	36.896	−4585.8	−4314.8	90.48	30.85	52.94	979
88	36.616	−4482.0	−4208.9	91.69	30.60	52.97	964
90	36.333	−4378.1	−4102.9	92.88	30.36	53.02	950
92	36.049	−4274.2	−3996.8	94.05	30.12	53.08	935
94	35.762	−4170.2	−3890.6	95.19	29.89	53.16	921
96	35.472	−4066.0	−3784.1	96.31	29.67	53.26	906
98	35.180	−3961.7	−3677.5	97.41	29.45	53.38	891
100	34.885	−3857.3	−3570.6	98.49	29.24	53.52	877
102	34.587	−3752.5	−3463.4	99.55	29.03	53.67	862
104	34.286	−3647.6	−3355.9	100.60	28.83	53.85	847
106	33.981	−3542.3	−3248.0	101.62	28.63	54.05	832
108	33.672	−3436.7	−3139.7	102.64	28.44	54.27	817
110	33.359	−3330.7	−3030.9	103.64	28.26	54.51	802
112	33.042	−3224.3	−2921.6	104.62	28.08	54.78	787
114	32.719	−3117.4	−2811.8	105.59	27.91	55.08	772
116	32.392	−3010.0	−2701.3	106.55	27.74	55.40	757
118	32.060	−2902.1	−2590.2	107.50	27.58	55.76	742
120	31.721	−2793.5	−2478.3	108.44	27.42	56.15	726
122	31.376	−2684.3	−2365.6	109.37	27.27	56.57	711
124	31.025	−2574.3	−2251.9	110.30	27.13	57.04	695
126	30.666	−2463.5	−2137.4	111.21	26.99	57.55	679
128	30.300	−2351.8	−2021.7	112.13	26.86	58.11	664
130	29.924	−2239.1	−1904.9	113.03	26.73	58.73	647
132	29.540	−2125.3	−1786.8	113.93	26.61	59.40	631
134	29.145	−2010.3	−1667.2	114.83	26.50	60.15	615
136	28.740	−1894.1	−1546.1	115.73	26.40	60.98	598
138	28.322	−1776.3	−1423.2	116.63	26.30	61.90	581
140	27.891	−1657.0	−1298.5	117.52	26.21	62.92	564
142	27.445	−1535.9	−1171.5	118.42	26.13	64.06	547
144	26.982	−1412.7	−1042.1	119.33	26.06	65.35	529
146	26.502	−1287.3	−910.0	120.24	26.01	66.80	511
148	26.001	−1159.4	−774.8	121.16	25.96	68.44	493
150	25.476	−1028.6	−636.1	122.09	25.93	70.32	475
152	24.925	−894.5	−493.3	123.04	25.92	72.47	456
154	24.345	−756.8	−346.0	124.00	25.92	74.95	437
156	23.730	−614.7	−193.3	124.98	25.94	77.83	418
158	23.075	−467.7	−34.4	126.00	25.98	81.18	398
160	22.376	−315.1	131.8	127.04	26.04	85.09	379
162	21.626	−156.0	306.4	128.13	26.11	89.63	360
164	20.818	10.4	490.8	129.26	26.20	94.81	341
166	19.949	184.7	686.0	130.44	26.30	100.51	323
168	19.017	367.1	892.9	131.68	26.39	106.39	306
170	18.032	556.7	1111.3	132.97	26.47	111.78	291
172	17.012	751.3	1339.1	134.30	26.51	115.78	278

TABLE 11. Thermodynamic properties of oxygen – Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			10.0 MPa Isobar – Continued				
174	15.987	947.2	1572.8	135.65	26.50	117.41	267
176	14.993	1139.8	1806.8	136.99	26.43	116.06	259
178	14.066	1324.2	2035.2	138.28	26.30	111.93	254
180	13.228	1497.3	2253.3	139.50	26.11	105.97	250
185	11.535	1874.8	2741.8	142.18	25.55	89.65	248
190	10.308	2185.6	3155.7	144.39	24.97	76.61	250
195	9.3907	2449.2	3514.1	146.25	24.45	67.29	254
200	8.6767	2680.5	3833.0	147.86	24.02	60.62	258
205	8.1014	2888.8	4123.2	149.30	23.66	55.71	263
210	7.6244	3080.5	4392.1	150.59	23.35	51.99	268
215	7.2203	3259.5	4644.4	151.78	23.10	49.09	273
220	6.8716	3428.6	4883.9	152.88	22.88	46.78	278
225	6.5664	3590.0	5112.9	153.91	22.70	44.90	282
230	6.2958	3745.0	5333.4	154.88	22.55	43.35	287
235	6.0537	3894.9	5546.8	155.80	22.42	42.05	291
240	5.8351	4040.4	5754.2	156.67	22.31	40.94	295
245	5.6364	4182.3	5956.5	157.51	22.22	40.00	299
250	5.4545	4321.0	6154.4	158.31	22.14	39.18	303
255	5.2872	4457.1	6348.4	159.07	22.07	38.47	307
260	5.1325	4590.8	6539.2	159.82	22.01	37.84	311
265	4.9888	4722.5	6727.0	160.53	21.96	37.29	315
270	4.8549	4852.4	6912.2	161.22	21.92	36.80	319
275	4.7297	4980.7	7095.0	161.89	21.88	36.36	322
280	4.6122	5107.7	7275.8	162.55	21.85	35.97	326
285	4.5017	5233.4	7454.8	163.18	21.83	35.61	329
290	4.3975	5358.0	7632.0	163.80	21.81	35.30	332
295	4.2990	5481.6	7807.8	164.40	21.80	35.01	336
300	4.2056	5604.4	7982.2	164.98	21.79	34.75	339
			15.0 MPa Isobar				
56.06[a]	41.106	−6164.9	−5800.0	67.43	36.28	52.10	1173
58	40.861	−6065.7	−5698.6	69.21	35.55	52.38	1172
60	40.605	−5963.0	−5593.6	70.99	35.01	52.61	1167
62	40.346	−5860.0	−5488.2	72.72	34.59	52.76	1158
64	40.085	−5756.8	−5382.6	74.40	34.23	52.85	1148
66	39.823	−5653.5	−5276.9	76.02	33.90	52.89	1136
68	39.560	−5550.3	−5171.1	77.60	33.60	52.89	1123
70	39.296	−5447.1	−5065.3	79.13	33.30	52.86	1109
72	39.033	−5344.0	−4959.7	80.62	33.01	52.81	1096
74	38.768	−5241.0	−4854.1	82.07	32.73	52.76	1082
76	38.503	−5138.2	−4748.7	83.48	32.45	52.70	1068
78	38.238	−5035.6	−4643.3	84.84	32.18	52.64	1054
80	37.972	−4933.1	−4538.1	86.18	31.91	52.59	1040
82	37.705	−4830.8	−4432.9	87.47	31.64	52.55	1026
84	37.437	−4728.5	−4327.9	88.74	31.38	52.52	1012
86	37.168	−4626.4	−4222.8	89.98	31.13	52.51	998
88	36.898	−4524.3	−4117.8	91.18	30.88	52.50	984
90	36.626	−4422.4	−4012.8	92.36	30.64	52.51	970
92	36.353	−4320.4	−3907.8	93.52	30.40	52.53	956
94	36.078	−4218.4	−3802.7	94.65	30.17	52.57	942

TABLE 11. Thermodynamic properties of oxygen – Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			15.0 MPa Isobar – Continued				
96	35.802	−4116.5	−3697.5	95.75	29.95	52.62	928
98	35.523	−4014.5	−3592.2	96.84	29.73	52.68	915
100	35.243	−3912.4	−3486.8	97.90	29.52	52.76	901
102	34.960	−3810.2	−3381.1	98.95	29.31	52.86	887
104	34.674	−3707.9	−3275.3	99.98	29.11	52.96	873
106	34.387	−3605.5	−3169.3	100.99	28.92	53.09	860
108	34.096	−3502.9	−3063.0	101.98	28.73	53.23	846
110	33.802	−3400.1	−2956.3	102.96	28.54	53.39	832
112	33.506	−3297.1	−2849.4	103.92	28.36	53.56	818
114	33.206	−3193.8	−2742.1	104.87	28.19	53.75	805
116	32.903	−3090.3	−2634.4	105.81	28.02	53.95	791
118	32.596	−2986.4	−2526.3	106.73	27.85	54.18	777
120	32.285	−2882.3	−2417.7	107.65	27.70	54.43	763
122	31.970	−2777.7	−2308.6	108.55	27.54	54.69	749
124	31.651	−2672.8	−2198.9	109.44	27.39	54.98	735
126	31.327	−2567.4	−2088.6	110.32	27.25	55.29	721
128	30.998	−2461.6	−1977.7	111.19	27.10	55.62	707
130	30.665	−2355.3	−1866.1	112.06	26.97	55.98	693
132	30.325	−2248.4	−1753.8	112.92	26.84	56.36	679
134	29.981	−2141.0	−1640.7	113.77	26.71	56.78	665
136	29.630	−2032.9	−1526.7	114.61	26.59	57.22	651
138	29.272	−1924.2	−1411.8	115.45	26.48	57.70	637
140	28.908	−1814.7	−1295.8	116.29	26.37	58.22	622
142	28.536	−1704.5	−1178.9	117.11	26.26	58.77	608
144	28.157	−1593.5	−1060.7	117.94	26.16	59.36	594
146	27.770	−1481.5	−941.4	118.76	26.07	60.00	580
148	27.374	−1368.7	−820.7	119.59	25.98	60.69	565
150	26.969	−1254.8	−698.6	120.40	25.90	61.42	551
152	26.554	−1139.8	−575.0	121.22	25.82	62.21	537
154	26.129	−1023.8	−449.7	122.04	25.75	63.06	522
156	25.693	−906.5	−322.7	122.86	25.68	63.96	508
158	25.246	−787.9	−193.8	123.68	25.63	64.93	494
160	24.787	−668.1	−62.9	124.51	25.57	65.95	480
162	24.316	−546.8	70.0	125.33	25.53	67.03	466
164	23.832	−424.2	205.2	126.16	25.49	68.17	453
166	23.335	−300.0	342.8	126.99	25.45	69.36	439
168	22.825	−174.5	482.7	127.83	25.42	70.58	426
170	22.302	−47.5	625.1	128.67	25.39	71.82	414
172	21.766	80.9	770.0	129.52	25.36	73.05	401
174	21.220	210.4	917.3	130.37	25.33	74.24	390
176	20.663	341.0	1066.9	131.23	25.31	75.34	378
178	20.099	472.2	1218.6	132.09	25.28	76.30	368
180	19.530	603.9	1372.0	132.94	25.25	77.08	358
185	18.108	931.9	1760.3	135.07	25.15	77.99	338
190	16.733	1252.4	2148.9	137.14	25.00	77.14	322
195	15.457	1558.5	2529.0	139.12	24.80	74.63	312
200	14.314	1845.4	2893.3	140.96	24.55	70.99	306
205	13.314	2111.5	3238.1	142.67	24.29	66.91	302
210	12.449	2357.7	3562.6	144.23	24.03	62.92	301
215	11.702	2586.1	3868.0	145.67	23.78	59.29	302

