Thermodynamic Properties of Helium 4 from 2 to 1500 K at Pressures to 10^8 Pa

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Tabular values of density, internal energy, enthalpy, entropy, heat capacity, and speed of sound for liquid and gaseous helium are presented for temperatures from 2 to 1500 kelvin at pressures from 1.0×10^4 to 1.0×10^8 pascals. Diagrams of temperature vs entropy are also given. The properties presented are calculated from an equation of state which was fitted to experimental P–V–T and other thermodynamic data from the world's literature. The equation of state was fitted to these data in three separate regions of pressure and temperature. The regional equations are forced to join smoothly at the preconceived boundaries. Extensive comparisons between the equation of state and experimental data have been made, and deviation plots are presented. A particularly careful determination of the second virial coefficient over the full temperature range 2–1500 kelvin is presented. The Joule-Thomson inversion curve has been calculated and comparisons made with other sources. Equations for the density of the saturated liquid and vapor are included as well as an equation which represents the 1958 helium vapor pressure temperature scale.

Key words: Critical point; critically evaluated data; enthalpy; entropy; equation of state; helium; internal energy; Joule-Thomson coefficient; lambda line; melting line; P–V–T; specific heat; vapor pressure; speed of sound; viral coefficient.

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1. Introduction

The investigation of the properties of helium has been one of the more popular endeavors in science since it was discovered in 1868. A large part of this interest can be attributed to the spectacular superfluid properties of helium. This work does not include the temperature and pressure range at which the superfluid properties of helium occur.

In recent years the application of helium as a refrigerant and other technical uses have accelerated interest in the thermodynamic properties of helium. Although many investigators have published data for the thermodynamic properties of helium, in most cases these investigations have been limited to narrow ranges of temperature and pressure which were of immediate interest to the individual. In no case has there been tabulations published which cover the range of temperature and pressure of this work. In addition, where published data do overlap, there is usually a substantial disagreement which, in many cases, makes the transition from one data set to another quite difficult for the user. For these reasons this laboratory undertook the job of critically analyzing the existing thermodynamic data for helium and creating from this analysis a new set of data which covers a more extensive range of pressure

and temperature than was previously available in a single document.

2. Survey of the Literature

A search of the world's scientific literature began with a computerized search of some 40,000 articles at the Cryogenic Data Center of the National Bureau of Standards at Boulder, Colorado. This search produced 634 references. The literature search was periodically updated so that current data were continually assimilated.

A bibliography by Barieau [2][1] contains all the references he could find with experimental P–V–T data for helium 4. The bibliography contains 163 references. In addition to these P–V–T data there are many references in the literature which contain other useful experimental data such as specific heat, speed of sound, and many others. All of the articles which contained appropriate experimental data were considered for possible contribution to the correlation of the thermodynamic properties of helium.

Over the past few years, a number of other correlations of properties of helium have been published. Most of these have been of limited scope and only one [53] has included the two-phase region. Since Mann's correlation many new experimental data for helium have been published. Other more recent correlations are [72] and [65]; both of these correlations are restricted to temperatures of 0 °C and above. The agreement between the above correlations and this one is discussed in detail in section 8.4.

Many of the references in the literature contain equations of state; however, none of the equations of state were adequate for the scope of this correlation.

In the last ten years or so, the continued increase in usage of the high speed digital computer has made the equation of state approach to thermodynamic properties more and more attractive. Many equations of state have been proposed in the literature. In every case the author has found these equations do not represent the existing data, or theory, adequately at one point or more on the P–V–T surface. However, this is not to say that the single equation of state presentation is not useful. In the majority of cases, the user is willing to accept these inadequacies or the inadequacies occur at points which will not affect his particular calculations. In this work an alternative is presented. A single equation of state is presented, with three different sets of adjustable parameters. The three sets of parameters were determined from data of limited temperature and pressure ranges and the three ranges were joined smoothly at their common boundaries by various means. The tabulations given here were calculated from the set of three equations.

In the case of helium, for a number of reasons, it is difficult to assess the general overall adequacy of an equation of state. First, the entire normal two-phase gaseous-liquid coexistence region takes place in a span of about three Kelvin. This amplifies by at least an order of magnitude the importance of temperature measurement errors. Second, these temperature measurements are made in an extremely difficult portion of the temperature scale, i.e., 2 to 5 K. Third, when determining an equation of state for a fluid, it is important to have accurate data from a single source covering both the gaseous and liquid region from the triple point to about twice critical temperature. For helium there is only one such set of data available [50]. Since there is only one such source of data for this region it is impossible to make extensive comparisons. In the regions of pressure and temperature where there is a small overlap of these data with others, there is about a 1.5 percent disagreement in density at high density which is disastrous for the determination of an equation of state.

In general, the three regional equations of state represent the existing experimental P–V–T data to within the accuracy of the data in their respective regions with the exception of the critical region. The critical region of helium has been investigated quite extensively and is treated here completely independently of the balance of the P–V–T surface.

3. Vapor Pressure

In recent years most of the experimental work at temperatures between 2 and 5 K has used the 1958 helium temperature scale [7], and when older data which are based on other temperature scales are compared and correlated with the newer data conversion to the 1958 scale has served to establish a common temperature scale. Some of the most recent experimental workers have used other temperature scales but these are almost always given in terms of "corrections" to the 1958 scale. Therefore, it seemed worthwhile to create an equation or equations to reproduce the 1958 helium vapor pressure temperature scale. These equations are:

$$\ln P = \sum_{i=1}^{10} A_i T^{(2-i)}. \tag{1}$$

where T is in kelvin and pressure is in micrometers of Hg (1 μm Hg = 133.322 P_a). The range of validity for eq (1) is 2.172 to 5.1994 K. For the temperature range of 0.5 to 2.172 K the equation

$$\ln P = \sum_{i=1}^{14} B_i T^{(2-i)}, \tag{2}$$

was determined. Equation (2) is in the same units as eq (1).

Equation (1) was fit to 611 smoothed points from [7], taken every 0.005 K between 2.172 and 5.1994 K. In addition to the 611 data points, six constraints were imposed on the least squares estimates of the parameters. These constraints are listed in table 1. The coefficients (A_i) are given in table 3.

[1] Figures in brackets indicate literature references in section 13.

TABLE 1. Constraints on equation (1)

P	=	37800 μm Hg	at	T	= 2.172 K
P	=	760000	at	T	= 4.215
P	=	1718000	at	T	= 5.1994
dP/dT	=	92960 μm HgK^{-1}	at	T	= 2.17
dP/dT	=	717100	at	T	= 4.22
dP/dT	=	1267000	at	T	= 5.2

TABLE 2. Constraints on equation (2)

P	=	37800 μm Hg	at	T	= 2.172 K
dP/dT	=	92960 μm Hg K^{-1}	at	T	= 2.17

TABLE 3. Coefficients for equation (1)

A_1	=	-3.9394635287
A_2	=	1.4127497598×10^2
A_3	=	$-1.6407741565 \times 10^3$
A_4	=	1.1974557102×10^4
A_5	=	$-5.5283309818 \times 10^4$
A_6	=	1.6621956504×10^5
A_7	=	$-3.2521282840 \times 10^5$
A_8	=	3.9884322750×10^5
A_9	=	$-2.7771806992 \times 10^5$
A_{10}	=	8.3395204183×10^4

Equation (2) was fit to 333 points taken every 0.005 K from 0.5 to 2.172 K [7]. In addition to the 333 data points, two constraints were imposed on the least squares estimate of the parameters (see table 2). The coefficients (B_i) for equation (2) are given in table 4. The maximum deviation in pressure for either equation (1) or (2) is 0.02 percent. The maximum deviation in temperature predicted by either equation (1) or (2) is 0.0001 K (see figure 1). Deviations are from the 1958 helium vapor pressure temperature scale as defined in [7].

TABLE 4. Coefficients for equation (2)

B_1	=	$-4.9510540356 \times 10^1$
B_2	=	6.5192364170×10^2
B_3	=	$-3.7075430856 \times 10^3$
B_4	=	1.2880673491×10^4
B_5	=	$-3.0048545554 \times 10^4$
B_6	=	4.9532267436×10^4
B_7	=	$-5.9337558548 \times 10^4$
B_8	=	5.2311296025×10^4
B_9	=	$-3.3950233134 \times 10^4$
B_{10}	=	1.6028674003×10^4
B_{11}	=	$-5.3541038967 \times 10^3$
B_{12}	=	1.1990301906×10^3
B_{13}	=	$-1.6146362959 \times 10^2$
B_{14}	=	9.8811553386

Temperature scales both practical and thermodynamic have always been a fascinating subject to scientists and engineers. The 1958 helium vapor pressure temperature scale (hereafter referred to as the T_{58} scale) is no exception, Cataland and Plumb [10] have been engaged in a program of accoustic thermometry which includes the liquid helium temperature range from about 2 K. Another paper by Rogers, et al. [70] makes an interesting comparison of various experimental temperature determinations with those calculated from the T_{58}. Figure 2 is from Rogers, et al. [70]. Two things are evident in

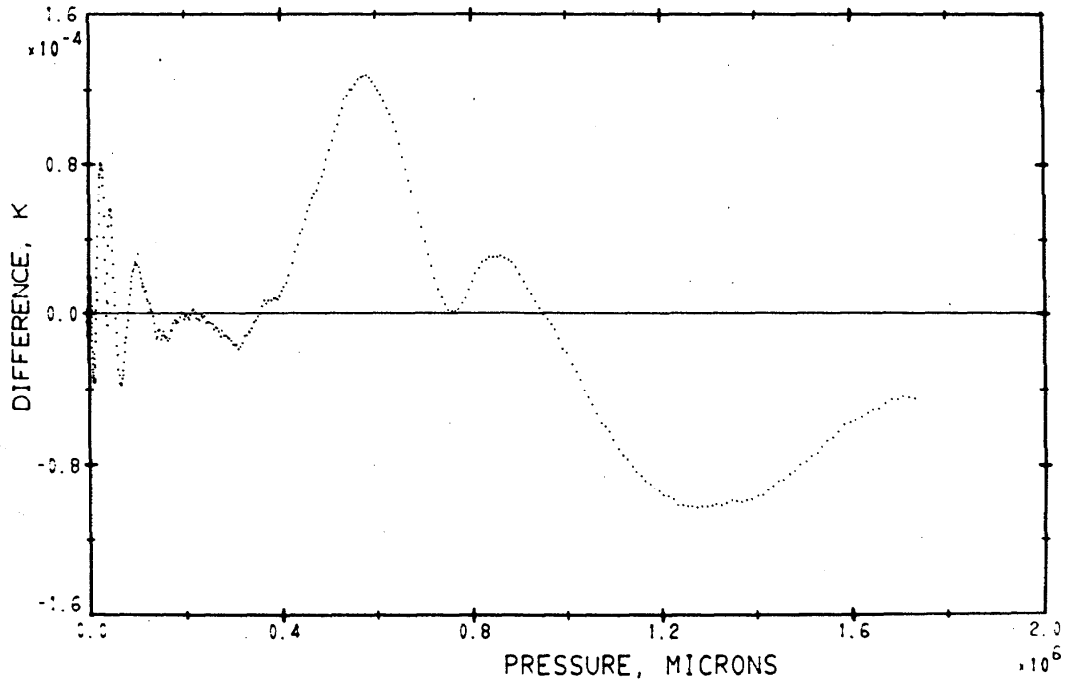

FIGURE 1. Deviations between the 1958 helium temperature scale and equations (1) and (2)

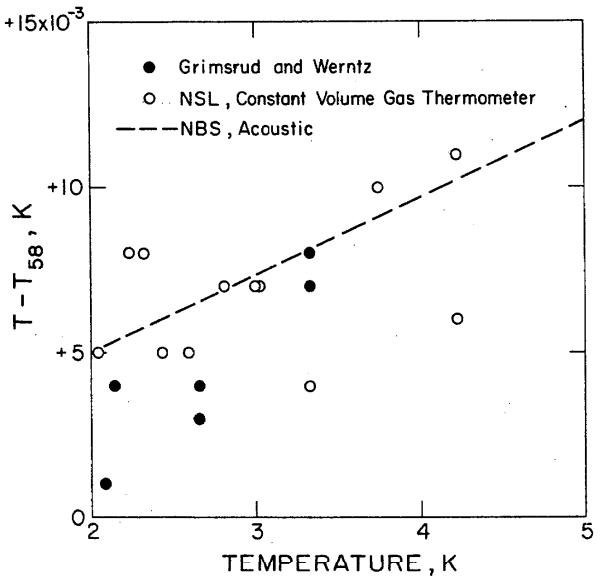

FIGURE 2. Differences between experimental measurements of temperature and the 1958 helium scale

figure 2. First, the T_{58} scale assigns temperatures lower than the thermodynamic temperature and, second, the temperature determinations have a scatter of about five millidegrees. On the basis of the above referenced work it was decided to adjust the T_{58} scale by

$$T = T_{58} + 0.001 + 0.002\ T_{58}, \tag{3}$$

which raises the temperatures assigned to the normal boiling point and the critical point of helium by about nine millidegrees and 11 millidegrees, respectively. After equation (3) was decided upon, more recent work by Cetas and Swenson [11, 12, 13], using a paramagnetic salt experiment to determine absolute temperatures, suggests that the adjustments from equation (3) are too large by about 4 or 5 millidegrees for temperatures approaching 5 K.

The measurements by Cetas and Swenson [11, 12, 13] have a greater precision than those in figure 2 by at least a factor of 2. Kierstead [45, 46] reports experimental P–V–T measurements in the critical region of helium which tend to confirm the T_{58} scale discrepancies reported by Cetas and Swenson [11, 12, 13]. Since the difference between the adjustments to the T_{58} scale given by equation (3) and those proposed by Cetas and Swenson [11, 12, 13] would have a significant effect only at temperatures in the near critical region and since the equation of state is admittedly not accurate in the critical region no further adjustments to the temperatures were made.

One of the fixed points of the T_{58} scale is the critical point. The value of pressure assigned to the critical point is 1718 mm of mercury reported by Kamerlingh Onnes [36]. Kamerlingh Onnes states that the determination of that value (1718 mm) was made by observing the disappearance of the meniscus and that this could be determined to no better than one centimeter of mercury. Some of the more recent measurements of the critical pressure [19] and [67] show that 1718 mm of mercury is too high and that a better value of the critical pressure of helium is 1706 mm of mercury.

If one takes as a best estimate the critical pressure of helium to be 1706.1 mm Hg and solves equations (3) and (1) for a temperature at this pressure, a critical temperature of 5.2014 results.

Before leaving the helium vapor pressure temperature scale there is one other disagreement between T_{58} and recent experiments that bears mentioning. Kierstead [46] made measurements of the slope of the critical isochore for helium 4 and found the slope $(\partial P/\partial T)$ at P_c and T_c to be 1289.2 torr/K as compared to 1267.0 torr/K as given by T_{58}. Since the T_{58} scale is based on an analytic representation of the behavior of the vapor pressure of helium this disagreement is not unexpected. For a nonanalytic representation of the helium vapor pressure see equation (33), section 9.

4. Density of the Saturated Liquid and Gaseous Phases

During the course of the correlation of the P–V–T data for helium, equations for the density of the saturated liquid and vapor phases of helium were developed as aids in the analysis. These equations have not been used to produce any of the numbers which appear in the numerical tabulations. They are presented here as a convenience for those who might have use for such equations. They do represent the experimental densities to which they were fit to within the precision of those densities.

The analysis of the experimental density data for the saturated liquid and gaseous phases of helium 4 included a number of sources, references [19], [20], [21], [22], [23], [42], [44], [54], and [67]. Most of these data are for the saturated liquid and are of limited temperature range. The data of Roach [67] and of Edwards [19, 20, 21] are mainly concerned with the critical region. Kerr's [42, 43, 44] experiments were mainly concerned with the region of the lambda transitions. His 1957 paper [42] does contain data up to 4.4 K, however, while it generally agrees with the more recent data of el Hadi [22, 23] it contains considerably more scatter. The paper by Kerr and Taylor [44] contains new data only for temperatures of 2.8 K and below. The old Leiden data by Mathias, et al. [54] were not in agreement with the newer data. The data by el Hadi [22, 23] cover the widest range of temperature and seemed to be the best suited for the formulation of useful saturation equations. Therefore, the el Hadi [22, 23] data were used in the least squares determination of the following two equations. The density of the saturated vapor is given by

$$\rho_g = \rho_c + \sum_{i=1}^{6} S_{gi}\ (1 - T/T_c)^{1/3}, \tag{4}$$

and that of the saturated liquid

$$\rho_l = \rho_c + \sum_{i=1}^{6} S_{l_i} (1 - T/T_c)^{1/3}, \quad (5)$$

where the density is in g/cm³, and the temperature is in kelvin. The parameters for equations (4) and (5) are given in table 5. The saturated liquid data below the

TABLE 5. Coefficients for equations (4) and (5)

ρ_c	= 0.06964 g/cm³	ρ_c	= 0.06964 g/cm³
s_{g_1}	= $-6.9267495322 \times 10^{-2}$	s_{l_1}	= $1.2874326484 \times 10^{-1}$
s_{g_2}	= $-1.2925325530 \times 10^{-1}$	s_{l_2}	= $-4.3128217346 \times 10^{-1}$
s_{g_3}	= $2.9347470712 \times 10^{-1}$	s_{l_3}	= 1.7851911824
s_{g_4}	= $-4.0806658212 \times 10^{-1}$	s_{l_4}	= −3.3509624489
s_{g_5}	= $3.5809505624 \times 10^{-1}$	s_{l_5}	= 3.0344215824
s_{g_6}	= $-1.1315580397 \times 10^{-1}$	s_{l_6}	= −1.0981289602

lambda temperature were omitted from the least squares fit. The average deviation for the liquid equation was 0.027 percent with a maximum of 0.1 percent (in density) at 4.4 K. The average deviation for the vapor equation was 0.1 percent with a maximum of 0.4 percent (in density) at 2.2 K. See figure 3. The range

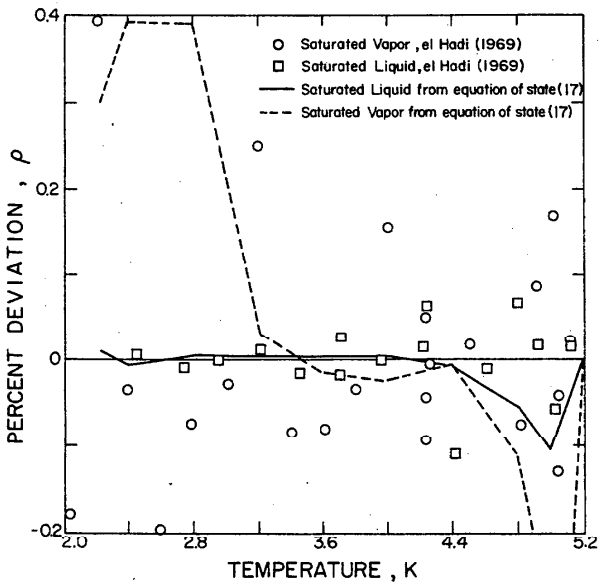

FIGURE 3. Deviations between equations (4), (5) and (17) and the experimental data by el Hadi [22, 23]

of the vapor equation is from 2.2 K to the critical point and the range of the liquid equation is from the lambda point to the critical point. If the best possible accuracy is desired between 5 and 5.2 K, equations (31) and (32) should be used.

5. The Second Virial Coefficient

The virial equation of state for gases is often given in form of

$$PV = RT(1 + B\rho + C\rho^2 + D\rho^3 + \ldots). \quad (6)$$

Although this is one of the earliest proposed equations of state for gases, it is still extensively used and the virial coefficients (B, C, D, etc.) are of special interest to theoreticians. The second virial coefficient, B, is the easiest to obtain, both from experimental data and from theory. Therefore, the experimentally derived B is of particular interest to theoreticians for investigation of the intermolecular potential.

Most of the existing experimental P–V–T data for helium have been published in the literature in isothermal form, and in many cases these articles include virial coefficients derived from the experimental isotherms. Unfortunately, the value of a virial coefficient derived from a given set of data is highly dependent upon a number of factors related to the method used in obtaining the virial coefficient from the data. Since the method almost always varies from one investigator to another and since the details of the method are often omitted, it is inappropriate, in most cases, to compare one author's virial coefficients directly with another's. There seemed to be enough low pressure isothermal P–V–T data in the literature to warrant a careful investigation of the second virial coefficient. Each experimental isotherm found in the literature was treated in exactly the same way. Least squares estimates of A, B, and C, were determined from the equation

$$PV = A + B\rho + C\rho^2. \quad (7)$$

The estimating procedure began by least squares fitting equation (7) to a few of the lowest density data points and repeating the fitting procedure many times, each successive time adding another data point of increasing density until the virial C became statistically significant. As soon as the virial C became significant, the last few data points (highest density) were removed and a final fit made. The point at which the third virial began to contribute to a detectable degree is dependent upon the random scatter of the data. Theoretically, it would contribute at all densities if there were no random error present. However, if the contribution (of C) is less than the random error in the data, it must not be included in the estimating equation because it will tend to compensate for random error by shifting the curve towards one or more of the data points with a large random error. This, in turn, will influence the value of the B, because of the strong covariance which exists between the B and C. A total of 148 isotherms were analyzed in this manner. The partial results of the analysis are shown in part in figures 4, 5, 6, and 7. Even when each experimental source of data is compared on

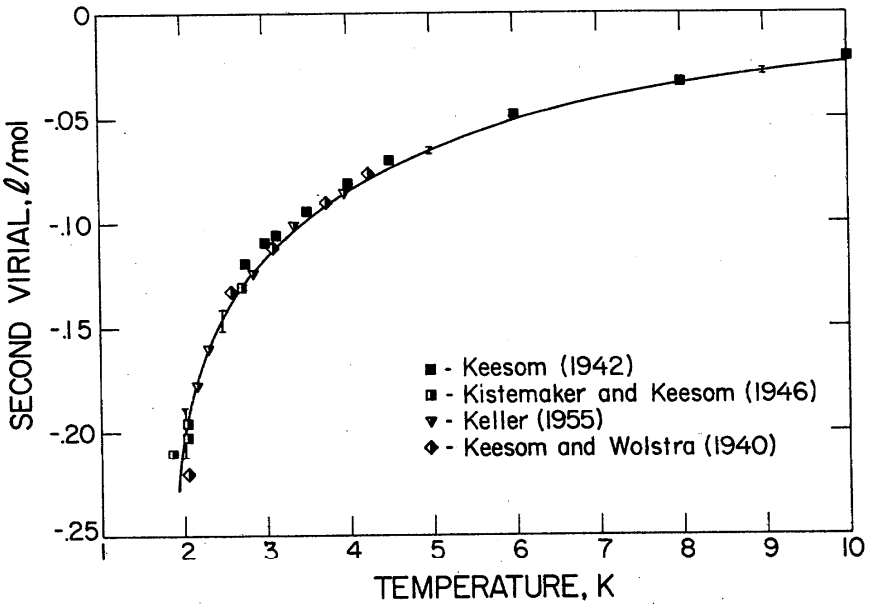

FIGURE 4. The second virial coefficient from 2 to 10 K. The solid line is from equation (8)

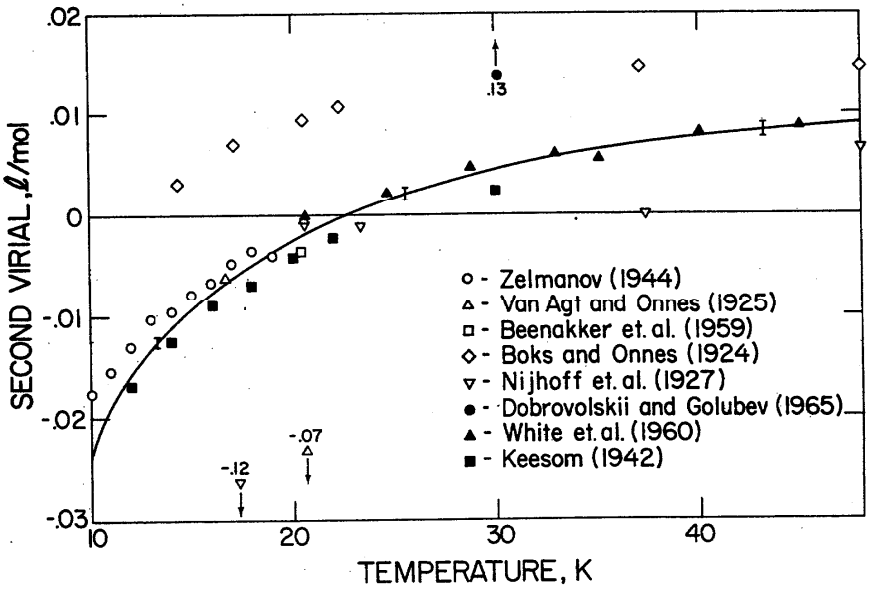

FIGURE 5. The second virial coefficient from 10 to 48 K. The solid line is from equation (8)

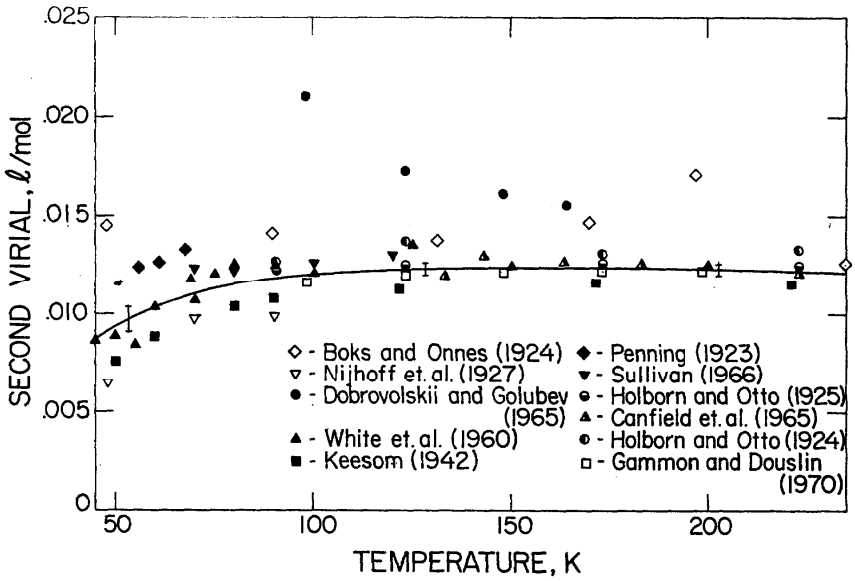

FIGURE 6. The second virial coefficient from 48 to 200 K. The solid line is from equation (8)