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			15.0 MPa Isobar — Continued				
220	11.053	2799.2	4156.3	146.99	23.55	56.11	303
225	10.487	2999.4	4429.7	148.22	23.34	53.36	305
230	9.9890	3188.8	4690.5	149.37	23.16	50.99	307
235	9.5473	3369.1	4940.3	150.44	22.99	48.97	310
240	9.1528	3541.8	5180.6	151.45	22.85	47.23	313
245	8.7979	3707.9	5412.9	152.41	22.73	45.72	316
250	8.4765	3868.5	5638.1	153.32	22.62	44.41	319
255	8.1837	4024.4	5857.3	154.19	22.52	43.27	323
260	7.9157	4176.1	6071.0	155.02	22.44	42.26	326
265	7.6691	4324.2	6280.1	155.82	22.37	41.37	329
270	7.4412	4469.1	6484.9	156.58	22.30	40.59	332
275	7.2297	4611.3	6686.1	157.32	22.25	39.89	336
280	7.0329	4751.1	6883.9	158.03	22.20	39.26	339
285	6.8490	4888.7	7078.8	158.72	22.17	38.70	342
290	6.6766	5024.4	7271.0	159.39	22.13	38.19	345
295	6.5147	5158.3	7460.8	160.04	22.10	37.73	348
300	6.3622	5290.7	7648.4	160.67	22.08	37.32	351
			20.0 MPa Isobar				
56.62[a]	41.198	−6155.6	−5670.1	67.58	35.93	51.82	1187
58	41.026	−6085.8	−5598.3	68.84	35.52	52.06	1185
60	40.775	−5984.4	−5493.9	70.61	35.07	52.35	1180
62	40.520	−5882.6	−5389.0	72.33	34.71	52.53	1171
64	40.265	−5780.5	−5283.8	74.00	34.39	52.64	1161
66	40.008	−5678.4	−5178.5	75.62	34.10	52.68	1149
68	39.751	−5576.2	−5073.1	77.19	33.81	52.68	1136
70	39.494	−5474.2	−4967.8	78.72	33.53	52.64	1123
72	39.237	−5372.3	−4862.6	80.20	33.25	52.59	1110
74	38.979	−5270.5	−4757.4	81.64	32.98	52.52	1096
76	38.721	−5169.0	−4652.5	83.04	32.70	52.44	1083
78	38.463	−5067.6	−4547.7	84.40	32.43	52.37	1069
80	38.205	−4966.5	−4443.0	85.72	32.17	52.30	1056
82	37.946	−4865.5	−4338.5	87.01	31.90	52.24	1042
84	37.686	−4764.7	−4234.0	88.27	31.64	52.18	1029
86	37.426	−4664.1	−4129.7	89.50	31.39	52.14	1015
88	37.165	−4563.6	−4025.5	90.70	31.14	52.10	1002
90	36.903	−4463.3	−3921.3	91.87	30.90	52.08	989
92	36.640	−4363.0	−3817.2	93.01	30.67	52.07	976
94	36.375	−4262.9	−3713.0	94.13	30.44	52.07	963
96	36.110	−4162.8	−3608.9	95.23	30.22	52.08	950
98	35.843	−4062.7	−3504.7	96.30	30.00	52.11	937
100	35.574	−3962.7	−3400.5	97.36	29.79	52.14	924
102	35.304	−3862.6	−3296.1	98.39	29.58	52.19	911
104	35.032	−3762.6	−3191.7	99.40	29.38	52.25	898
106	34.759	−3662.5	−3087.1	100.40	29.18	52.32	885
108	34.483	−3562.4	−2982.4	101.38	28.99	52.41	872
110	34.205	−3462.2	−2877.5	102.34	28.81	52.50	859
112	33.925	−3361.9	−2772.4	103.29	28.63	52.61	846
114	33.643	−3261.5	−2667.0	104.22	28.46	52.73	833

TABLE 11. Thermodynamic properties of oxygen – Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			20.0 MPa Isobar – Continued				
116	33.359	−3161.0	−2561.5	105.14	28.29	52.86	820
118	33.072	−3060.4	−2455.6	106.04	28.12	53.00	808
120	32.782	−2959.5	−2349.5	106.93	27.96	53.15	795
122	32.489	−2858.6	−2243.0	107.81	27.80	53.32	782
124	32.194	−2757.4	−2136.2	108.68	27.65	53.50	769
126	31.895	−2656.0	−2029.0	109.54	27.50	53.69	757
128	31.594	−2554.4	−1921.4	110.39	27.36	53.90	744
130	31.289	−2452.6	−1813.4	111.22	27.22	54.12	731
132	30.981	−2350.5	−1704.9	112.05	27.08	54.35	719
134	30.669	−2248.1	−1596.0	112.87	26.95	54.60	706
136	30.353	−2145.4	−1486.5	113.68	26.82	54.86	694
138	30.034	−2042.4	−1376.5	114.49	26.70	55.14	681
140	29.710	−1939.1	−1265.9	115.28	26.58	55.43	669
142	29.383	−1835.4	−1154.7	116.07	26.47	55.74	656
144	29.051	−1731.4	−1042.9	116.85	26.35	56.07	644
146	28.714	−1627.0	−930.5	117.63	26.25	56.41	631
148	28.373	−1522.2	−817.3	118.40	26.14	56.77	619
150	28.028	−1416.9	−703.3	119.16	26.04	57.15	607
152	27.677	−1311.3	−588.6	119.92	25.95	57.55	595
154	27.322	−1205.2	−473.2	120.68	25.86	57.96	583
156	26.961	−1098.6	−356.8	121.43	25.77	58.38	571
158	26.595	−991.6	−239.6	122.17	25.69	58.83	559
160	26.224	−884.2	−121.5	122.92	25.61	59.28	547
162	25.848	−776.2	−2.5	123.66	25.53	59.75	536
164	25.467	−667.8	117.5	124.39	25.46	60.23	524
166	25.080	−559.0	238.5	125.12	25.39	60.72	513
168	24.688	−449.7	360.4	125.85	25.32	61.21	502
170	24.291	−340.0	483.3	126.58	25.26	61.71	492
172	23.889	−230.0	607.2	127.31	25.20	62.19	481
174	23.483	−119.6	732.1	128.03	25.14	62.67	471
176	23.073	−8.9	857.9	128.75	25.08	63.13	461
178	22.659	101.9	984.6	129.46	25.03	63.57	452
180	22.242	212.9	1112.1	130.18	24.97	63.97	442
185	21.191	490.3	1434.1	131.94	24.84	64.76	421
190	20.140	766.0	1759.1	133.67	24.71	65.15	403
195	19.106	1038.0	2084.8	135.37	24.58	65.04	387
200	18.104	1303.9	2408.6	137.00	24.43	64.39	375
205	17.152	1561.8	2727.9	138.58	24.28	63.26	365
210	16.258	1810.4	3040.5	140.09	24.11	61.73	357
215	15.431	2048.7	3344.8	141.52	23.94	59.93	352
220	14.672	2276.5	3639.6	142.88	23.77	58.00	348
225	13.980	2494.1	3924.7	144.16	23.61	56.04	346
230	13.350	2701.9	4200.1	145.37	23.45	54.13	344
235	12.777	2900.9	4466.2	146.51	23.30	52.34	344
240	12.256	3091.8	4723.6	147.60	23.17	50.67	344
245	11.781	3275.4	4973.1	148.63	23.05	49.15	345
250	11.346	3452.6	5215.3	149.60	22.94	47.76	346
255	10.948	3624.1	5451.0	150.54	22.84	46.51	348
260	10.581	3790.5	5680.6	151.43	22.75	45.37	350
265	10.243	3952.4	5904.9	152.28	22.67	44.35	352

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			20.0 MPa Isobar — Continued				
270	9.9303	4110.2	6124.3	153.10	22.60	43.42	354
275	9.6397	4264.5	6339.3	153.89	22.53	42.59	356
280	9.3690	4415.6	6550.3	154.65	22.48	41.83	359
285	9.1162	4563.7	6757.6	155.39	22.43	41.14	361
290	8.8795	4709.4	6961.8	156.10	22.39	40.51	364
295	8.6572	4852.7	7162.9	156.79	22.35	39.94	366
300	8.4481	4993.9	7361.3	157.45	22.32	39.42	369
			25.0 MPa Isobar				
57.17[a]	41.289	−6146.3	−5540.8	67.72	35.68	51.60	1199
58	41.187	−6105.0	−5498.0	68.47	35.50	51.77	1198
60	40.940	−6004.7	−5394.1	70.23	35.13	52.11	1192
62	40.690	−5904.0	−5289.6	71.94	34.82	52.32	1184
64	40.440	−5803.0	−5184.8	73.61	34.55	52.45	1173
66	40.188	−5701.9	−5079.9	75.22	34.28	52.50	1161
68	39.937	−5600.9	−4974.9	76.79	34.02	52.50	1149
70	39.685	−5499.9	−4869.9	78.31	33.75	52.46	1136
72	39.434	−5399.0	−4765.0	79.79	33.48	52.39	1123
74	39.182	−5298.4	−4660.3	81.22	33.21	52.31	1110
76	38.931	−5198.0	−4555.8	82.61	32.94	52.22	1097
78	38.679	−5097.8	−4451.4	83.97	32.67	52.13	1084
80	38.428	−4997.8	−4347.3	85.29	32.41	52.05	1071
82	38.176	−4898.1	−4243.3	86.57	32.15	51.96	1058
84	37.924	−4798.6	−4139.4	87.82	31.89	51.89	1045
86	37.671	−4699.3	−4035.7	89.04	31.64	51.82	1033
88	37.418	−4600.3	−3932.1	90.23	31.39	51.76	1020
90	37.165	−4501.3	−3828.7	91.40	31.15	51.71	1007
92	36.910	−4402.6	−3725.3	92.53	30.92	51.67	995
94	36.655	−4304.0	−3622.0	93.64	30.69	51.65	982
96	36.399	−4205.5	−3518.7	94.73	30.47	51.63	970
98	36.142	−4107.1	−3415.4	95.80	30.25	51.62	957
100	35.884	−4008.9	−3312.2	96.84	30.04	51.63	945
102	35.625	−3910.7	−3208.9	97.86	29.83	51.64	932
104	35.365	−3812.5	−3105.6	98.86	29.63	51.66	920
106	35.103	−3714.4	−3002.3	99.85	29.44	51.70	908
108	34.840	−3616.4	−2898.8	100.82	29.25	51.74	896
110	34.576	−3518.4	−2795.3	101.77	29.06	51.79	884
112	34.310	−3420.3	−2691.7	102.70	28.88	51.85	872
114	34.042	−3322.3	−2587.9	103.62	28.71	51.91	860
116	33.773	−3224.3	−2484.0	104.52	28.54	51.99	848
118	33.501	−3126.2	−2379.9	105.41	28.37	52.08	836
120	33.228	−3028.1	−2275.7	106.29	28.21	52.17	824
122	32.954	−2929.9	−2171.3	107.15	28.05	52.27	812
124	32.677	−2831.7	−2066.6	108.00	27.90	52.38	800
126	32.398	−2733.4	−1961.7	108.84	27.75	52.50	788
128	32.117	−2635.0	−1856.6	109.67	27.60	52.63	777
130	31.833	−2536.5	−1751.2	110.48	27.46	52.76	765
132	31.548	−2438.0	−1645.5	111.29	27.32	52.90	753
134	31.260	−2339.3	−1539.6	112.09	27.19	53.06	742

TABLE 11. Thermodynamic properties of oxygen – Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			25.0 MPa Isobar – Continued				
136	30.970	−2240.6	−1433.3	112.87	27.06	53.21	730
138	30.677	−2141.7	−1326.7	113.65	26.93	53.38	719
140	30.382	−2042.6	−1219.8	114.42	26.81	53.56	708
142	30.085	−1943.5	−1112.5	115.18	26.69	53.74	696
144	29.784	−1844.2	−1004.8	115.94	26.57	53.93	685
146	29.481	−1744.8	−896.8	116.68	26.46	54.13	674
148	29.176	−1645.2	−788.3	117.42	26.35	54.33	663
150	28.867	−1545.5	−679.4	118.15	26.24	54.55	652
152	28.556	−1445.6	−570.1	118.87	26.14	54.76	641
154	28.242	−1345.6	−460.4	119.59	26.04	54.99	631
156	27.926	−1245.4	−350.2	120.30	25.94	55.22	620
158	27.606	−1145.1	−239.5	121.01	25.85	55.46	610
160	27.284	−1044.6	−128.3	121.71	25.76	55.69	599
162	26.959	−944.0	−16.7	122.40	25.67	55.94	589
164	26.632	−843.3	95.4	123.09	25.59	56.18	579
166	26.302	−742.5	208.0	123.77	25.51	56.43	569
168	25.969	−641.6	321.1	124.45	25.43	56.67	559
170	25.634	−540.6	434.7	125.12	25.35	56.91	550
172	25.297	−439.5	548.8	125.79	25.27	57.15	541
174	24.958	−338.4	663.3	126.45	25.20	57.38	532
176	24.616	−237.3	778.3	127.11	25.13	57.60	523
178	24.273	−136.2	893.7	127.76	25.06	57.82	514
180	23.929	−35.2	1009.5	128.40	25.00	58.01	506
185	23.065	216.8	1300.7	130.00	24.84	58.43	486
190	22.199	467.4	1593.6	131.56	24.69	58.69	468
195	21.339	715.7	1887.3	133.09	24.54	58.77	452
200	20.491	960.9	2180.9	134.57	24.40	58.63	437
205	19.664	1201.8	2473.2	136.02	24.27	58.25	425
210	18.864	1437.8	2763.1	137.42	24.13	57.66	415
215	18.096	1668.0	3049.5	138.76	23.99	56.86	406
220	17.367	1891.9	3331.4	140.06	23.86	55.90	399
225	16.677	2109.2	3608.2	141.30	23.72	54.81	393
230	16.029	2319.7	3879.4	142.50	23.60	53.65	389
235	15.422	2523.7	4144.7	143.64	23.47	52.45	386
240	14.856	2721.1	4403.9	144.73	23.35	51.25	383
245	14.329	2912.5	4657.2	145.77	23.25	50.07	382
250	13.837	3098.1	4904.7	146.77	23.14	48.94	381
255	13.380	3278.3	5146.7	147.73	23.05	47.86	380
260	12.954	3453.5	5383.5	148.65	22.96	46.85	380
265	12.556	3624.3	5615.3	149.53	22.88	45.90	381
270	12.185	3790.8	5842.6	150.38	22.81	45.01	382
275	11.838	3953.6	6065.6	151.20	22.75	44.19	383
280	11.512	4112.9	6284.6	151.99	22.69	43.43	384
285	11.207	4269.1	6499.9	152.75	22.64	42.73	385
290	10.919	4422.4	6711.9	153.49	22.60	42.07	387
295	10.649	4573.1	6920.8	154.21	22.56	41.47	389
300	10.393	4721.4	7126.7	154.90	22.52	40.92	390

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			30.0 MPa Isobar				
57.72[a]	41.378	−6137.0	−5411.9	67.86	35.52	51.44	1211
58	41.344	−6123.2	−5397.6	68.11	35.47	51.50	1211
60	41.101	−6024.1	−5294.1	69.86	35.18	51.89	1205
62	40.855	−5924.4	−5190.1	71.57	34.93	52.14	1196
64	40.609	−5824.4	−5085.7	73.23	34.69	52.28	1185
66	40.363	−5724.3	−4981.0	74.84	34.45	52.34	1174
68	40.116	−5624.2	−4876.4	76.40	34.21	52.34	1162
70	39.870	−5524.2	−4771.7	77.92	33.96	52.29	1150
72	39.624	−5424.3	−4667.2	79.39	33.70	52.22	1137
74	39.378	−5324.7	−4562.8	80.82	33.43	52.13	1124
76	39.133	−5225.3	−4458.7	82.21	33.17	52.03	1112
78	38.887	−5126.2	−4354.7	83.56	32.90	51.93	1099
80	38.642	−5027.3	−4251.0	84.87	32.64	51.82	1086
82	38.397	−4928.7	−4147.4	86.15	32.38	51.72	1074
84	38.151	−4830.4	−4044.1	87.39	32.12	51.63	1061
86	37.906	−4732.3	−3940.9	88.61	31.87	51.54	1049
88	37.660	−4634.5	−3837.9	89.79	31.63	51.47	1037
90	37.414	−4536.9	−3735.0	90.95	31.39	51.40	1025
92	37.168	−4439.5	−3632.3	92.08	31.15	51.34	1013
94	36.921	−4342.2	−3529.7	93.18	30.92	51.29	1000
96	36.673	−4245.2	−3427.1	94.26	30.70	51.25	989
98	36.425	−4148.3	−3324.7	95.32	30.48	51.21	977
100	36.176	−4051.6	−3222.3	96.35	30.27	51.19	965
102	35.927	−3955.0	−3119.9	97.36	30.07	51.18	953
104	35.676	−3858.5	−3017.6	98.36	29.87	51.17	941
106	35.425	−3762.1	−2915.2	99.33	29.67	51.17	930
108	35.173	−3665.8	−2812.9	100.29	29.48	51.18	918
110	34.919	−3569.6	−2710.5	101.23	29.30	51.20	907
112	34.665	−3473.5	−2608.1	102.15	29.12	51.22	895
114	34.409	−3377.5	−2505.6	103.06	28.94	51.25	884
116	34.153	−3281.5	−2403.1	103.95	28.77	51.29	872
118	33.895	−3185.5	−2300.4	104.83	28.61	51.33	861
120	33.636	−3089.6	−2197.7	105.69	28.45	51.38	850
122	33.375	−2993.8	−2094.9	106.54	28.29	51.44	839
124	33.113	−2897.9	−1992.0	107.38	28.13	51.50	828
126	32.850	−2802.1	−1888.9	108.20	27.98	51.57	817
128	32.585	−2706.3	−1785.7	109.01	27.84	51.64	806
130	32.319	−2610.5	−1682.3	109.82	27.70	51.72	795
132	32.052	−2514.8	−1578.8	110.61	27.56	51.81	784
134	31.782	−2419.0	−1475.1	111.39	27.42	51.89	773
136	31.512	−2323.2	−1371.2	112.15	27.29	51.99	763
138	31.239	−2227.4	−1267.1	112.91	27.16	52.09	752
140	30.965	−2131.7	−1162.8	113.66	27.04	52.19	742
142	30.690	−2035.9	−1058.4	114.41	26.91	52.30	731
144	30.413	−1940.1	−953.7	115.14	26.79	52.41	721
146	30.134	−1844.3	−848.7	115.86	26.68	52.52	711
148	29.854	−1748.5	−743.6	116.58	26.57	52.64	701
150	29.571	−1652.7	−638.2	117.28	26.46	52.76	691
152	29.288	−1556.9	−532.5	117.98	26.35	52.88	681
154	29.002	−1461.0	−426.6	118.68	26.25	53.01	671