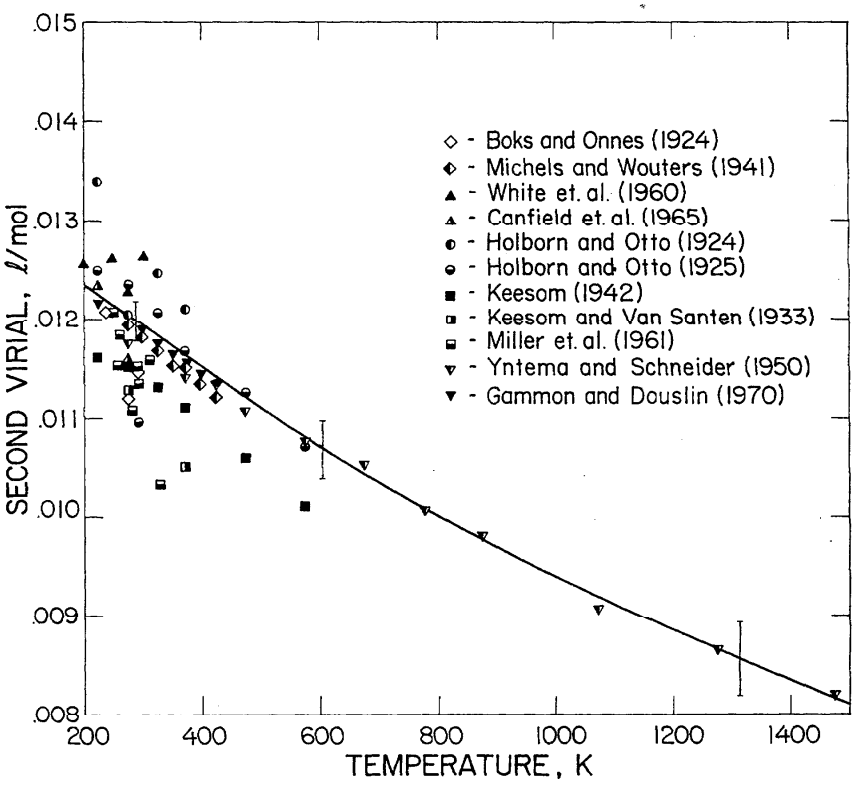

FIGURE 7. The second virial coefficient from 200 to 1500 K. The solid line is from equation (8)

a common base, small differences in the data tend to influence the virial coefficients. Even though the results of the analysis were less than expected from the standpoint of the second virial coefficient, other information which came out of the analysis proved to be very valuable. The estimates of the variance of the B's from each source of data provided an absolute and a relative estimate of the experimental random error in the data. In equation (7), A appears as a parameter to be estimated by the least squares procedure, which corresponds in the virial equation to RT. Using a commonly accepted value of R it was then possible to place confidence limits on the temperature of the isotherm. In some cases the temperature assigned to the isotherm by the original source was outside the confidence limit by a wide margin, indicating some systematic error in the measurement of the P–V–T data. In a few of the cases where systematic error was detected, the error could be assigned to the temperature measurement and therefore corrected. If this was not possible, the data were eliminated from further consideration unless they happened to be the only data available for that temperature and pressure range.

On the basis of the information gained from the isothermal analysis just described, particular sets of P–V–T data were chosen for the final estimation of B. The data of Canfield, et al. [9] were chosen for the temperature range of 133 to 273 K. The data of Sullivan [71] were chosen for the temperature range of 70 to 120 K. The data of White, et al. [76] were chosen for the temperature range of 20 to 70 K, and finally, the data of Keller [41] were used for temperatures from 2.154 to 3.957 K. In the case of Canfield, et al. [9] and Sullivan [71], care was taken to exclude data above densities where higher order virials began to contribute.

In addition to the P–V–T data mentioned above, two other kinds of data were fitted to equation (8) simultaneously with the P–V–T data. The speed of sound data by Plumb and Cataland [66], which cover the temperature range between 2.323 and 20.051 K, were inserted into the fit as well as the second virial coefficient data of Yntema and Schneider [79] which cover the temperature range of 273 to 1473 K.

The function chosen to represent the temperature dependence of the second virial coefficient is

$$B(b_i, T)=\sum_{i=1}^{9} b_i T^{(1.5-i/2)}, \tag{8}$$

where T is in kelvin and B is in liters/mole. The technique of simultaneously fitting different kinds of data requires only that the different kinds of data being used are mathematically related and that the resulting equations are linear and separable in the parameters being estimated. For the second virial data equation (8) was used. For the P–V–T data equation (9) was used.

$$PV/RT-1.0=\sum_{i=1}^{9} b_i \rho T^{(1.5-i/2)}, \tag{9}$$

where P is in atmospheres, V is in liters/mole and T is in kelvin.

To introduce the speed of sound into the least squares equations, the virial expansion is again truncated after the second virial. If no higher order virial contribution is present the following relationships are valid.

$$W^2=W_0^2(1+\alpha P), \tag{10}$$

where W^2 is the speed of sound squared; $W_0^2=(C_P/C_v)_{P=0}\frac{RT}{M}$ is the ideal-gas speed of sound; $\alpha=1/RT(2B+4/3TdB/dT+4/15T^2d^2B/dT^2)$; and P is the pressure. Since the second virial coefficient has the same value in either the pressure or density form of the virial equation of state, it is now possible to write equation (10) as

$$\left(\frac{W^2}{W_0^2}-1.0\right)RT=\left(2B+\frac{4}{3}T\frac{dB}{dT}+\frac{4}{15}T^2\frac{d^2B}{dT^2}\right)P. \tag{11}$$

Substituting for B from equation (8) into equation (11) results in

$$\left(\frac{W^2}{W_0^2}-1.0\right)\frac{RT}{P}=\sum_{i=1}^{9} b_i\left[2+\frac{4}{3}(1.5-i/2)+\frac{4}{15}(1.5-i/2)(0.5-i/2)\right][T^{(1.5-i/2)}], \tag{12}$$

where the units of P, T and R are the same as in equation (9). The right hand side of equations (8), (9), and (12) are now all linear in the b_i. In least squares estimating procedures a general equation is sometimes written as

$$y=\sum_{i=1}^{n} b_i X_i. \tag{13}$$

The left hand side of equations (8), (9), and (12) become the y in equation (13) and the term multiplying the b_i in equations (8), (9), and (12) becomes the X_i in equation (13). For more details on simultaneous data fitting see Hust and McCarty [35].

Since the least squares estimating procedure minimizes the sum of the squares of the deviations in the dependent variable (the y in equation (13)) with respect to the parameters being estimated (the b_i in equation (13)) it is important that the variance in y be as nearly a constant as possible. This is especially true in the case of simultaneous data fitting because the independent variable differs in magnitude from one kind of data to the next; therefore the variance is likely to differ more than when using only one kind of data. Fortunately, a transformation via a weighting factor will compensate for this to a large degree. Applying the weighting factor to equation (13) at the nth data points gives

$$y_n W_n=\sum_{i=1}^{m} W_n b_i X_n, \tag{14}$$

where

$$W_n = \frac{1}{\hat{\sigma}_{y_n}}, \tag{15}$$

and $\hat{\sigma}_{y_n}$ is an estimate of the standard deviation in the nth y. An estimate of $\hat{\sigma}_{y_n}$ may be had from the precision of the experiment. If there are large random errors in one or more of the independent variables of the X_i in equations (13) and (14), or if the random error is small in X_i but a small error in the X_i causes a large error in the y, i.e., $\partial y/\partial X_i$ is large, then these random errors should also be taken into account. This is easily done by modifying the weighting factor to include

$$W_n = \frac{1}{\left[\hat{\sigma}^2_{y_n} + \sum_{i=1}^{m} \hat{\sigma}^2_{x_{i,n}} \left(\frac{\partial y_n}{\partial x_{i,n}}\right)^2\right]^{1/2}}, \tag{16}$$

where the $\hat{\sigma}_{x_{i,n}}$ is estimated again from the precision of the experimental measurements and the $(\partial y_n/\partial x_{i,n})$ is estimated by obtaining a preliminary set of parameters and using them to form the proper partial derivatives.

Ideally, if the estimates are exact the variance of the resulting weighted least squares fit would be one, and would be distributed statistically as χ^2. An approximate rule of thumb is that if the variance of the fit is between 0.1 and 10, the weighting is probably quite good. Combining the above procedures and the referenced data the estimated parameters for equation (8) which are given in table 6 were obtained. The number of terms in equation (8) was determined by successively adding terms to the expansion until the statistical significance of one or more of the coefficients was lost.

The error bars shown in figures 4, 5, 6 and 7 are estimated uncertainties for a 95 percent confidence. The second virial coefficients of Gammon and Douslin [24] shown in figures 6 and 7 were derived from speed of sound measurements. These data appeared in the literature after the parameters for equation (8) were determined. The agreement between Gammon and Douslin's [24] virials and those from equation (8) is good, ranging from slightly less than 1 percent difference at the highest temperature to slightly more than 2 percent at the lowest temperature, all well within the uncertainties assigned to equation (8).

TABLE 6. Coefficients for equation (8)[a]

b_1	=	$-5.0815710041 \times 10^{-7}$
b_2	=	$-1.1168680862 \times 10^{-4}$
b_3	=	$1.1652480354 \times 10^{-2}$
b_4	=	$7.4474587998 \times 10^{-2}$
b_5	=	$-5.3143174768 \times 10^{-1}$
b_6	=	$-9.5759219306 \times 10^{-1}$
b_7	=	3.9374414843
b_8	=	−5.1370239224
b_9	=	2.0804456338

[a] The number of significant figures listed for these and all other tabulations is in no way indicative of the accuracy of the properties calculated from the equations. However, the number of significant figures given is necessary to avoid errors due to computational round off.

Even more recently Berry [5] reported second virial coefficients of −2.35, −43.6 and −79.0 cm³/mol for the temperatures of 20.2746, 6.6989, and 4.2240 K, respectively. Using equation (8) values of −2.0, −44.0, and −80.3 were calculated for the above temperatures, respectively.

Figure 8 shows the shape and relative size of the second virial for helium over the entire range of tempera-

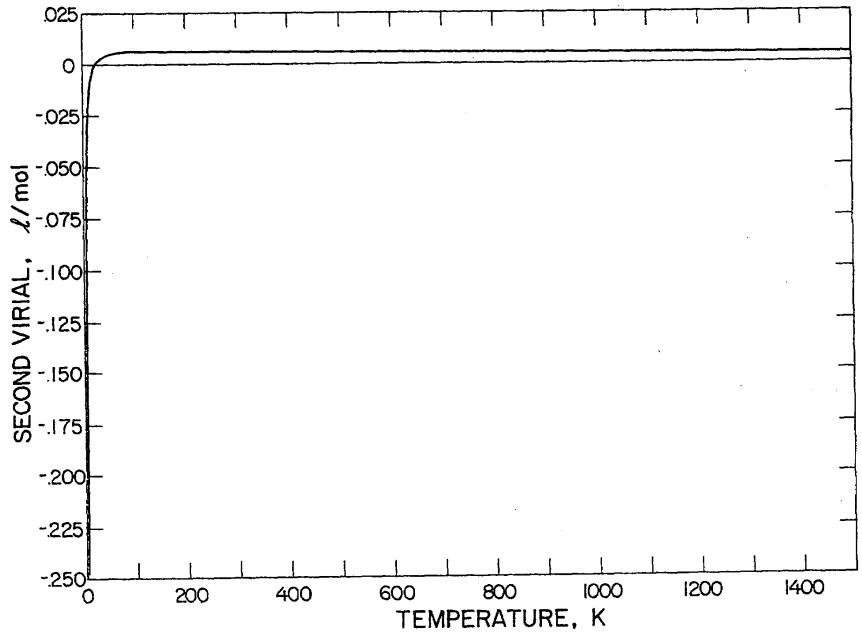

FIGURE 8. Second virial coefficient from 2 to 1500 K

ure from 2 to 1500 K; table 7 gives values of the second virials calculated from eq 8.

TABLE 7. Second virial coefficients for helium-4

Temp K	$B \times 10^3$ l/mol	Temp K	$B \times 10^3$ l/mol	Temp K	$B \times 10^3$ l/mol
2	−203.8	22	−0.37	200	12.33
3	−122.0	24	1.17	250	12.16
4	−85.83	26	2.47	300	11.95
5	−64.08	28	3.56	350	11.73
6	−51.20	30	4.49	400	11.51
7	−41.33	32	5.29	450	11.30
8	−33.88	34	5.99	500	11.10
9	−28.05	36	6.60	550	10.90
10	−23.37	38	7.14	600	10.71
11	−19.52	40	7.62	650	10.53
12	−16.31	50	9.33	700	10.35
13	−13.60	60	10.37	750	10.18
14	−11.27	70	11.04	800	10.02
15	−9.25	80	11.49	900	9.71
16	−7.49	90	11.79	1000	9.41
17	−5.94	100	12.00	1200	8.86
18	−4.57	125	12.29	1300	8.60
19	−3.35	150	12.38	1400	8.36
20	−2.25	175	12.38	1500	8.12

6. The Equation of State

When the task of correlating the thermodynamic properties of helium was undertaken, one of the ultimate goals was the production of a single equation of state which would adequately predict the existing experimental data from 2 to 1500 K with pressures as high as possible. As is always the case when trying to fit a large surface such as a P–V–T surface, part of the surface is compromised to allow even a reasonable fit of another part of the surface. It was therefore decided after a long and tedious period of experimentation with, and development of, various mathematical models for the equation of state of helium that further efforts along the single equation of state approach would likely be fruitless.