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			30.0 MPa Isobar — Continued				
156	28.716	−1365.2	−320.5	119.36	26.14	53.14	661
158	28.427	−1269.4	−214.1	120.04	26.05	53.27	652
160	28.137	−1173.6	−107.4	120.71	25.95	53.40	642
162	27.846	−1077.9	−.5	121.37	25.86	53.53	633
164	27.553	−982.1	106.7	122.03	25.77	53.66	624
166	27.258	−886.4	214.1	122.68	25.68	53.79	615
168	26.963	−790.8	321.9	123.33	25.59	53.92	606
170	26.666	−695.2	429.8	123.97	25.51	54.04	598
172	26.368	−599.7	538.0	124.60	25.43	54.17	589
174	26.069	−504.3	646.5	125.23	25.35	54.28	581
176	25.770	−409.0	755.2	125.85	25.27	54.39	573
178	25.469	−313.8	864.1	126.46	25.20	54.50	565
180	25.168	−218.8	973.2	127.07	25.12	54.60	557
185	24.415	17.9	1246.7	128.57	24.95	54.80	538
190	23.662	253.1	1521.0	130.03	24.78	54.92	521
195	22.912	486.4	1795.7	131.46	24.63	54.96	505
200	22.171	717.3	2070.4	132.85	24.48	54.88	491
205	21.441	945.2	2344.4	134.20	24.34	54.69	478
210	20.727	1169.7	2617.1	135.52	24.20	54.38	466
215	20.033	1390.4	2887.9	136.79	24.07	53.94	456
220	19.361	1606.8	3156.3	138.03	23.95	53.40	448
225	18.714	1818.7	3421.8	139.22	23.83	52.76	440
230	18.094	2025.9	3683.8	140.37	23.71	52.05	434
235	17.503	2228.2	3942.2	141.48	23.60	51.27	429
240	16.941	2425.6	4196.5	142.56	23.49	50.46	424
245	16.408	2618.3	4446.7	143.59	23.39	49.63	421
250	15.903	2806.3	4692.8	144.58	23.30	48.79	418
255	15.426	2989.8	4934.6	145.54	23.21	47.95	416
260	14.975	3169.0	5172.3	146.46	23.13	47.14	414
265	14.549	3344.1	5406.1	147.35	23.05	46.35	413
270	14.148	3515.4	5635.9	148.21	22.98	45.60	413
275	13.768	3683.2	5862.1	149.04	22.92	44.88	412
280	13.410	3847.6	6084.8	149.84	22.86	44.19	412
285	13.071	4009.0	6304.1	150.62	22.81	43.55	413
290	12.750	4167.4	6520.3	151.37	22.76	42.94	413
295	12.446	4323.2	6733.6	152.10	22.72	42.37	414
300	12.158	4476.6	6944.0	152.81	22.68	41.83	415
			35.0 MPa Isobar				
58.27[a]	41.465	−6127.6	−5283.5	68.00	35.41	51.32	1222
60	41.257	−6042.5	−5194.2	69.51	35.23	51.68	1217
62	41.016	−5943.8	−5090.5	71.21	35.03	51.96	1208
64	40.775	−5844.8	−4986.4	72.86	34.83	52.12	1198
66	40.533	−5745.6	−4882.1	74.46	34.62	52.19	1186
68	40.291	−5646.3	−4777.7	76.02	34.39	52.20	1175
70	40.049	−5547.2	−4673.3	77.53	34.15	52.15	1162
72	39.808	−5448.3	−4569.1	79.00	33.90	52.07	1150
74	39.568	−5349.6	−4465.0	80.43	33.64	51.97	1138
76	39.327	−5251.2	−4361.2	81.81	33.38	51.86	1126

TABLE 11. Thermodynamic properties of oxygen – Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			35.0 MPa Isobar – Continued				
78	39.088	−5153.0	−4257.6	83.16	33.12	51.75	1113
80	38.848	−5055.2	−4154.2	84.47	32.86	51.63	1101
82	38.609	−4957.6	−4051.1	85.74	32.60	51.52	1089
84	38.370	−4860.3	−3948.1	86.98	32.35	51.41	1077
86	38.130	−4763.3	−3845.4	88.19	32.09	51.31	1065
88	37.891	−4666.6	−3742.9	89.37	31.85	51.21	1053
90	37.652	−4570.1	−3640.6	90.52	31.61	51.12	1041
92	37.413	−4473.9	−3538.4	91.64	31.37	51.05	1030
94	37.173	−4377.9	−3436.4	92.74	31.15	50.98	1018
96	36.933	−4282.2	−3334.5	93.81	30.92	50.92	1007
98	36.693	−4186.6	−3232.7	94.86	30.71	50.86	995
100	36.452	−4091.2	−3131.0	95.89	30.50	50.82	984
102	36.211	−3996.0	−3029.4	96.89	30.29	50.78	973
104	35.969	−3901.0	−2927.9	97.88	30.09	50.75	961
106	35.727	−3806.1	−2826.4	98.84	29.90	50.73	950
108	35.484	−3711.3	−2725.0	99.79	29.71	50.71	939
110	35.241	−3616.7	−2623.6	100.72	29.52	50.70	928
112	34.996	−3522.3	−2522.2	101.64	29.34	50.70	917
114	34.751	−3427.9	−2420.8	102.53	29.17	50.70	906
116	34.505	−3333.7	−2319.3	103.42	29.00	50.71	896
118	34.259	−3239.6	−2217.9	104.28	28.83	50.72	885
120	34.011	−3145.5	−2116.4	105.14	28.67	50.74	874
122	33.763	−3051.6	−2014.9	105.97	28.51	50.77	864
124	33.513	−2957.7	−1913.4	106.80	28.36	50.79	853
126	33.263	−2864.0	−1811.8	107.61	28.21	50.82	843
128	33.012	−2770.3	−1710.1	108.41	28.06	50.86	833
130	32.759	−2676.7	−1608.3	109.20	27.92	50.90	822
132	32.506	−2583.2	−1506.5	109.98	27.78	50.94	812
134	32.252	−2489.8	−1404.6	110.75	27.64	50.99	802
136	31.997	−2396.4	−1302.5	111.50	27.51	51.04	792
138	31.741	−2303.1	−1200.4	112.25	27.38	51.09	782
140	31.483	−2209.9	−1098.2	112.98	27.25	51.14	772
142	31.225	−2116.7	−995.8	113.71	27.13	51.20	763
144	30.966	−2023.7	−893.4	114.43	27.01	51.26	753
146	30.706	−1930.7	−790.8	115.13	26.89	51.32	743
148	30.445	−1837.7	−688.1	115.83	26.78	51.38	734
150	30.182	−1744.9	−585.3	116.52	26.67	51.45	725
152	29.919	−1652.1	−482.3	117.20	26.56	51.51	716
154	29.655	−1559.5	−379.2	117.88	26.45	51.58	706
156	29.390	−1466.9	−276.0	118.54	26.35	51.65	697
158	29.124	−1374.4	−172.6	119.20	26.25	51.72	689
160	28.857	−1282.0	−69.1	119.85	26.15	51.78	680
162	28.590	−1189.7	34.5	120.50	26.05	51.85	671
164	28.321	−1097.5	138.3	121.13	25.96	51.92	663
166	28.052	−1005.5	242.2	121.76	25.86	51.98	654
168	27.783	−913.5	346.2	122.39	25.78	52.05	646
170	27.513	−821.8	450.4	123.00	25.69	52.11	638
172	27.242	−730.1	554.6	123.61	25.60	52.16	630
174	26.971	−638.7	659.0	124.22	25.52	52.22	622
176	26.700	−547.4	763.5	124.81	25.44	52.27	615

TABLE 11. Thermodynamic properties of oxygen – Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			35.0 MPa Isobar – Continued				
178	26.428	−456.2	868.1	125.40	25.36	52.32	607
180	26.156	−365.3	972.8	125.99	25.28	52.36	600
185	25.477	−139.0	1234.8	127.42	25.10	52.43	583
190	24.800	85.8	1497.1	128.82	24.93	52.47	566
195	24.127	308.7	1759.4	130.19	24.76	52.45	551
200	23.460	529.5	2021.4	131.51	24.61	52.36	537
205	22.802	747.9	2282.9	132.80	24.46	52.21	524
210	22.155	963.6	2543.4	134.06	24.32	51.99	512
215	21.521	1176.3	2802.7	135.28	24.19	51.70	502
220	20.902	1385.8	3060.3	136.46	24.07	51.34	492
225	20.302	1591.9	3315.9	137.61	23.95	50.91	484
230	19.720	1794.4	3569.3	138.73	23.83	50.42	476
235	19.158	1993.2	3820.1	139.81	23.72	49.89	470
240	18.618	2188.2	4068.1	140.85	23.62	49.31	464
245	18.099	2379.4	4313.2	141.86	23.52	48.71	459
250	17.602	2566.8	4555.2	142.84	23.43	48.09	455
255	17.127	2750.5	4794.1	143.78	23.35	47.46	452
260	16.674	2930.7	5029.8	144.70	23.27	46.83	449
265	16.241	3107.3	5262.3	145.59	23.19	46.20	447
270	15.829	3280.7	5491.8	146.44	23.13	45.58	445
275	15.437	3450.8	5718.2	147.27	23.06	44.98	443
280	15.062	3617.9	5941.6	148.08	23.00	44.40	442
285	14.706	3782.2	6162.2	148.86	22.95	43.84	442
290	14.367	3943.8	6380.0	149.62	22.90	43.30	441
295	14.043	4102.8	6595.2	150.35	22.86	42.78	441
300	13.734	4259.5	6807.8	151.07	22.82	42.29	441
			40.0 MPa Isobar				
58.81[a]	41.551	−6118.0	−5155.4	68.13	35.36	51.23	1233
60	41.410	−6060.1	−5094.1	69.16	35.28	51.49	1229
62	41.173	−5962.3	−4990.8	70.85	35.13	51.81	1220
64	40.935	−5864.2	−4887.0	72.50	34.96	51.98	1210
66	40.697	−5765.8	−4782.9	74.10	34.78	52.06	1199
68	40.460	−5667.4	−4678.8	75.65	34.56	52.07	1187
70	40.223	−5569.1	−4574.7	77.16	34.34	52.02	1175
72	39.987	−5471.1	−4470.7	78.63	34.09	51.94	1163
74	39.751	−5373.2	−4366.9	80.05	33.84	51.84	1151
76	39.516	−5275.6	−4263.4	81.43	33.59	51.72	1139
78	39.281	−5178.4	−4160.1	82.77	33.33	51.59	1127
80	39.047	−5081.4	−4057.0	84.08	33.07	51.46	1115
82	38.813	−4984.8	−3954.2	85.35	32.81	51.34	1104
84	38.579	−4888.5	−3851.7	86.58	32.55	51.21	1092
86	38.346	−4792.5	−3749.4	87.79	32.30	51.10	1080
88	38.113	−4696.8	−3647.3	88.96	32.06	50.99	1069
90	37.880	−4601.4	−3545.4	90.10	31.82	50.89	1058
92	37.647	−4506.3	−3443.8	91.22	31.58	50.79	1046
94	37.414	−4411.4	−3342.3	92.31	31.36	50.71	1035
96	37.181	−4316.7	−3240.9	93.38	31.13	50.63	1024
98	36.948	−4222.3	−3139.7	94.42	30.92	50.56	1013
100	36.714	−4128.2	−3038.7	95.44	30.71	50.50	1002
102	36.481	−4034.2	−2937.7	96.44	30.50	50.44	991
104	36.247	−3940.5	−2836.9	97.42	30.30	50.39	981
106	36.012	−3846.9	−2736.2	98.38	30.11	50.35	970

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			40.0 MPa Isobar — Continued				
108	35.778	−3753.5	−2635.5	99.32	29.92	50.32	959
110	35.543	−3660.3	−2534.9	100.24	29.73	50.29	949
112	35.307	−3567.3	−2434.3	101.15	29.55	50.26	938
114	35.071	−3474.4	−2333.8	102.04	29.38	50.24	928
116	34.834	−3381.7	−2233.4	102.91	29.21	50.23	918
118	34.597	−3289.1	−2132.9	103.77	29.04	50.21	907
120	34.360	−3196.7	−2032.5	104.62	28.88	50.21	897
122	34.122	−3104.4	−1932.1	105.45	28.72	50.21	887
124	33.883	−3012.2	−1831.7	106.26	28.57	50.21	877
126	33.644	−2920.2	−1731.3	107.07	28.42	50.21	867
128	33.404	−2828.3	−1630.9	107.86	28.27	50.22	858
130	33.163	−2736.6	−1530.4	108.64	28.13	50.23	848
132	32.922	−2644.9	−1429.9	109.40	27.99	50.24	838
134	32.680	−2553.4	−1329.4	110.16	27.85	50.26	829
136	32.438	−2462.0	−1228.9	110.90	27.72	50.27	819
138	32.195	−2370.8	−1128.3	111.64	27.59	50.29	810
140	31.951	−2279.7	−1027.7	112.36	27.46	50.31	800
142	31.707	−2188.6	−927.1	113.07	27.34	50.34	791
144	31.462	−2097.8	−826.4	113.78	27.21	50.36	782
146	31.217	−2007.0	−725.6	114.47	27.10	50.39	773
148	30.971	−1916.4	−624.9	115.16	26.98	50.41	764
150	30.724	−1825.9	−524.0	115.84	26.87	50.44	755
152	30.477	−1735.5	−423.1	116.50	26.76	50.47	747
154	30.230	−1645.3	−322.1	117.16	26.65	50.50	738
156	29.982	−1555.3	−221.1	117.82	26.54	50.52	730
158	29.733	−1465.3	−120.0	118.46	26.44	50.55	721
160	29.484	−1375.6	−18.9	119.10	26.34	50.58	713
162	29.235	−1285.9	82.3	119.72	26.24	50.61	705
164	28.985	−1196.5	183.5	120.34	26.15	50.63	697
166	28.735	−1107.2	284.8	120.96	26.05	50.66	689
168	28.485	−1018.1	386.1	121.57	25.96	50.68	682
170	28.235	−929.2	487.5	122.17	25.87	50.70	674
172	27.984	−840.4	589.0	122.76	25.78	50.72	667
174	27.734	−751.9	690.4	123.35	25.70	50.74	659
176	27.484	−663.5	791.9	123.93	25.62	50.75	652
178	27.233	−575.4	893.4	124.50	25.54	50.76	645
180	26.983	−487.5	994.9	125.07	25.46	50.77	638
185	26.358	−268.8	1248.8	126.46	25.27	50.77	622
190	25.737	−51.7	1502.5	127.81	25.09	50.74	606
195	25.119	163.7	1756.1	129.13	24.92	50.67	591
200	24.507	377.0	2009.2	130.41	24.76	50.57	577
205	23.903	588.3	2261.7	131.66	24.60	50.43	565
210	23.307	797.1	2513.4	132.87	24.46	50.24	553
215	22.721	1003.5	2764.0	134.05	24.33	50.00	542
220	22.147	1207.3	3013.3	135.19	24.20	49.72	532
225	21.587	1408.2	3261.1	136.31	24.08	49.40	523
230	21.041	1606.2	3507.2	137.39	23.96	49.03	515
235	20.510	1801.2	3751.4	138.44	23.85	48.63	508
240	19.996	1993.1	3993.5	139.46	23.75	48.20	502
245	19.498	2181.9	4233.4	140.45	23.65	47.74	496

TABLE 11. Thermodynamic properties of oxygen – Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			45.0 MPa Isobar – Continued				
250	19.018	2367.6	4470.9	141.41	23.56	47.26	491
255	18.555	2550.2	4706.0	142.34	23.48	46.77	487
260	18.109	2729.8	4938.6	143.24	23.40	46.27	483
265	17.681	2906.4	5168.7	144.12	23.32	45.77	480
270	17.270	3080.1	5396.3	144.97	23.26	45.27	477
275	16.875	3251.0	5621.4	145.80	23.19	44.77	474
280	16.497	3419.3	5844.0	146.60	23.13	44.28	473
285	16.134	3584.9	6064.2	147.38	23.08	43.80	471
290	15.786	3748.1	6282.1	148.14	23.03	43.34	470
295	15.452	3909.0	6497.6	148.87	22.99	42.89	469
300	15.133	4067.7	6711.0	149.59	22.95	42.45	468
			45.0 MPa Isobar				
59.35[a]	41.635	−6108.4	−5027.6	68.25	35.35	51.17	1243
60	41.559	−6076.9	−4994.1	68.82	35.32	51.32	1241
62	41.326	−5980.0	−4891.1	70.51	35.22	51.66	1232
64	41.092	−5882.6	−4787.5	72.15	35.09	51.86	1222
66	40.858	−5785.1	−4683.7	73.75	34.92	51.95	1211
68	40.625	−5687.5	−4579.8	75.30	34.73	51.96	1199
70	40.392	−5590.0	−4475.9	76.80	34.51	51.91	1188
72	40.160	−5492.7	−4372.2	78.26	34.28	51.83	1176
74	39.929	−5395.6	−4268.6	79.68	34.03	51.71	1164
76	39.698	−5298.9	−4165.3	81.06	33.78	51.59	1153
78	39.468	−5202.4	−4062.3	82.40	33.52	51.45	1141
80	39.239	−5106.3	−3959.5	83.70	33.26	51.31	1130
82	39.010	−5010.6	−3857.0	84.96	33.01	51.18	1118
84	38.782	−4915.2	−3754.8	86.20	32.75	51.04	1107
86	38.554	−4820.1	−3652.9	87.40	32.50	50.91	1096
88	38.326	−4725.3	−3551.1	88.56	32.26	50.79	1084
90	38.099	−4630.8	−3449.7	89.70	32.02	50.68	1073
92	37.872	−4536.7	−3348.4	90.82	31.78	50.57	1063
94	37.645	−4442.8	−3247.4	91.90	31.55	50.47	1052
96	37.418	−4349.2	−3146.5	92.97	31.33	50.38	1041
98	37.191	−4255.8	−3045.9	94.00	31.12	50.30	1030
100	36.964	−4162.8	−2945.4	95.02	30.90	50.22	1020
102	36.737	−4069.9	−2845.0	96.01	30.70	50.15	1009
104	36.510	−3977.3	−2744.8	96.99	30.50	50.08	999
106	36.283	−3884.9	−2644.7	97.94	30.30	50.03	989
108	36.055	−3792.7	−2544.7	98.87	30.12	49.97	978
110	35.828	−3700.8	−2444.8	99.79	29.93	49.93	968
112	35.600	−3609.0	−2345.0	100.69	29.75	49.88	958
114	35.372	−3517.4	−2245.2	101.57	29.58	49.85	948
116	35.144	−3426.0	−2145.6	102.44	29.41	49.81	938
118	34.915	−3334.8	−2046.0	103.29	29.24	49.78	929
120	34.686	−3243.8	−1946.4	104.13	29.08	49.76	919
122	34.457	−3152.9	−1846.9	104.95	28.92	49.73	909
124	34.227	−3062.2	−1747.5	105.76	28.77	49.71	900
126	33.998	−2971.7	−1648.1	106.55	28.61	49.70	890
128	33.767	−2881.4	−1548.7	107.34	28.47	49.68	881
130	33.537	−2791.2	−1449.3	108.11	28.32	49.67	872
132	33.306	−2701.1	−1350.0	108.86	28.18	49.66	862
134	33.075	−2611.3	−1250.7	109.61	28.05	49.65	853
136	32.843	−2521.6	−1151.4	110.35	27.91	49.65	844