The alternative to a single equation approach is obviously a multiple equation approach which presents a problem of matching two or more surfaces at a common boundary. Since the equation of state does do a reasonable job of representing the entire P–V–T surface, it seemed reasonable to assume that it would do a better job for just part of the surface. Maintaining the mathematical form of the equation of state from region to region also has some practical advantages. The matching at the boundaries is greatly simplified and the computer programming is minimal as one only needs to switch coefficients to go from one region to another. The form of the equation of state used for helium is:

$$P=\rho RT[1+B(b_i,T)\rho]+\sum_{i=1}^{8} n_{1i}\rho^3 T^{(1.5-i/2)} + \sum_{i=1}^{4} n_{2i}\rho^4 T^{(1.5-i)} + \sum_{i=1}^{6} n_{3i}\rho^5 T^{(0.75-i/4)} + \sum_{i=1}^{3} n_{4i}\rho^3 e^{\gamma\rho^2} T^{(1.0-i)} + \sum_{i=1}^{3} n_{5i}\rho^5 e^{\gamma\rho^2} T^{(1.0-i)} + \sum_{i=1}^{2} n_{6i}\rho^6 T^{(1-i)}, \quad (17)$$

where P is in atmospheres, ρ is in moles per liter, T is in

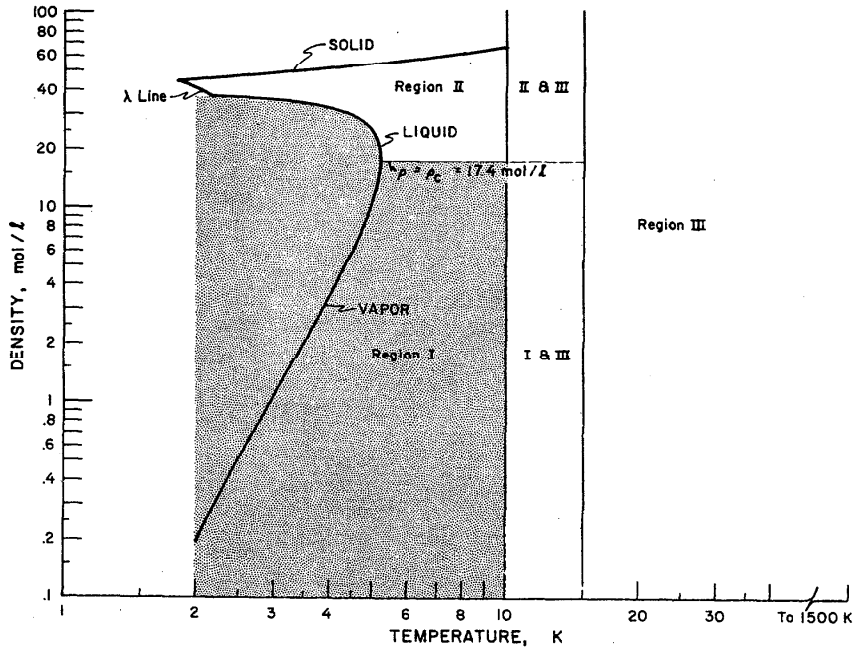

FIGURE 9. Schematic ρ-T diagram for helium showing regions represented by different equations

kelvin, $R = 0.0820558$ l·atm/mol·K and $B(b_i, T)$ is given by equation (8).

The P–V–T surface was divided into three regions as shown in figure 9.

The thermodynamic properties for helium tabulated in appendices D and E have been calculated using the multisurface approach. All properties in region I were calculated using equation (17) together with the coefficients in table 8. Region I is defined to include temperatures from 2 to 10 K with densities to the saturated liquid density for temperatures from the lambda point to the critical point, for temperatures between the critical temperature and 10 K, the limiting density is the critical density.

All properties in region II were calculated using equation (17) together with the coefficients in tables 8 and 9. Region II is defined to include temperatures from the lambda line to 10 K with densities from the boundary of region I to the solid line. The transition between regions I and II was accomplished along a line of constant temperature in the following manner,

$$\underset{\text{Region II}}{\text{Prop}}\ (\rho, T) = \underset{\text{Region I}}{\text{Prop}}\ (\rho_{\text{boundary}}, T) + \left[\underset{\text{Region II}}{\text{Prop}}\ (\rho, T) - \underset{\text{Region II}}{\text{Prop}}\ (\rho_{\text{boundary}}, T)\right] \tag{18}$$

This formulation insures a continuity between the two regions; however, to obtain the best results in region II equation (18) must actually be used in the least squares estimation of the coefficients for region II. More will be said about the estimation of the coefficients later in this section.

All the properties in region III were calculated using equation (17) together with the coefficients in table 10. Region III is defined to include temperatures from 15 to 1500 K with limiting densities determined by a maximum pressure of 1000 atm.

In the temperature range of 10 to 15 K either regions I or II may be extrapolated upward or region III may be extrapolated downward (in temperature); however, to insure a smooth transition in the tabulations a weighted average of the two extrapolations was used. The actual calculations were made as follows:

$$\text{Prop}\ (\rho, T) = \underset{\text{Region I or II}}{\text{Prop}}\ (\rho, T)(15. - T)/5 + \underset{\text{Region III}}{\text{Prop}}\ (\rho, T)[1 + (T - 15.)/5.]. \tag{19}$$

To insure a smooth transition between the various regions, equations (18, 19) were used for all properties tabulated in Appendices D and E.

TABLE 8. Coefficients for equation (17) (Region I)

$n_{11} = 1.4792568148 \times 10^{-4}$	$n_{32} = -3.7910190353 \times 10^{-4}$
$n_{12} = -3.2531355477 \times 10^{-3}$	$n_{33} = 1.3806454049 \times 10^{-3}$
$n_{13} = 1.9518739286 \times 10^{-2}$	$n_{34} = -2.5085412058 \times 10^{-3}$
$n_{14} = -1.0571817135 \times 10^{-1}$	$n_{35} = 2.3697560398 \times 10^{-3}$
$n_{15} = 3.3164944449 \times 10^{-1}$	$n_{36} = -9.5726461066 \times 10^{-4}$
$n_{16} = -5.1130022525 \times 10^{-1}$	$n_{41} = 4.9062640310 \times 10^{-3}$
$n_{17} = 3.9940004906 \times 10^{-1}$	$n_{42} = -2.6148004377 \times 10^{-2}$
$n_{18} = -1.5555244471 \times 10^{-1}$	$n_{43} = 3.4221685545 \times 10^{-2}$
$n_{21} = 3.7405931828 \times 10^{-5}$	$n_{51} = 5.4159662622 \times 10^{-6}$
$n_{22} = -6.4103220333 \times 10^{-4}$	$n_{52} = -1.0687806777 \times 10^{-5}$
$n_{23} = 1.8579366177 \times 10^{-3}$	$n_{53} = -8.9484651869 \times 10^{-6}$
$n_{24} = 7.4007986606 \times 10^{-4}$	$n_{61} = -1.5096862619 \times 10^{-7}$
$n_{31} = 4.1362357367 \times 10^{-5}$	$n_{62} = 6.4640898904 \times 10^{-7}$
	$\gamma = -2.50 \times 10^{-3}$

TABLE 9. Coefficients for equation (17) (Region II)

$n_{11} = 2.0461501117 \times 10^{-5}$	$n_{32} = 8.5254608956 \times 10^{-5}$
$n_{12} = 1.2746996288 \times 10^{-3}$	$n_{33} = -2.5163069255 \times 10^{-4}$
$n_{13} = -2.0272929583 \times 10^{-2}$	$n_{34} = 3.2877709285 \times 10^{-4}$
$n_{14} = 7.4648036615 \times 10^{-2}$	$n_{35} = -1.0601957580 \times 10^{-4}$
$n_{15} = -1.7217966521 \times 10^{-1}$	$n_{36} = -1.0687738074 \times 10^{-4}$
$n_{16} = 5.1053439738 \times 10^{-1}$	$n_{41} = 7.9066012040 \times 10^{-3}$
$n_{17} = -4.0178202697 \times 10^{-1}$	$n_{42} = -8.9393485656 \times 10^{-2}$
$n_{18} = 2.6829864632 \times 10^{-1}$	$n_{43} = -1.5076580053 \times 10^{-1}$
$n_{21} = -3.2120950632 \times 10^{-5}$	$n_{51} = 2.6882494327 \times 10^{-6}$
$n_{22} = 1.4159018970 \times 10^{-4}$	$n_{52} = -3.3794316835 \times 10^{-5}$
$n_{23} = 1.4725630701 \times 10^{-3}$	$n_{53} = -2.4495951195 \times 10^{-5}$
$n_{24} = -2.6183549410 \times 10^{-3}$	$n_{61} = -4.2287454626 \times 10^{-8}$
$n_{31} = -1.0246150954 \times 10^{-5}$	$n_{62} = 4.4529354413 \times 10^{-7}$
	$\gamma = -5.00 \times 10^{-4}$

TABLE 10. Coefficients for equation (17) (Region III)

$n_{11} = -3.6027735292 \times 10^{-5}$	$n_{32} = 4.0855110880 \times 10^{-7}$
$n_{12} = -1.6079946555 \times 10^{-3}$	$n_{33} = 1.0900567964 \times 10^{-5}$
$n_{13} = -2.7441763615 \times 10^{-2}$	$n_{34} = -5.0060952775 \times 10^{-5}$
$n_{14} = 1.4739506957 \times 10^{-1}$	$n_{35} = 1.1312765043 \times 10^{-4}$
$n_{15} = -4.3559344838 \times 10^{-1}$	$n_{36} = -1.2539843287 \times 10^{-4}$
$n_{16} = 1.3447956078$	$n_{41} = 5.6875644111 \times 10^{-3}$
$n_{17} = -1.7040375125$	$n_{42} = -1.4438146625 \times 10^{-1}$
$n_{18} = 9.0262674040 \times 10^{-1}$	$n_{43} = 3.3768874851 \times 10^{-3}$
$n_{21} = 1.9661380688 \times 10^{-6}$	$n_{51} = 1.0754201218 \times 10^{-6}$
$n_{22} = 1.7122932666 \times 10^{-4}$	$n_{52} = -4.5264622308 \times 10^{-5}$
$n_{23} = 2.3051000563 \times 10^{-4}$	$n_{53} = 3.8597388864 \times 10^{-5}$
$n_{24} = -9.6564739100 \times 10^{-4}$	$n_{61} = -1.4802195348 \times 10^{-8}$
$n_{31} = -2.3326553271 \times 10^{-7}$	$n_{62} = 4.1721791119 \times 10^{-7}$
	$\gamma = -5.00 \times 10^{-4}$

6.1. Estimation of the Coefficients for the Equation of State

In the case of helium there exists in the world literature a large amount of experimental data which are applicable to the development of an equation of state. A bibliography of references to helium 4 experimental P–V–T data was published by Barieau [2]. The list contains 163 references.

All of these data were considered; however, only a selected set was used in the estimation of the coefficients. Many of these data are quite old and are not of sufficient precision to be of value in estimating the coefficients of an equation of state. For the temperature range

of 60 to 300 K the existing experimental $P-V-T$ data seem to be adequate in precision, accuracy, and quantity. For temperatures below 60 K additional experimental data would be highly desirable for the determination of an equation of state. Such an experimental program should include as wide a temperature and pressure range as possible, particularly below 20 K. In addition to the $P-V-T$ needed, higher order data such as specific heat and speed of sound data would be extremely valuable. Using modern multidata least squares estimation techniques, the inclusion of data such as specific heat data together with the traditional $P-V-T$ data is necessary if the resulting equation of state is to be used for calculating higher order thermodynamic properties. The other most important factor in determining an equation of state is the availability of accurate data from a single source over a wide enough pressure and temperature range. As is the case for helium, data coming from several different laboratories often vary systematically from one source to another although each individual source is internally consistent. The discontinuities caused by such systematic disagreement are very detrimental to the results of least squares estimation techniques.

6.2. Estimation of the Coefficients for Region I of the Multi-Function Equation of State

The coefficients for equation (17) given in table 8 were determined by least squares estimation using several different kinds of data simultaneously. Selected $P-V-T$ data from Lounasmaa [50], el Hadi, et al. [22, 23], Roach [67] and Sullivan [71] were included in the fit together with C_v data from Lounasmaa [50]. The experimental data used in the least squares fit of region I include temperatures and densities much higher than the limiting densities and temperatures of the boundaries of region I. Data for temperatures to 70 K and densities to $3\rho_c$ were included in the fit. The data outside of region I included in the least squares fit were given a very low weight. However, their inclusion in the fit insures proper qualitative behavior of the surface at densities and temperatures higher than those at the boundaries of the region.

In addition to the experimental data mentioned above, the condition of isothermal thermodynamic equilibrium of the coexisting liquid and vapor phases was inserted into the fit at 30 temperatures between 2.2 and 5.1 K. Also, the entropy of vaporization was included in the fit at these temperatures. The thermodynamic relationships for these two conditions are given in equations (20) and (21):

$$G_l - G_g = 0 = \int_{\rho_{\text{sat}_g}}^{\rho_{\text{sat}_l}} \frac{1}{\rho}\left(\frac{\partial P}{\partial \rho}\right)_T d\rho, \tag{20}$$

$$S_g - S_l = \left(\frac{dP}{dT}\right)_{\text{sat}} (V_g - V_l) = -\int_{\rho_{\text{sat}_l}}^{\rho_{\text{sat}_g}} \frac{1}{\rho^2}\left(\frac{\partial P}{\partial T}\right)_\rho d\rho, \tag{21}$$

where G is the Gibbs energy, S is the entropy and the subscripts l and g refer to the liquid and gaseous phases, respectively. The entropy of vaporization, necessary for the implementation of equation (21), was calculated using equations (2), (3), (4), and (5).

The actual fitting of equation (17) was accomplished by using many different thermodynamic properties simultaneously. However, for each property the second virial $B(\rho, T)$, as discussed in section 5, was preserved, and the fitting was performed on a ΔP of

$$\Delta P = P - \rho RT[1 + B(b_i, T)\rho] = \text{remainder of equation (17)}, \tag{22}$$

or some function of ΔP.

For an example of simultaneous use of different kinds of data in least squares techniques see section 5.

As a result of including the thermodynamic relationships of equations (20) and (21) in the actual least squares estimation procedure, the derived thermodynamic properties in the liquid state ($T < T_c$ and $\rho > \rho_{\text{sat liq}}$) may be calculated by the integration of the equation of state across the two-phase region assuring mathematical continuity. Usually when an equation of state is used to calculate the derived properties in the compressed liquid region ($T < T_c$ and $\rho > \rho_{\text{sat liq}}$) some alternate method of crossing the two-phase region is used which always creates a discontinuity in the calculations at T_c for all $\rho > \rho_c$.

The least squares fit as described above was also constrained at the critical point to

$$\left(\frac{\partial^2 P}{\partial \rho^2}\right)_T = \left(\frac{\partial P}{\partial \rho}\right)_T = 0 \tag{23}$$

and to the state point of $P_c = 2.2449$ atmospheres, $\rho_c = 17.3987$ moles/liter, and $T_c = 5.2014$ kelvin.

6.3. Estimation of the Coefficients for Region II of the Multi-Function Equation of State

The coefficients for equation (17) in table 9 were determined by least squares estimation using several different kinds of input data simultaneously. Selected $P-V-T$ data from Lounasmaa [50], el Hadi [22], Roach [67], Glassford and Smith [25] Kierstad [47], Edeskuty and Sherman [17], and Grilly and Mills [28] were included in the fit together with C_v data from Lounasmaa [50]. In addition to the experimental $P-V-T$ and C_v data, values of $P-V-T$, $(\partial P/\partial \rho)_T$, $(\partial P/\partial T)_\rho$, and C_v calculated from the equation for region III were included in the least squares treatment of region II. About 20 points for each of the above properties were used for both 10 and 15 K.

The critical point constraints of section 6.1 were also included in the fit of this region. The accuracy of the resulting $P-V-T$ surface is discussed in a later section.

6.4. Estimation of the Coefficients for Region III of the Multi-Function Equation of State

The coefficients for equation (17) in table 10 were determined by least squares estimation using several

different kinds of data simultaneously. Selected P–V–T data from Lounasmaa [50], Glassford and Smith [25], Canfield, et al. [9], Sullivan [71], Wiebe, et al. [77], Hall and Canfield [30], Grilly and Mills [28], were included in the fit together with C_v data from Lounasmaa [50] and Dugdale and Franck [16].

The critical point constraints of section 6.2 were also included in the fit of this region. The accuracy of the resulting P–V–T surface is discussed in a later section.

7. Derived Thermodynamic Properties Relationships

All of the tabulated property values appearing in in appendices C and D have been calculated using equation (17) as explained in section 6, and the following relationships:

$$S = S^0_{T_0} - R \ln\left(\frac{\rho RT}{P_0}\right) + \int_T^{\rho}\left[\frac{R}{\rho} - \frac{1}{\rho^2}\left(\frac{\partial P}{\partial T}\right)_\rho\right] d\rho + \int_{T_0}^{T} C^0_p \frac{dT}{T}, \quad (24)$$

$$H = H^0_{T_0} + \int_T^{\rho}\left[\frac{P}{\rho^2} - \frac{T}{\rho^2}\left(\frac{\partial P}{\partial T}\right)_\rho\right] d\rho + \frac{P}{\rho} - RT + \int_{T_0}^{T} C^0_p dT, \quad (25)$$

where $S^0_{T_0} = 37.511$ J/mol K, and $H^0_{T_0} = 87.348$ J/mol, $C^0_p = 5/2\ R$, $C^0_v = 3/2\ R$, $T_0 = 4.22$ K and $P_0 = 1.0$ atmosphere. The above values of $S^0_{T_0}$ and $H^0_{T_0}$ are based on the key values for thermodynamics reported in CODATA Bulletin [14]. The $S^0_{T_0}$ and $H^0_{T_0}$ given here differ by 0.443 J/mol K and − 58.980 J/mol, respectively from the earlier tables of McCarty [55, 56] and Mann [53]:

$$C_v = C^0_v - \int_T^{\rho} \frac{T}{\rho^2}\left(\frac{\partial^2 P}{\partial T^2}\right)_\rho d\rho, \quad (26)$$

$$C_p = C_v + T\left(\frac{\partial P}{\partial T}\right)^2_\rho \Big/ \left(\frac{\partial P}{\partial \rho}\right)_T \frac{1}{\rho^2}, \quad (27)$$

$$W = \left[\left(\frac{C_p}{C_v}\right)\left(\frac{\partial P}{\partial \rho}\right)_T\right]^{1/2} \quad (28)$$

In all cases the input variable pair was pressure (P) and temperature (T). This requires an iterative solution of equation (17). In the course of preparing the tabulations it was learned that in solving equation (17) for density, for all pressures at temperatures below 15 K, it is important to begin the iteration with a reasonable guess. For $T < T_c$, and $P < P_{sat}$, the starting value for density should be $\rho < \rho_{sat}$. For $T < T_c$, and $P > P_{sat}$, the starting value for density should be $\rho > \rho_{sat}$. For $T > T_c$, the starting density of 1.5 ρ_c will work for all pressures. The reason for this is that a whole set of unwanted solutions exist in the liquid-vapor coexistence region and another set exist at densities slightly larger than the solid densities at temperatures to 20 K.

The transition between the various regions of equation (17) was handled the same way with the derived properties as it was with the P–V–T. For a detailed explanation of this see section 6.

8. Evaluation of the Equation of State and Tables

There are numerous tests which can be applied to an equation of state. One of the most important is how well the equation reproduces experimental data. Others are not quite so direct, but nevertheless they are important. Each subsection in this section will deal with a particular property or problem relating to the validity of the equation of state or the tabular data.

8.1. Comparison of Experimental and Calculated P–V–T Data

No attempt will be made to compare the equation of state with all of the existing experimental data. Comparisons with the data used in the fit will be made, and in some cases data which were not used in the fit but which are of particular interest.

Wiebe, et al. [77] reported helium P–V–T data for six isotherms from −70 to 200 °C for pressures to 1000 atmospheres. The 50, 100, and 200 °C isotherms were used in estimation of parameters for equation (17). A comparison of their data for the higher temperature isotherms with values from the region III equation of state in section 6 is shown in figure 10.

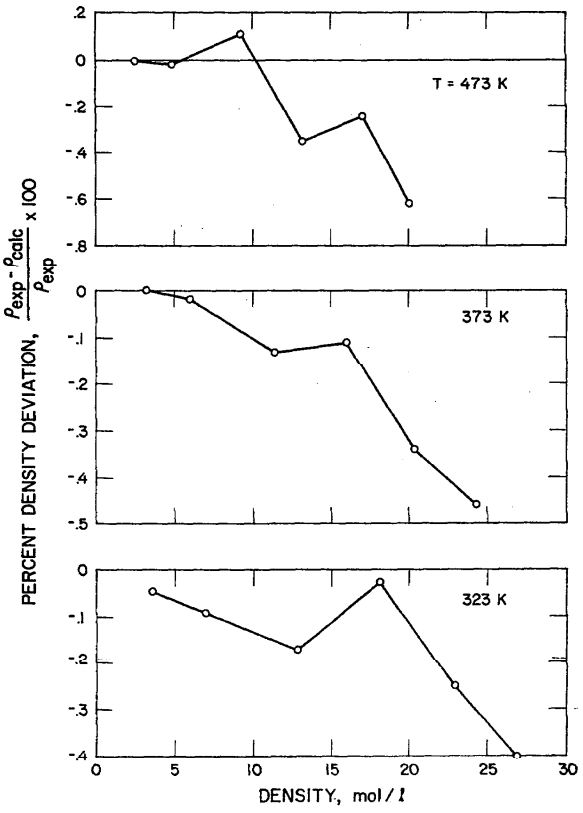

FIGURE 10. Comparison of densities from Wiebe, et al. [77] with equation of state

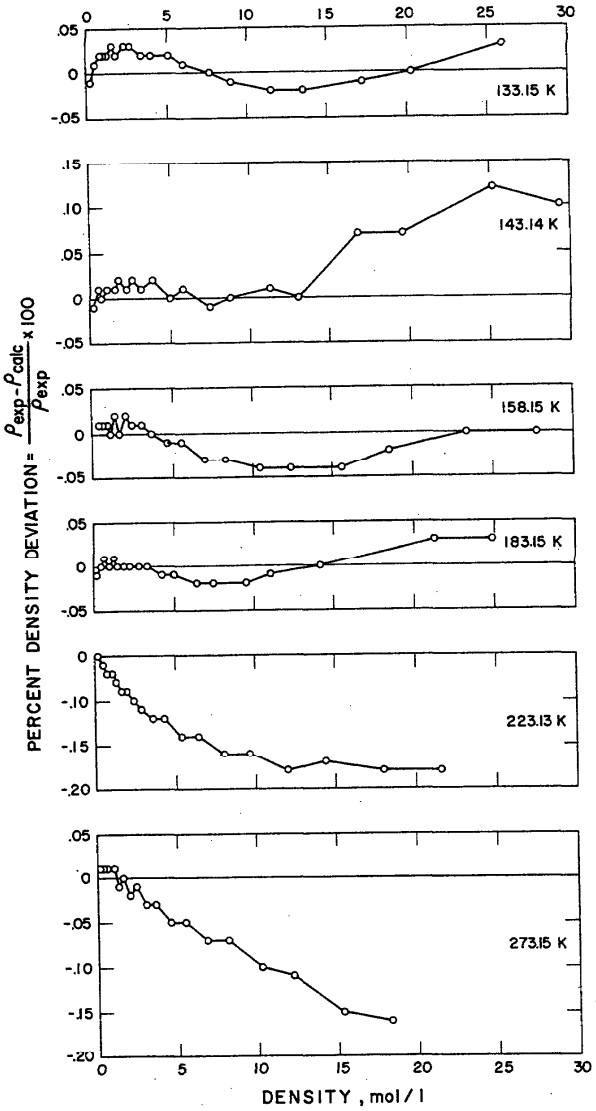

FIGURE 11. Comparison of densities from Canfield, et al. [9] with equation of state

The *P–V–T* measurements by Canfield, et al. [9] cover the temperature range from 133.15 to 273.15 K, with intermediate isotherms of 143.14, 158.15, 183.15, and 223.15 K. A selected set of data from each isotherm was used in the estimation of parameters for the equations of state. A comparison of these data with values from the region III equation of state in section 6 is shown in figure 11.

Briggs, et al. [8] measured the 0 °C isotherm to 800 atmospheres with exceptional care. They claim an accuracy of 0.025 percent in Z. These data were not used in the estimation of the equation of state parameters because they were of limited scope in a region where adequate data exist over a much larger range of pressure and temperature. Figure 12 is a deviation plot between these data and values calculated from the region III equation of state.

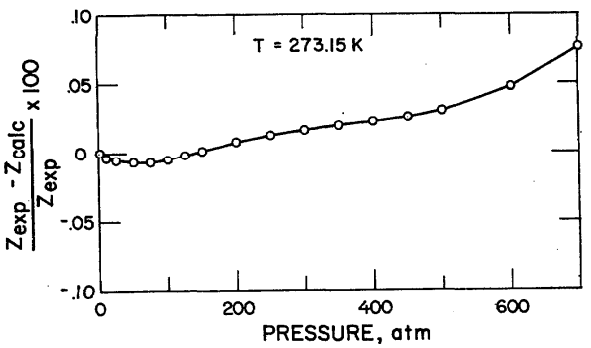

FIGURE 12. Comparison of compressiblity factors from Briggs, et al. [8] with equation of state

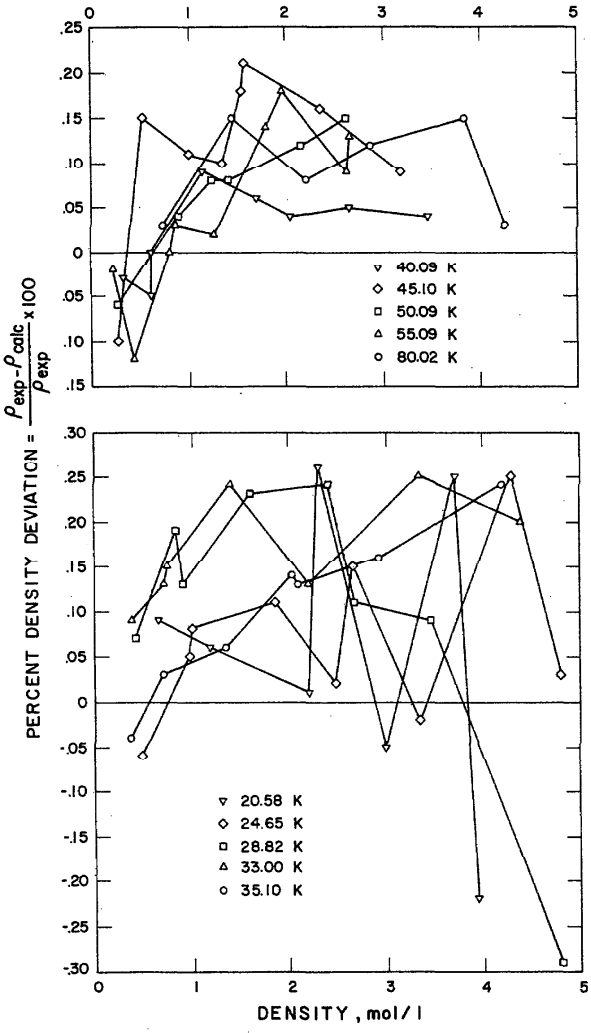

FIGURE 13. Comparison of densities from White, et al. [76] with equation of state

The *P–V–T* measurements of White, et al. [76] cover the range of temperatures from 20.0 to 273.15 K. These isotherms were included in the second virial analysis and exhibited more scatter than some of the other data. Only the isotherms from 20 to 60 K were included in the estimation of the parameters for the equations of state given in section 6. A comparison of these data with values calculated from the region III equation of state in section 6 is given in figure 13.