TABLE 11. Thermodynamic properties of oxygen – Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			45.0 MPa Isobar – Continued				
138	32.611	−2432.0	−1052.1	111.07	27.78	49.64	835
140	32.379	−2342.6	−952.8	111.79	27.66	49.64	826
142	32.146	−2253.4	−853.5	112.49	27.53	49.64	818
144	31.913	−2164.3	−754.3	113.18	27.41	49.64	809
146	31.680	−2075.4	−655.0	113.87	27.29	49.64	801
148	31.447	−1986.7	−555.7	114.54	27.17	49.64	792
150	31.213	−1898.2	−456.4	115.21	27.06	49.64	784
152	30.979	−1809.8	−357.2	115.87	26.95	49.64	775
154	30.745	−1721.5	−257.9	116.52	26.84	49.64	767
156	30.511	−1633.5	−158.6	117.16	26.73	49.64	759
158	30.276	−1545.6	−59.3	117.79	26.63	49.64	751
160	30.041	−1458.0	40.0	118.41	26.53	49.64	744
162	29.807	−1370.5	139.2	119.03	26.43	49.64	736
164	29.572	−1283.2	238.5	119.64	26.33	49.64	728
166	29.337	−1196.1	337.8	120.24	26.23	49.64	721
168	29.102	−1109.2	437.1	120.84	26.14	49.63	714
170	28.867	−1022.5	536.3	121.42	26.05	49.63	706
172	28.633	−936.0	635.6	122.00	25.96	49.62	699
174	28.398	−849.8	734.8	122.58	25.88	49.61	692
176	28.164	−763.7	834.0	123.14	25.79	49.60	686
178	27.930	−677.9	933.2	123.70	25.71	49.59	679
180	27.696	−592.4	1032.4	124.26	25.63	49.57	672
185	27.114	−379.5	1280.1	125.62	25.43	49.52	656
190	26.535	−168.3	1527.6	126.94	25.25	49.45	641
195	25.960	41.2	1774.6	128.22	25.07	49.35	627
200	25.390	248.8	2021.1	129.47	24.91	49.23	614
205	24.827	454.4	2266.9	130.68	24.75	49.08	601
210	24.272	657.9	2511.9	131.86	24.61	48.91	590
215	23.725	859.2	2755.9	133.01	24.47	48.70	579
220	23.188	1058.1	2998.8	134.13	24.34	48.46	569
225	22.662	1254.7	3240.4	135.21	24.21	48.19	560
230	22.147	1448.7	3480.6	136.27	24.09	47.89	551
235	21.645	1640.2	3719.3	137.30	23.98	47.57	544
240	21.155	1829.1	3956.3	138.29	23.88	47.22	537
245	20.679	2015.4	4191.5	139.26	23.78	46.85	531
250	20.218	2199.0	4424.8	140.21	23.69	46.47	525
255	19.770	2379.9	4656.1	141.12	23.60	46.07	520
260	19.337	2558.3	4885.5	142.01	23.52	45.66	515
265	18.918	2734.1	5112.8	142.88	23.45	45.25	511
270	18.514	2907.3	5338.0	143.72	23.38	44.84	508
275	18.123	3078.1	5561.1	144.54	23.31	44.42	505
280	17.747	3246.5	5782.2	145.34	23.25	44.01	502
285	17.384	3412.6	6001.2	146.11	23.20	43.60	500
290	17.035	3576.5	6218.2	146.87	23.15	43.20	498
295	16.698	3738.3	6433.2	147.60	23.10	42.81	497
300	16.374	3898.0	6646.3	148.32	23.06	42.43	495

TABLE 11. Thermodynamic properties of oxygen – Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			50.0 MPa Isobar				
59.88[a]	41.719	−6098.6	−4900.1	68.38	35.36	51.13	1253
60	41.705	−6092.9	−4894.0	68.48	35.36	51.16	1252
62	41.475	−5996.8	−4791.3	70.17	35.31	51.53	1243
64	41.245	−5900.3	−4688.0	71.81	35.21	51.75	1233
66	41.014	−5803.5	−4584.4	73.40	35.06	51.84	1223
68	40.785	−5706.6	−4480.7	74.95	34.89	51.86	1212
70	40.556	−5609.8	−4377.0	76.45	34.68	51.81	1200
72	40.328	−5513.3	−4273.4	77.91	34.45	51.72	1189
74	40.101	−5417.0	−4170.1	79.33	34.21	51.61	1177
76	39.875	−5320.9	−4067.0	80.70	33.96	51.47	1166
78	39.649	−5225.3	−3964.2	82.04	33.71	51.33	1155
80	39.424	−5130.0	−3861.7	83.33	33.45	51.18	1143
82	39.200	−5035.0	−3759.5	84.59	33.19	51.04	1132
84	38.977	−4940.4	−3657.6	85.82	32.94	50.89	1121
86	38.754	−4846.1	−3555.9	87.02	32.69	50.75	1110
88	38.531	−4752.2	−3454.5	88.18	32.45	50.62	1099
90	38.309	−4658.6	−3353.4	89.32	32.21	50.50	1089
92	38.087	−4565.3	−3252.6	90.43	31.97	50.38	1078
94	37.866	−4472.4	−3151.9	91.51	31.74	50.27	1068
96	37.645	−4379.7	−3051.5	92.57	31.52	50.16	1057
98	37.424	−4287.3	−2951.3	93.60	31.30	50.06	1047
100	37.203	−4195.2	−2851.2	94.61	31.09	49.97	1037
102	36.982	−4103.4	−2751.4	95.60	30.89	49.89	1027
104	36.761	−4011.8	−2651.7	96.57	30.69	49.81	1017
106	36.540	−3920.5	−2552.1	97.52	30.49	49.74	1007
108	36.319	−3829.4	−2452.7	98.45	30.30	49.68	997
110	36.099	−3738.5	−2353.4	99.36	30.12	49.61	987
112	35.878	−3647.9	−2254.2	100.25	29.94	49.56	977
114	35.657	−3557.4	−2155.2	101.13	29.76	49.50	968
116	35.436	−3467.2	−2056.2	101.99	29.59	49.46	958
118	35.215	−3377.2	−1957.3	102.83	29.43	49.41	949
120	34.993	−3287.4	−1858.6	103.66	29.26	49.37	939
122	34.772	−3197.8	−1759.8	104.48	29.11	49.33	930
124	34.551	−3108.4	−1661.2	105.28	28.95	49.30	921
126	34.329	−3019.2	−1562.7	106.07	28.80	49.26	912
128	34.107	−2930.1	−1464.2	106.84	28.65	49.23	903
130	33.885	−2841.3	−1365.7	107.61	28.51	49.20	894
132	33.663	−2752.7	−1267.4	108.36	28.37	49.18	885
134	33.441	−2664.2	−1169.0	109.10	28.23	49.15	876
136	33.219	−2575.9	−1070.8	109.83	28.10	49.13	868
138	32.996	−2487.9	−972.5	110.54	27.97	49.10	859
140	32.774	−2400.0	−874.3	111.25	27.84	49.08	851
142	32.551	−2312.3	−776.2	111.95	27.71	49.06	842
144	32.328	−2224.7	−678.1	112.63	27.59	49.04	834
146	32.105	−2137.4	−580.0	113.31	27.47	49.02	826
148	31.882	−2050.3	−482.0	113.97	27.35	49.00	818
150	31.659	−1963.3	−384.0	114.63	27.24	48.98	810
152	31.436	−1876.6	−286.1	115.28	27.13	48.97	802
154	31.213	−1790.0	−188.2	115.92	27.02	48.95	794
156	30.990	−1703.7	−90.3	116.55	26.91	48.93	787

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			50.0 MPa Isobar — Continued				
158	30.767	−1617.5	7.6	117.18	26.81	48.91	779
160	30.544	−1531.6	105.4	117.79	26.70	48.89	772
162	30.322	−1445.9	203.1	118.40	26.60	48.87	764
164	30.099	−1360.3	300.8	119.00	26.50	48.85	757
166	29.876	−1275.0	398.5	119.59	26.41	48.83	750
168	29.654	−1189.9	496.2	120.17	26.31	48.81	743
170	29.432	−1105.1	593.7	120.75	26.22	48.78	736
172	29.210	−1020.4	691.3	121.32	26.13	48.76	729
174	28.989	−936.0	788.8	121.89	26.04	48.73	723
176	28.767	−851.9	886.2	122.44	25.96	48.70	716
178	28.547	−767.9	983.6	122.99	25.87	48.67	710
180	28.326	−684.2	1080.9	123.54	25.79	48.64	703
185	27.777	−476.1	1323.9	124.87	25.59	48.56	688
190	27.232	−269.6	1566.4	126.16	25.40	48.45	674
195	26.691	−64.8	1808.4	127.42	25.23	48.33	660
200	26.156	138.1	2049.8	128.64	25.06	48.20	647
205	25.626	339.2	2290.4	129.83	24.90	48.04	635
210	25.104	538.4	2530.2	130.98	24.75	47.87	623
215	24.588	735.5	2769.0	132.11	24.61	47.67	613
220	24.082	930.6	3006.8	133.20	24.47	47.45	603
225	23.584	1123.4	3243.5	134.27	24.35	47.21	593
230	23.096	1314.1	3478.9	135.30	24.23	46.96	585
235	22.618	1502.5	3713.0	136.31	24.11	46.68	577
240	22.152	1688.6	3945.7	137.29	24.01	46.39	570
245	21.697	1872.4	4176.9	138.24	23.91	46.08	563
250	21.253	2053.8	4406.5	139.17	23.81	45.75	557
255	20.821	2233.0	4634.4	140.07	23.72	45.42	551
260	20.402	2409.9	4860.6	140.95	23.64	45.08	546
265	19.995	2584.5	5085.2	141.81	23.56	44.73	542
270	19.600	2756.9	5307.9.	142.64	23.49	44.38	538
275	19.217	2927.0	5528.9	143.45	23.43	44.02	534
280	18.846	3095.1	5748.2	144.24	23.36	43.67	531
285	18.487	3261.1	5965.7	145.01	23.31	43.32	528
290	18.140	3425.0	6181.4	145.76	23.26	42.97	526
295	17.804	3587.1	6395.4	146.49	23.21	42.63	524
300	17.480	3747.3	6607.7	147.20	23.16	42.30	522
			60.0 MPa Isobar				
60.94[a]	41.882	−6078.6	−4646.0	68.63	35.46	51.10	1272
62	41.763	−6028.3	−4591.6	69.51	35.47	51.30	1267
64	41.539	−5933.2	−4488.8	71.14	35.43	51.55	1257
66	41.316	−5837.8	−4385.5	72.73	35.33	51.67	1246
68	41.093	−5742.3	−4282.2	74.28	35.18	51.69	1235
70	40.872	−5646.8	−4178.8	75.77	34.99	51.65	1224
72	40.651	−5551.6	−4075.6	77.23	34.78	51.56	1213
74	40.432	−5456.6	−3972.6	78.64	34.55	51.43	1202
76	40.213	−5361.9	−3869.9	80.01	34.30	51.29	1192
78	39.996	−5267.6	−3767.5	81.34	34.05	51.13	1181
80	39.779	−5173.7	−3665.4	82.63	33.80	50.97	1170
82	39.563	−5080.1	−3563.6	83.89	33.55	50.81	1159
84	39.348	−4987.0	−3462.1	85.11	33.29	50.65	1149
86	39.134	−4894.2	−3361.0	86.30	33.04	50.49	1139
88	38.921	−4801.8	−3260.2	87.46	32.80	50.34	1128

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			60.0 MPa Isobar — Continued				
90	38.708	−4709.7	−3159.6	88.59	32.56	50.19	1118
92	38.495	−4618.0	−3059.4	89.69	32.32	50.05	1108
94	38.284	−4526.7	−2959.4	90.76	32.09	49.92	1098
96	38.072	−4435.7	−2859.7	91.81	31.87	49.80	1089
98	37.861	−4345.0	−2760.2	92.84	31.65	49.68	1079
100	37.651	−4254.6	−2661.0	93.84	31.44	49.57	1069
102	37.440	−4164.5	−2561.9	94.82	31.23	49.47	1060
104	37.231	−4074.7	−2463.1	95.78	31.03	49.37	1050
106	37.021	−3985.2	−2364.5	96.72	30.84	49.27	1041
108	36.811	−3895.9	−2266.0	97.64	30.65	49.19	1032
110	36.602	−3807.0	−2167.7	98.54	30.46	49.10	1022
112	36.393	−3718.2	−2069.6	99.43	30.28	49.02	1013
114	36.185	−3629.8	−1971.6	100.30	30.11	48.95	1004
116	35.976	−3541.6	−1873.8	101.15	29.94	48.88	996
118	35.768	−3453.6	−1776.1	101.98	29.77	48.81	987
120	35.559	−3365.9	−1678.5	102.80	29.61	48.75	978
122	35.351	−3278.4	−1581.1	103.61	29.45	48.68	969
124	35.143	−3191.1	−1483.8	104.40	29.29	48.62	961
126	34.935	−3104.1	−1386.6	105.17	29.14	48.57	952
128	34.728	−3017.3	−1289.5	105.94	29.00	48.51	944
130	34.520	−2930.7	−1192.6	106.69	28.85	48.46	936
132	34.313	−2844.3	−1095.7	107.43	28.71	48.41	927
134	34.105	−2758.2	−998.9	108.16	28.57	48.36	919
136	33.898	−2672.3	−902.3	108.87	28.44	48.31	911
138	33.691	−2586.6	−805.7	109.58	28.31	48.26	903
140	33.484	−2501.1	−709.2	110.27	28.18	48.21	896
142	33.278	−2415.9	−612.9	110.96	28.05	48.16	888
144	33.071	−2330.9	−516.6	111.63	27.93	48.12	880
146	32.865	−2246.1	−420.4	112.29	27.81	48.07	873
148	32.659	−2161.5	−324.3	112.95	27.69	48.03	865
150	32.453	−2077.1	−228.3	113.59	27.57	47.98	858
152	32.247	−1993.0	−132.4	114.23	27.46	47.94	851
154	32.042	−1909.1	−36.5	114.85	27.35	47.89	843
156	31.837	−1825.4	59.2	115.47	27.24	47.85	836
158	31.632	−1741.9	154.9	116.08	27.13	47.81	829
160	31.428	−1658.7	250.4	116.68	27.03	47.76	822
162	31.224	−1575.7	345.9	117.27	26.93	47.72	816
164	31.020	−1493.0	441.3	117.86	26.83	47.67	809
166	30.816	−1410.4	536.6	118.44	26.73	47.62	802
168	30.613	−1328.1	631.8	119.01	26.63	47.58	796
170	30.411	−1246.1	726.9	119.57	26.54	47.53	789
172	30.208	−1164.3	821.9	120.13	26.45	47.48	783
174	30.007	−1082.7	916.8	120.67	26.36	47.43	777
176	29.805	−1001.4	1011.7	121.22	26.27	47.38	771
178	29.605	−920.3	1106.4	121.75	26.18	47.33	765
180	29.405	−839.5	1201.0	122.28	26.10	47.28	759
185	28.907	−638.6	1437.1	123.57	25.89	47.15	745
190	28.413	−439.2	1672.5	124.83	25.70	47.01	731
195	27.924	−241.6	1907.2	126.05	25.52	46.86	718
200	27.439	−45.6	2141.1	127.23	25.34	46.70	706

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			60.0 MPa Isobar — Continued				
205	26.960	148.7	2374.2	128.38	25.18	46.54	694
210	26.487	341.2	2606.4	129.50	25.02	46.36	683
215	26.021	531.9	2837.7	130.59	24.87	46.17	673
220	25.561	720.8	3068.1	131.65	24.73	45.97	663
225	25.108	907.8	3297.4	132.68	24.60	45.76	654
230	24.664	1093.0	3525.7	133.69	24.48	45.55	645
235	24.227	1276.3	3752.9	134.66	24.36	45.32	637
240	23.798	1457.7	3978.9	135.61	24.25	45.08	629
245	23.378	1637.2	4203.7	136.54	24.14	44.84	622
250	22.967	1814.8	4427.2	137.44	24.04	44.58	616
255	22.565	1990.5	4649.5	138.32	23.95	44.32	610
260	22.172	2164.4	4870.5	139.18	23.86	44.06	604
265	21.789	2336.4	5090.1	140.02	23.78	43.79	599
270	21.414	2506.5	5308.4	140.84	23.71	43.52	594
275	21.050	2674.9	5525.3	141.63	23.64	43.25	590
280	20.694	2841.6	5740.9	142.41	23.57	42.98	586
285	20.348	3006.5	5955.1	143.17	23.51	42.71	582
290	20.012	3169.7	6168.0	143.91	23.45	42.44	579
295	19.684	3331.3	6379.5	144.63	23.40	42.17	576
300	19.365	3491.4	6589.7	145.34	23.35	41.90	573
			70.0 MPa Isobar				
61.98[a]	42.040	−6058.0	−4392.9	68.87	35.61	51.10	1290
62	42.038	−6057.2	−4392.0	68.88	35.61	51.10	1290
64	41.820	−5963.3	−4289.5	70.51	35.63	51.39	1280
66	41.603	−5869.1	−4186.5	72.09	35.57	51.53	1269
68	41.387	−5774.8	−4083.4	73.63	35.44	51.57	1259
70	41.172	−5680.5	−3980.3	75.13	35.28	51.52	1248
72	40.958	−5586.5	−3877.4	76.58	35.08	51.43	1238
74	40.745	−5492.7	−3774.6	77.98	34.86	51.30	1227
76	40.533	−5399.2	−3672.2	79.35	34.62	51.15	1217
78	40.323	−5306.1	−3570.1	80.68	34.37	50.98	1206
80	40.113	−5213.3	−3468.3	81.97	34.12	50.81	1196
82	39.905	−5121.0	−3366.8	83.22	33.87	50.63	1186
84	39.697	−5029.1	−3265.8	84.44	33.62	50.45	1176
86	39.491	−4937.6	−3165.0	85.62	33.37	50.28	1166
88	39.285	−4846.5	−3064.6	86.77	33.12	50.12	1156
90	39.080	−4755.7	−2964.6	87.90	32.88	49.96	1147
92	38.876	−4665.4	−2864.8	89.00	32.64	49.80	1137
94	38.673	−4575.4	−2765.3	90.06	32.41	49.65	1128
96	38.470	−4485.8	−2666.2	91.11	32.19	49.51	1118
98	38.267	−4396.5	−2567.3	92.13	31.97	49.38	1109
100	38.066	−4307.6	−2468.7	93.12	31.76	49.25	1100
102	37.865	−4219.0	−2370.3	94.10	31.55	49.13	1091
104	37.664	−4130.7	−2272.1	95.05	31.35	49.02	1082
106	37.463	−4042.7	−2174.2	95.98	31.15	48.91	1073
108	37.264	−3955.0	−2076.5	96.90	30.96	48.81	1064
110	37.064	−3867.6	−1979.0	97.79	30.78	48.71	1056
112	36.865	−3780.5	−1881.6	98.67	30.60	48.61	1047
114	36.666	−3693.6	−1784.5	99.53	30.42	48.52	1039
116	36.468	−3607.1	−1687.5	100.37	30.25	48.43	1030
118	36.270	−3520.8	−1590.8	101.20	30.08	48.35	1022