The *P–V–T* data for helium by Sullivan [71] include isotherms from 70 to 120 K with pressures to 690 atmospheres. Most of these data were included in the estimation of the parameters for the equations of state in section 6. A comparison of these data with values calculated from the region III equation of state in section 6 is given in figure 14.

Hall and Canfield [30] reported isothermal *P–V–T* data for the He-N_2 system. These measurements include data for pure helium at three temperatures, −190 °C, −170 °C, and −160 °C with pressures to 700 atmospheres. Most of these data were included in the estimation of the parameters for the equations of state in section 6. A comparison of these data with values calculated from the equation of state for region III is given in figure 15.

Lounasmaa [50] reported experimental *P–V–T* data for helium between the temperatures of 3 and 20 K. These data were taken along isochores for 25 different densities ranging from about 0.5 critical density to about three times critical density. This particular set of data is of prime importance to this correlation and they will be discussed at greater length than most of the other data sources. When forming an equation of state for a fluid it is highly desirable to have a single data source which extends from the gaseous region at temperatures well below critical temperature to the liquid region at corresponding temperatures and extending to temperatures of at least three times critical for the same range of densities covered by the subcritical temperature range. These data cover this important range of state conditions, and there are over 250 data points; however, there are some other problems. First it is the only data set for helium which covers this range of pressures and temperatures making comparison possible only at isolated points usually at the extremities of the data. Where these comparisons are possible the agreement is not good. Lounasmaa [50] compares his results with the earlier work of Keesom and Keesom [38] and Holborn and Otto [34]. Keesom and Keesom's [38] data were taken in the liquid region at temperatures of 3 to 4 K with pressures from 10 to 30 atmospheres and disagree with Lounasmaa [50] systematically by slightly more than 1 percent in density (Lounasmaa's densities are higher). The comparison with Holborn and Otto's [34] data is made for 20 and 15 K with pressures to 92 atmospheres and the disagreement is from −1 percent to +1 percent in density. Edeskuty and Sherman [17] reported helium-4 *P–V–T* data for the dense liquid phase in the temperature range of 2.2 to 4.2 K with pressures to 140 atmospheres. These data generally disagree with Lounasmaa by about 0.8 percent in density. Glassford and Smith [25] measured *P–V–T* data from 4.2 to 20 K at pressures from 100 to 1300 atmospheres and in the small region of overlap with Lounasmaa's data the disagreement is 1.3 percent in density. Figures 16, 17, and 18 show the deviations between densities calculated using equation (17) and Lounasmaa [50], Edeskuty and Sherman [17], and Glassford and Smith [25], respectively.

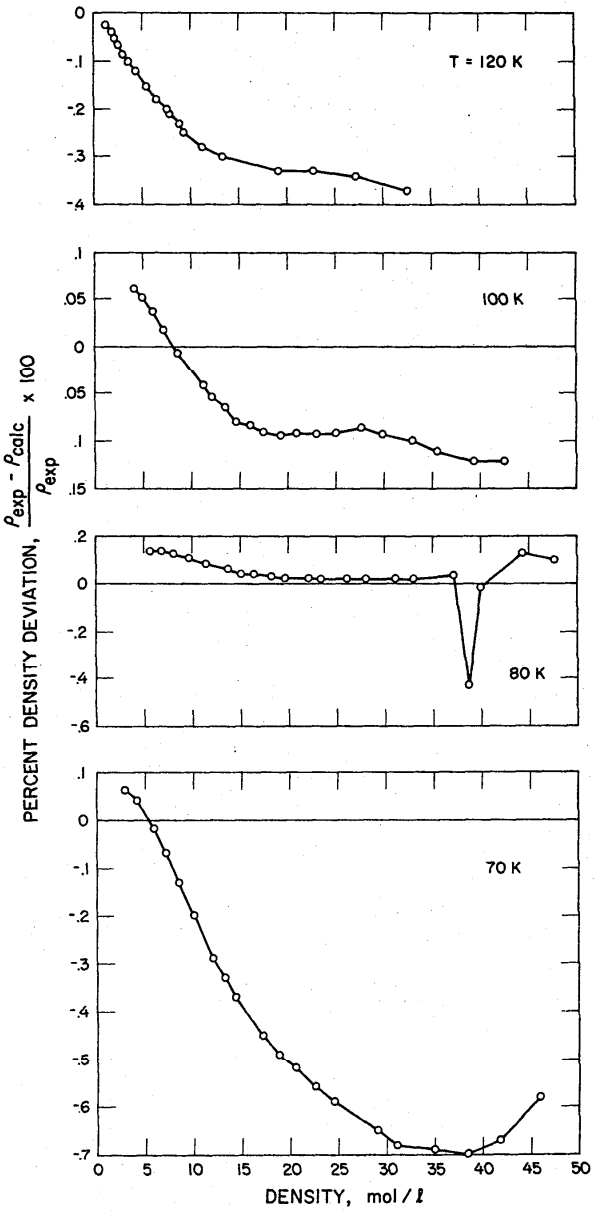

FIGURE 14. Comparison of densities from Sullivan [71] with equation of state

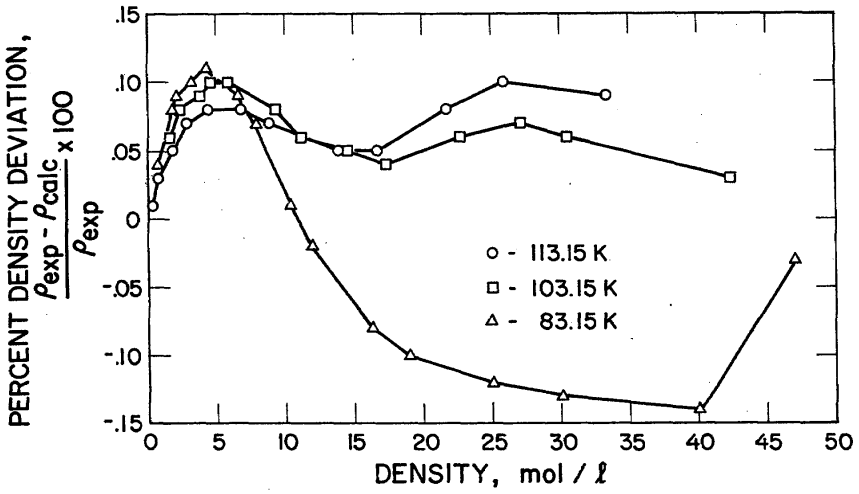

FIGURE 15. Comparison of densities from Hall and Canfield [30] with equation of state

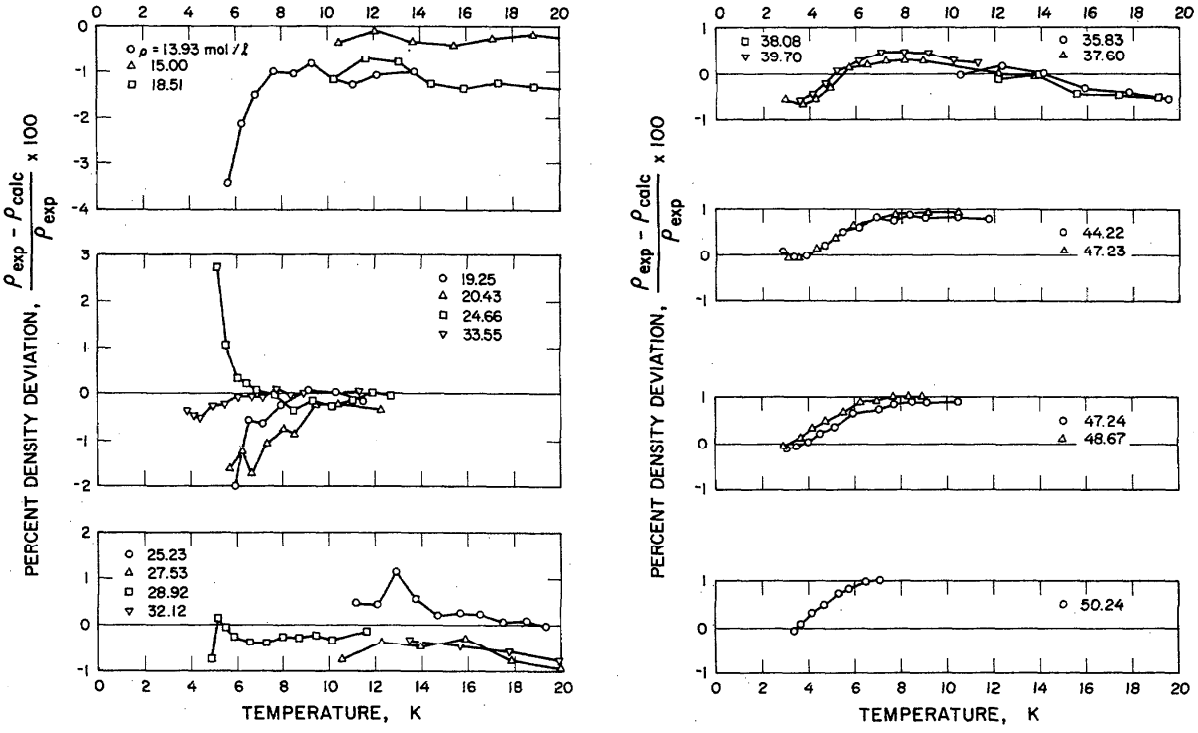

FIGURE 16. Comparison of densities from Lounasmaa [50] with the equation of state

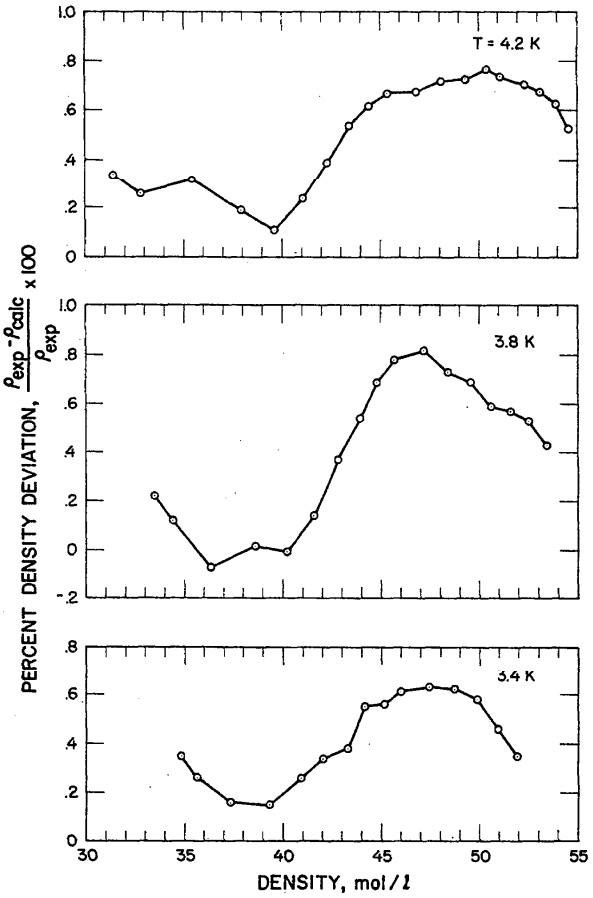

FIGURE 17. Comparison of densities from Edeskuty and Sherman [17] with the equation of state

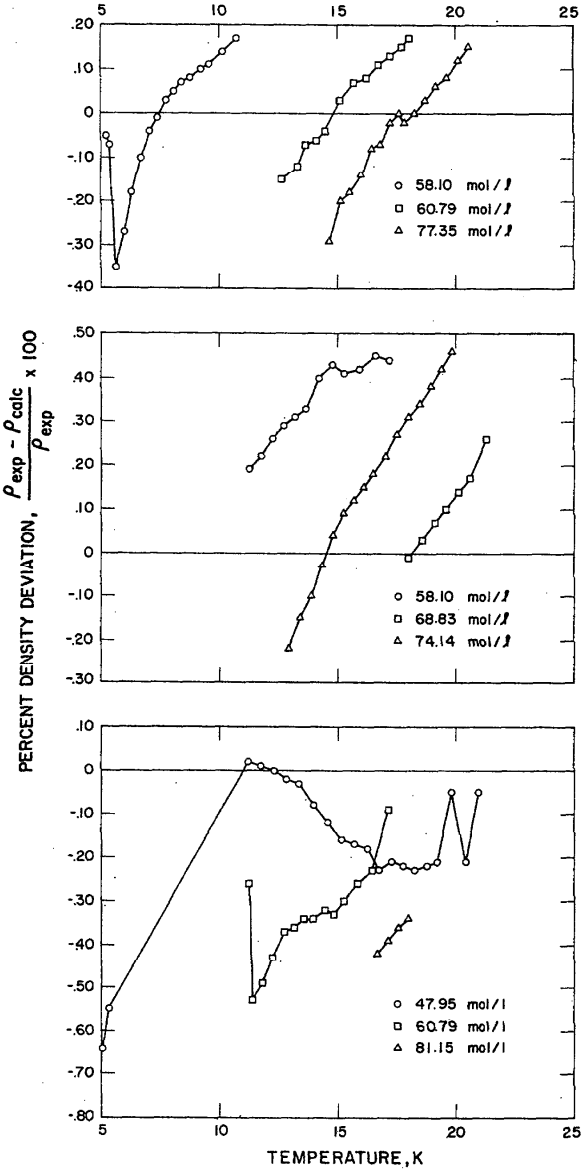

FIGURE 18. Comparison of densities from Glassford and Smith [25] with the equation of state

The deviation plot for the Lounasmaa data (figure 16) shows the largest deviations at temperatures approaching the critical temperature for densities of 25 moles/liter and below. This is possibly due to the uncertainty in the temperature measurement. Lounasmaa used a carbon resistance thermometer calibrated against a gas thermometer to measure temperatures between 4.2 and 12 K. He estimates the accuracy of the gas thermometer to be ±0.005 K. The uncertainty of Lounasmaa's temperature measurements between 4.2 and 12 K are estimated here to be ± .015 K. Near critical conditions where $(\partial\rho/\partial T)_v$ is large, an error in measuring the temperature corresponds to a large uncertainty in density. For example at 5.2 K and 2.3 atmospheres the density is 0.0886 gm/cm³ and an error of 0.015 K in temperature would correspond to an error of 0.0035 g/cm³ or about 4 percent. However, the classic equation of state density deviation pattern for the near critical region is also illustrated in figure 16, i.e., for densities less than critical density an equation of state tends to predict densities which are too large and for densities larger than critical density, an equation of state tends to predict densities which are too small. The 13.93[2] and the 24.66 moles/liter isochores show such a pattern while the 19.25 and 20.45 moles/liter isochores do not follow this pattern. In the author's opinion the questions that these strange deviation patterns raise will only be answered when new definitive measurements are made.

Grilly and Mills [28] published P–V–T data for helium-4 along the melting line. Figure 19 shows the difference between the densities reported by Grilly and Mills [28] and those calculated from equation (17). The

[2] The densities in Lounasmaa's thesis are tabulated in reduced form. By private correspondence with Lounasmaa he suggested that the correct reducing factor is 0.0688 g/cm³ instead of 0.0693 as reported in the thesis.

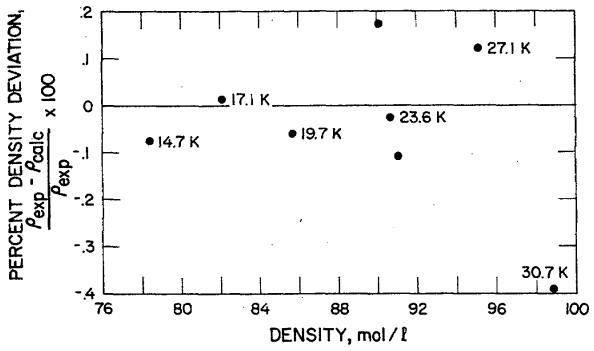

FIGURE 19. Comparison of densities from Grilly and Mills [28] with the equation of state

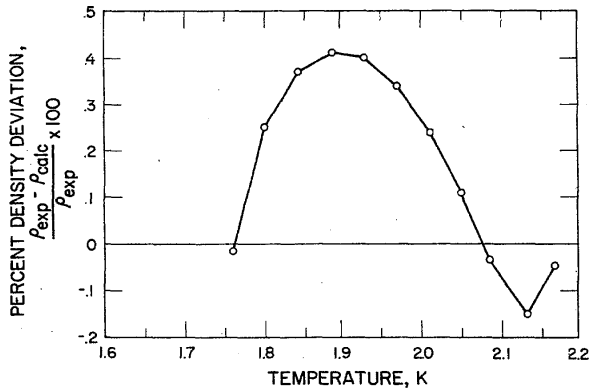

FIGURE 20. Comparison of densities from Kierstead [47] with the equation of state

30.7 K point corresponds to a pressure of 3555.6 kg/cm^2. These data were included in the least squares estimation of the equation of state parameters in regions II and III.

Kierstead [47] published P–V–T data along the lambda line. These data were included in the least squares estimation of the equation of state parameters for region II. Figure 20 is a deviation plot for density between Kierstead's [47] experimental densities and densities calculated from equation (17).

Keller [41] published isothermal P–V–T data for helium-4 at low densities for temperatures between 2.15 and 3.96 K. These data were included in the determination of the second virial coefficient as described earlier. Figure 21 shows the deviations between the experimental and calculated pressures.

The P–V–T data for the saturated liquid and vapor of helium-4 used in the determination of the parameters for the equation of state in regions I and II are primarily from el Hadi [22, 23]. A few points from Roach [67] were also included (see the section on the critical point). A deviation plot for the el Hadi [22, 23] data is given in figure 3.

As mentioned earlier in this section, the Glassford and Smith [25] data disagree with those of Lounasmaa

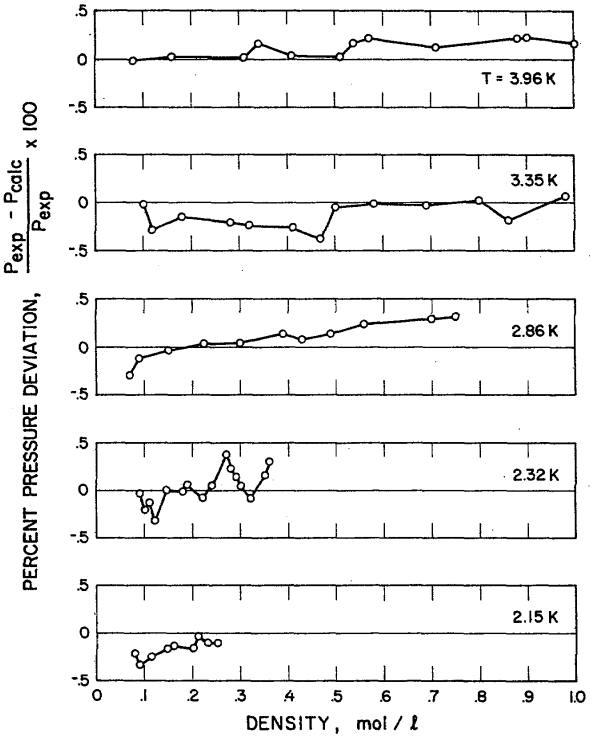

FIGURE 21. Comparison of pressures from Keller [41] with the equation of state

[50] by about 1.3 percent in density in their small region of overlap. This region of overlap occurs at the lowest densities measured by Glassford and Smith [25] When a comparison of Glassford and Smith's [25] data along the melting curve is made with similar data by Grilly and Mills [28], two major disagreements result. First, the melting curves (P–T curve) agree at temperatures of about 6 K and below, but differ systematically from a 0 difference at 6 K to about a 0.15 K difference at 16.5 K. (Glassford and Smith's [25] P–T curve is above the Grilly and Mills' [28] curve.) Second, the densities of Glassford and Smith [25] along the melting line disagree in a more random fashion with those of Grilly and Mills [28] by as much as 2 percent.

Figure 18 shows a pronounced systematic deviation pattern between the data of Glassford and Smith [25] and the equation of state. This systematic difference between the Glassford and Smith [25] data and the equation of state, in the author's opinion, is due primarily to systematic errors in the experimental data.

8.2. Comparisons of Experimental and Calculated C_v Data

A selected set of the experimental C_v data of Lounasmaa [50] were included simultaneously with P–V–T and other data in the least squares estimation of the parameters for equation (17). In figure 22 the solid lines are C_v for helium along lines of constant density, taken from the smoothed tables in Lounasmaa's thesis. The

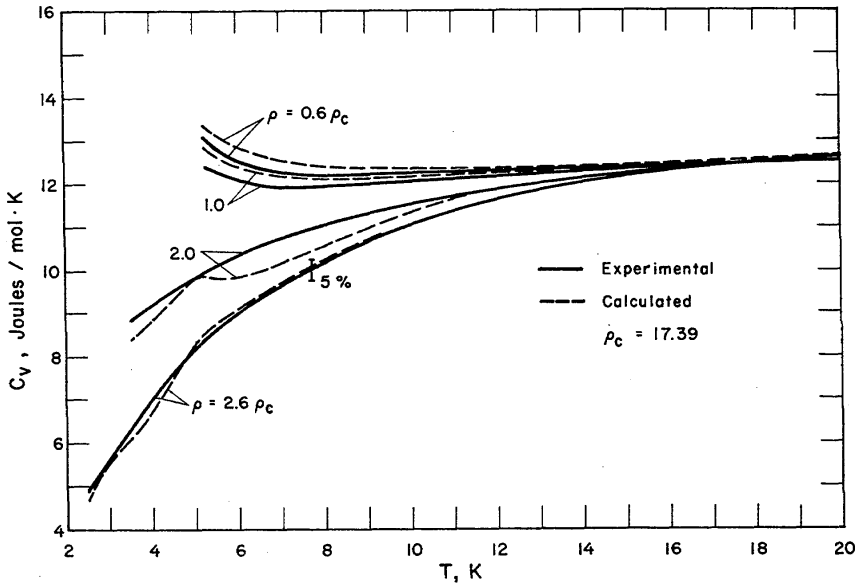

FIGURE 22. Comparison of C_V's from Lounasmaa [50] with values calculated using equation (17)

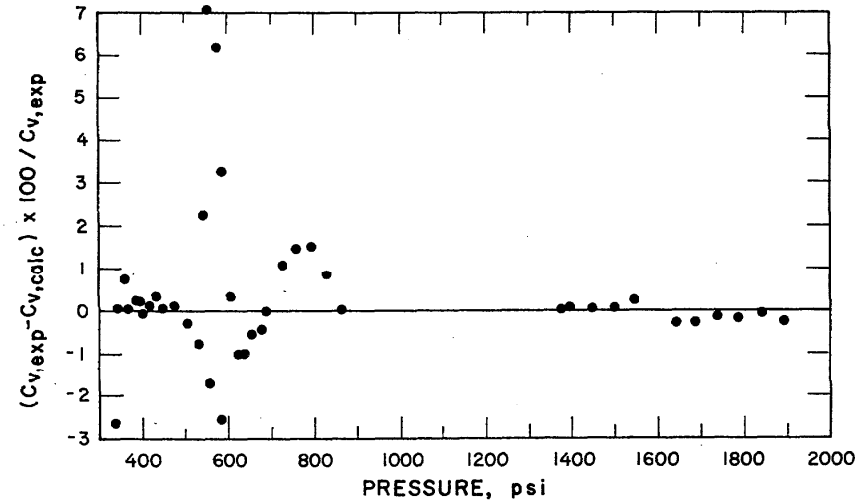

FIGURE 23. Comparison of C_v's from Dugdale and Frank [16] with those calculated from the equation of state

dashed line is the C_v predicted by equation (17) for the same line of constant density.

Dugdale and Franck [16] measured the C_v of helium-4 of the solid and highly dense liquid phases at temperatures from about 7 to 30 K. Figure 23 shows the difference between the experimental C_v data and the C_v predicted by equation (17) for the same density and temperature. The C_v at a density of 84–96 moles/liter and a temperature of 29 K corresponds to a pressure of 1892 atmospheres. For a discussion of C_v errors see section 8.5.

8.3. Comparison of Experimental and Calculated Speed of Sound

Gammon and Douslin [24] published experimental speeds of sound for helium-4 for 14 isotherms covering the range of temperature from −175 to 150 °C with pressures to 150 atmospheres. Figure 24 shows the difference between the experimental and calculated velocities of sound for two isobars. The deviations for the intermediate isobars all lie between these two, and the deviations at lower pressures are all less than those shown for the 50 atmosphere isobar.

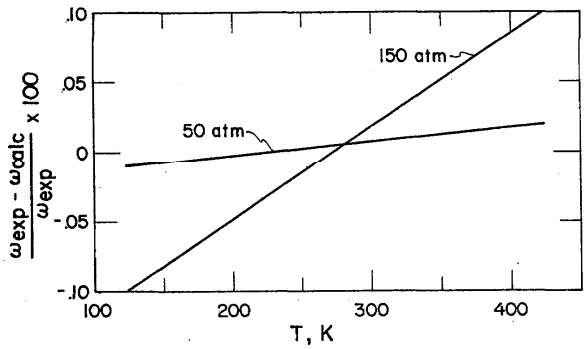

FIGURE 24. Comparison of speed of sound data from Gammon and Douslin [24] with values calculated from the equation of state

Van Itterbeek, et al. [75] measured the speed of sound for helium-4 at 4 temperatures ranging from 70.2 to 91 K for pressures to 75 kg/cm^2. A comparison of these data with those predicted by the equation of state (equation (17)) indicated a maximum deviation of 0.39 percent and an average deviation of 0.15 percent.

The speed of sound data of Plumb and Cataland [66] were used to determine the second virial coefficient (see section 5). These data range in temperature from 3.23 to 20 K with pressures to about 1 atm. The equation of state reproduces these data with a maximum difference of 0.1 percent and an average difference of 0.02 percent.

Atkins and Stasior [1] measured the speed of sound for liquid helium-4 from 1.2 to 4.2 K for pressures to 69 atmospheres. A comparison between their data for temperatures and pressures included in this correlation with those calculated from equation (17) show a 2–4 percent disagreement (values calculated from equation (17) are lower) for the saturated liquid and an average and maximum disagreement of about 0.75 percent and 1.75 percent, respectively, for the remainder of the data.

8.4. Comparison with Other Correlations

Comparisons with several other correlations have been made. A correlation carried out in the USSR by Tsederberg, et al. [72] covered the temperature range of 0 to 3000 °C with pressures to 200 bar. The maximum difference in pressure between Tsederberg [72] and this work is −0.2 percent at 200 bar and 0 °C. The only other point which deviated as much as 0.1 percent is at 3000 °C and 200 bar. This represents an extrapolation of the equation of state (equation (17)) used here from 1400 to 3273.15 K.

Another correlation of the properties of helium by Peterson [65] of the Danish Atomic Energy Commission covers the range of temperature from 273 to 1800 K with pressures to 100 bar. A comparison of the tables by Peterson [65] with this work, revealed no differences greater than 0.06 percent in pressure over the entire range of pressure and temperature.