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			70.0 MPa Isobar — Continued				
120	36.072	−3434.7	−1494.2	102.01	29.92	48.27	1014
122	35.875	−3348.9	−1397.7	102.81	29.76	48.19	1006
124	35.678	−3263.4	−1301.4	103.59	29.60	48.11	997
126	35.481	−3178.1	−1205.3	104.36	29.45	48.04	990
128	35.285	−3093.1	−1109.3	105.12	29.30	47.97	982
130	35.089	−3008.3	−1013.4	105.86	29.16	47.89	974
132	34.893	−2923.8	−917.7	106.59	29.01	47.83	966
134	34.697	−2839.5	−822.1	107.31	28.88	47.76	959
136	34.502	−2755.5	−726.6	108.02	28.74	47.69	951
138	34.308	−2671.7	−631.3	108.71	28.61	47.63	944
140	34.113	−2588.1	−536.1	109.40	28.48	47.56	936
142	33.919	−2504.8	−441.1	110.07	28.35	47.50	929
144	33.725	−2421.7	−346.1	110.73	28.23	47.44	922
146	33.532	−2338.9	−251.3	111.39	28.10	47.38	915
148	33.339	−2256.3	−156.6	112.03	27.99	47.31	908
150	33.146	−2173.9	−62.1	112.67	27.87	47.25	901
152	32.954	−2091.8	32.4	113.29	27.75	47.19	894
154	32.762	−2009.9	126.7	113.91	27.64	47.13	887
156	32.571	−1928.3	220.9	114.52	27.53	47.07	881
158	32.380	−1846.8	315.0	115.12	27.42	47.01	874
160	32.189	−1765.7	409.0	115.71	27.32	46.95	868
162	31.999	−1684.8	502.8	116.29	27.22	46.89	861
164	31.809	−1604.1	596.5	116.87	27.11	46.83	855
166	31.620	−1523.6	690.1	117.43	27.01	46.77	849
168	31.431	−1443.4	783.6	117.99	26.92	46.71	843
170	31.243	−1363.5	877.0	118.54	26.82	46.65	837
172	31.056	−1283.8	970.2	119.09	26.73	46.59	831
174	30.869	−1204.3	1063.3	119.63	26.64	46.53	825
176	30.682	−1125.1	1156.3	120.16	26.55	46.46	819
178	30.496	−1046.2	1249.2	120.68	26.46	46.40	814
180	30.311	−967.5	1341.9	121.20	26.37	46.34	808
185	29.851	−771.8	1573.2	122.47	26.17	46.18	795
190	29.394	−577.7	1803.7	123.70	25.97	46.02	782
195	28.942	−385.2	2033.4	124.89	25.78	45.85	770
200	28.496	−194.4	2262.2	126.05	25.60	45.68	758
205	28.054	−5.1	2490.1	127.18	25.43	45.50	747
210	27.617	182.5	2717.2	128.27	25.27	45.32	736
215	27.186	368.4	2943.3	129.34	25.12	45.13	726
220	26.761	552.7	3168.5	130.37	24.97	44.94	716
225	26.343	735.4	3392.7	131.38	24.83	44.75	707
230	25.930	916.4	3615.9	132.36	24.70	44.54	698
235	25.525	1095.7	3838.1	133.32	24.58	44.34	690
240	25.126	1273.3	4059.3	134.25	24.47	44.13	683
245	24.735	1449.4	4279.4	135.15	24.36	43.92	676
250	24.350	1623.7	4498.5	136.04	24.25	43.70	669
255	23.973	1796.5	4716.4	136.90	24.16	43.48	662
260	23.603	1967.6	4933.3	137.74	24.06	43.26	657
265	23.241	2137.1	5149.0	138.57	23.98	43.04	651
270	22.887	2305.1	5363.6	139.37	23.90	42.81	646
275	22.540	2471.6	5577.1	140.15	23.82	42.59	641

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			70.0 MPa Isobar — Continued				
280	22.201	2636.5	5789.5	140.92	23.75	42.36	637
285	21.870	2800.0	6000.8	141.67	23.69	42.14	633
290	21.546	2962.0	6210.9	142.40	23.63	41.91	629
295	21.229	3122.6	6419.9	143.11	23.57	41.69	625
300	20.921	3281.8	6627.8	143.81	23.52	41.47	622
			80.0 MPa Isobar				
63.01[a]	42.194	−6036.7	−4140.7	69.10	35.79	51.12	1307
64	42.089	−5990.9	−4090.2	69.90	35.81	51.26	1302
66	41.878	−5897.8	−3987.5	71.48	35.79	51.42	1292
68	41.667	−5804.6	−3884.6	73.02	35.69	51.47	1282
70	41.457	−5711.4	−3781.7	74.51	35.54	51.43	1272
72	41.249	−5618.3	−3678.9	75.95	35.36	51.34	1261
74	41.043	−5525.6	−3576.4	77.36	35.14	51.20	1251
76	40.837	−5433.1	−3474.1	78.72	34.91	51.04	1241
78	40.633	−5341.1	−3372.2	80.05	34.67	50.87	1231
80	40.430	−5249.4	−3270.7	81.33	34.42	50.68	1221
82	40.228	−5158.2	−3169.5	82.58	34.17	50.49	1211
84	40.027	−5067.4	−3068.7	83.80	33.92	50.31	1202
86	39.827	−4977.0	−2968.3	84.98	33.67	50.12	1192
88	39.628	−4887.0	−2868.2	86.13	33.42	49.94	1183
90	39.431	−4797.4	−2768.5	87.25	33.18	49.77	1174
92	39.234	−4708.2	−2669.1	88.34	32.94	49.60	1164
94	39.037	−4619.4	−2570.1	89.40	32.71	49.44	1155
96	38.842	−4531.0	−2471.3	90.44	32.48	49.29	1147
98	38.647	−4442.9	−2372.9	91.46	32.26	49.14	1138
100	38.453	−4355.2	−2274.8	92.45	32.05	49.00	1129
102	38.259	−4267.9	−2176.9	93.42	31.84	48.87	1120
104	38.066	−4180.9	−2079.3	94.37	31.64	48.74	1112
106	37.874	−4094.2	−1981.9	95.29	31.44	48.62	1104
108	37.682	−4007.8	−1884.8	96.20	31.25	48.50	1095
110	37.491	−3921.7	−1787.9	97.09	31.06	48.39	1087
112	37.300	−3836.0	−1691.2	97.96	30.88	48.28	1079
114	37.110	−3750.5	−1594.7	98.82	30.70	48.18	1071
116	36.921	−3665.3	−1498.5	99.65	30.53	48.08	1063
118	36.731	−3580.4	−1402.4	100.47	30.36	47.98	1055
120	36.542	−3495.8	−1306.6	101.28	30.20	47.89	1047
122	36.354	−3411.5	−1210.9	102.07	30.04	47.80	1039
124	36.166	−3327.4	−1115.4	102.85	29.88	47.71	1032
126	35.979	−3243.6	−1020.0	103.61	29.73	47.62	1024
128	35.792	−3160.0	−924.9	104.36	29.58	47.54	1017
130	35.605	−3076.7	−829.9	105.10	29.43	47.46	1009
132	35.419	−2993.7	−735.0	105.82	29.29	47.38	1002
134	35.233	−2910.9	−640.4	106.53	29.15	47.30	995
136	35.048	−2828.4	−545.9	107.23	29.01	47.22	988
138	34.863	−2746.2	−451.5	107.92	28.88	47.14	981
140	34.679	−2664.2	−357.3	108.60	28.75	47.07	974
142	34.495	−2582.4	−263.2	109.26	28.62	46.99	967
144	34.311	−2500.9	−169.3	109.92	28.50	46.92	960
146	34.128	−2419.6	−75.5	110.57	28.37	46.85	954
148	33.946	−2338.6	18.1	111.20	28.25	46.77	947
150	33.764	−2257.9	111.5	111.83	28.13	46.70	941

TABLE 11. Thermodynamic properties of oxygen — Continued

Temp. K	Density mol/dm³	Internal energy J/mol	Enthalpy J/mol	Entropy J/mol K	C_v J/mol K	C_p J/mol K	Velocity of sound m/s
			80.0 MPa Isobar — Continued				
152	33.582	−2177.3	204.9	112.45	28.02	46.63	934
154	33.401	−2097.1	298.1	113.06	27.91	46.56	928
156	33.221	−2017.0	391.1	113.66	27.79	46.49	922
158	33.040	−1937.3	484.0	114.25	27.69	46.42	915
160	32.861	−1857.7	576.8	114.83	27.58	46.35	909
162	32.682	−1778.5	669.4	115.41	27.47	46.28	903
164	32.503	−1699.4	761.9	115.98	27.37	46.21	897
166	32.325	−1620.6	854.2	116.54	27.27	46.14	891
168	32.148	−1542.1	946.4	117.09	27.17	46.07	886
170	31.971	−1463.8	1038.5	117.63	27.08	46.00	880
172	31.795	−1385.7	1130.4	118.17	26.98	45.93	874
174	31.619	−1307.9	1222.2	118.70	26.89	45.86	869
176	31.444	−1230.4	1313.8	119.23	26.80	45.79	863
178	31.270	−1153.0	1405.3	119.74	26.71	45.72	858
180	31.096	−1076.0	1496.7	120.25	26.62	45.64	853
185	30.665	−884.4	1724.5	121.50	26.41	45.47	840
190	30.237	−694.4	1951.4	122.71	26.21	45.29	828
195	29.814	−505.9	2177.4	123.89	26.01	45.11	816
200	29.396	−319.0	2402.5	125.03	25.83	44.93	805
205	28.983	−133.6	2626.7	126.13	25.66	44.75	794
210	28.574	50.2	2849.9	127.21	25.49	44.56	784
215	28.171	232.5	3072.3	128.26	25.34	44.38	774
220	27.773	413.2	3293.7	129.27	25.19	44.19	764
225	27.381	592.4	3514.2	130.26	25.04	44.00	755
230	26.994	770.1	3733.7	131.23	24.91	43.81	747
235	26.614	946.2	3952.2	132.17	24.78	43.61	739
240	26.239	1120.9	4169.8	133.09	24.66	43.42	731
245	25.870	1294.0	4386.4	133.98	24.55	43.22	724
250	25.508	1465.7	4602.0	134.85	24.44	43.03	717
255	25.151	1635.9	4816.7	135.70	24.34	42.83	711
260	24.801	1804.7	5030.3	136.53	24.24	42.63	705
265	24.458	1972.1	5243.0	137.34	24.16	42.43	699
270	24.121	2138.1	5454.7	138.13	24.07	42.24	694
275	23.790	2302.7	5665.4	138.90	23.99	42.04	688
280	23.466	2466.0	5875.1	139.66	23.92	41.85	684
285	23.149	2627.9	6083.8	140.40	23.85	41.65	679
290	22.838	2788.6	6291.6	141.12	23.79	41.46	675
295	22.533	2948.1	6498.4	141.83	23.73	41.27	671
300	22.234	3106.3	6704.3	142.52	23.67	41.08	667

[a]Two phase boundary.