A correlation of the thermodynamic properties of helium by Mann [53] covered the range of temperature from 3 to 300 K with pressures to 100 atmospheres. Figure 25 shows the percent deviation between Mann [53] and this work for all the properties tabulated by Mann. There are two points to be noted in figure 25; first, the deviations were calculated on the basis of specifying a pressure and temperature; and second, for temperatures greater than 10 K, the differences seldom exceed 1 percent.

A correlation of the thermodynamic properties of helium by McCarty [55] was issued on an unpublished interim basis and is a report on work preliminary to this document. The tables in this earlier report were calculated with the same equation (equation (17)) but with a single set of coefficients for the entire temperature pressure range. The properties in this preliminary report are not as accurate as those tabulated here especially in the region of high density ($\rho > \rho_c$) at temperatures below 15 K. The present tabulations should be used in preference to the earlier ones.

A correlation of the thermophysical properties of helium by McCarty [56] is based on this work, and the thermodynamic properties in that publication are identical with those tabulated here with the exception of units and a different reference state for entropy and enthalpy (see section 7). The earlier publication was intended to make tabulations available as soon as possible and does not contain any of the details of the correlation given here, the earlier publication does tabulate a number of properties such as thermal conductivity, viscosity, dielectric constant, and special parameters used in heat transfer calculations. The additional properties tabulated in the earlier publication are of interest to a limited audience and in some cases are highly uncertain and are therefore not appropriate to include here.

8.5. Discussion of Errors

There are a few general comments which may be made about the accuracy of the helium tables. First it seems that for temperatures above 15 K the maximum error in any of the properties should not be much more than 1 percent, except perhaps the C_p in the transposed critical region (locus of maxima of C_p along isobars for pressures greater than critical pressure) which is still evident between 15 and 20 K. In the range of temperature from 30 to 70 K there are no reliable experimental data above about 30 atmospheres, which makes the estimate of 1 percent in this range a speculation; however at 30 K there are P–ρ–T and C_v–ρ–T data to nearly 3000 atmospheres, and these data agree well with the equation of state. For temperatures above about 500 K there are no data for pressures beyond the second virial coefficient range, but the contribution of higher order virials becomes so small that the 1 percent estimate seems realistic.

Below about 10 K one begins to encounter uncertain-

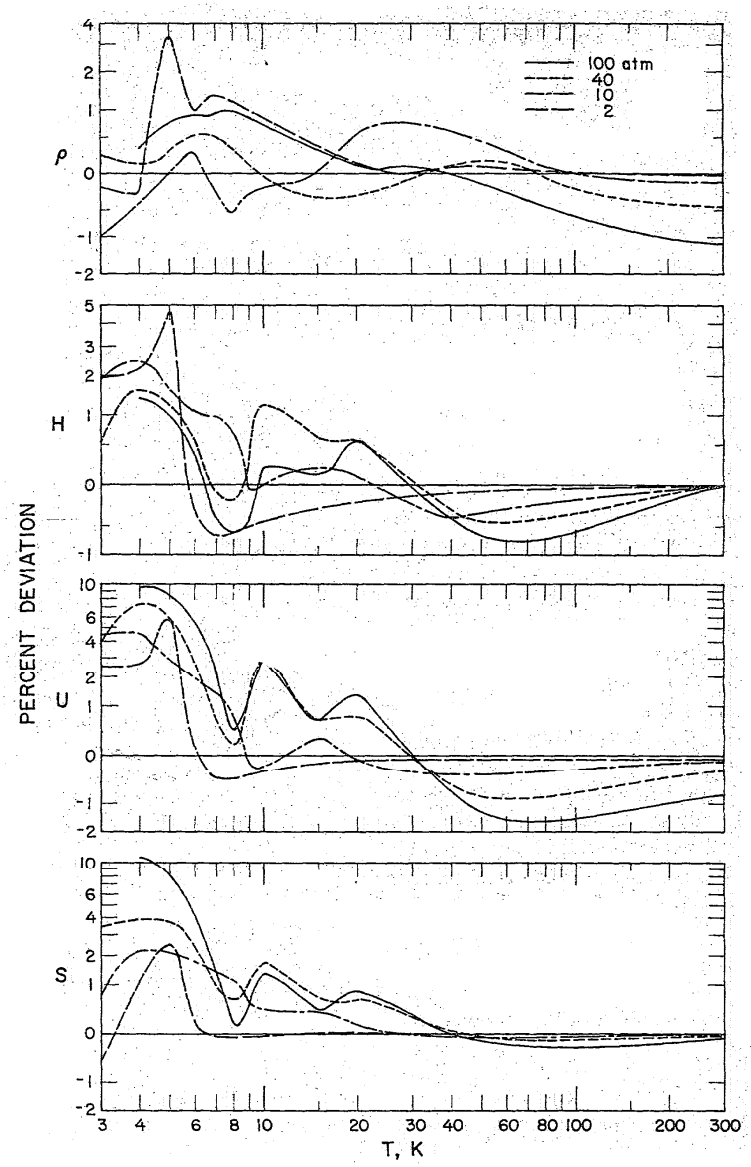

FIGURE 25. Differences between correlation of the thermodynamic properties of helium by Mann [53] and this work]

ties greater than 1 percent in most of the properties, especially in the high density fluid. The region of greatest uncertainty in the tabulated properties is for temperatures below 7 K and densities greater than critical density. The estimates of errors shown in figures 26, 27, and 28 are based on many different factors but primarily on the uncertainties of the experimental data used in determining the equation of state and the agreement between those data and the equation of state.

In general the estimated error of C_p is the same as C_v, except in the critical region and the transposed critical region where the calculation of C_p depends heavily on the compressibility, and the compressibility in this region is uncertain by several percent. Therefore, the uncertainty of C_p in the region outlined above is greater, but unfortunately it is difficult to estimate how much greater.

In the two regions of uncertainty of greater than 10 percent in figure 28, the incorrect functional form of the equation of state is at fault. In the critical region the calculated C_v is too small because the equation of state is analytic at the critical point, and in the dense fluid region along the solid line, the equation of state predicts a C_v which is too large because the influence of the upturn in C_v as the lambda line is approached has carried on up the solid line to a region where experimental evidence indicates no such upturn exists. The C_p calculated via the equation of state in these two regions

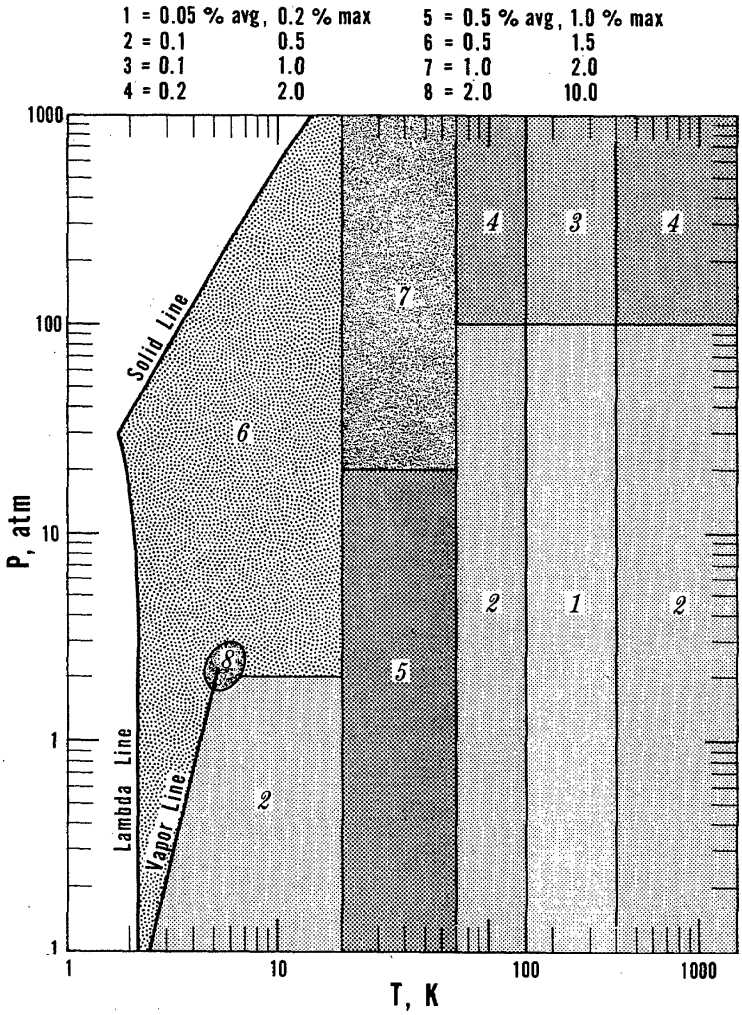

FIGURE 26. Estimates of uncertainty in densities calculated using the equation of state

will also be affected but not in the same manner. The C_p from the equation of state at the critical point is infinite as it should be and therefore will not directly follow the error in C_v, however in the dense fluid region along the solid line, the error in C_p will follow the error in C_v more closely. See section 11 for the C_v along the melting curve.

9. Thermodynamic Properties in the Critical Region

The equation of state given in section 6 is constrained to a critical point of $P_c = 2.2449$ atm (2.2746×10^5 P_a); $T_c = 5.2014$ K; and $\rho_c = 17.399$ mol/l. The first and second partial derivative of pressure with respect to density at constant temperature are also constrained to be zero at the above critical point. These constraints are quite easily made with essentially no detrimental effect to the P–V–T surface of the equation of state in other areas; however, even with the above constraints imposed upon the equation of state, the behavior is still not qualitatively correct at or near the critical point. To achieve the qualitatively correct C_v in the critical region, the partial derivative $(\partial^2 P/\partial T^2)_\rho$ must become large. If this condition is included with the other constraints, the deterioration of the P–V–T surface outside the critical region is disastrous. In other words, the mathematical form of the equation of state is not correct at the critical point. Quite a lot of experimenting was done with different mathematical forms which permit the proper behavior of C_v at the critical point. In every case, if the equation had proper C_v behavior, the necessary parameter estimations became difficult and the equation would not allow a closed form of the integrations necessary for the fitting and calculation of the derived thermodynamic properties.

In the last four or five years there has been quite a lot of theoretical and semi-theoretical work done on the equation of state and scaling laws for fluids in the near critical region (see, for example, Hohenberg and

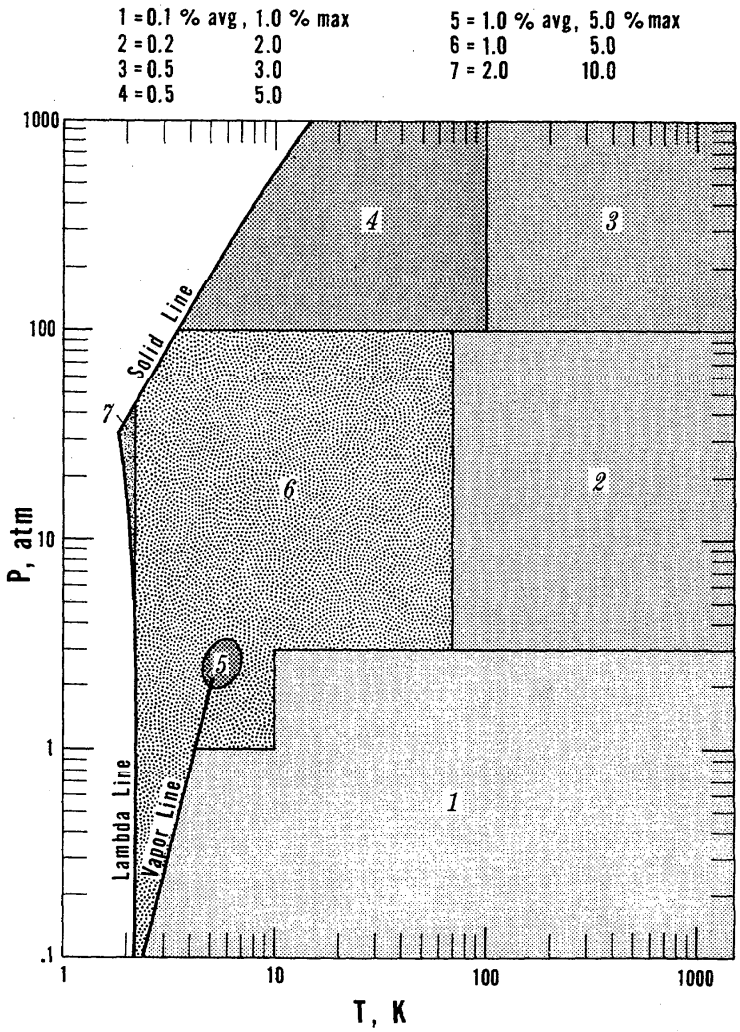

FIGURE 27. Estimates of uncertainty in enthalpies calculated using the equation of state

Barmatz [31], Kierstead [45] and Greer, et al. [27], and Vicentini-Missoni [75a]). These equations have been quite successful in predicting the thermodynamic properties of fluids in the critical region.

All of these equations predict the anomalous behavior of fluids at the critical point, are therefore non-analytic and present the same problems encountered by the author in a more empirical approach to the problem of a mathematical model that would give qualitatively correct C_v's in the near-critical region. There does not seem to be any simple way of combining the non-analytic equation of state, in the critical region with the analytic forms of the equation of state which is a more desirable form over the rest of the fluid phase space. For this reason the properties of the critical region will be given in the form of tables, graphs and references. If the reader needs a mathematical model of the equation of state for helium he is referred to the three references in the previous paragraph.

9.1. *P–V–T* in the Critical Region

The critical region of helium-4 has been the subject of intensive experimental investigation in recent years. Many properties of helium have been measured. Roach [67], using the capacitive technique, measured the dielectric constant of helium-4 at over 500 different state points in the immediate vicinity of the critical point. The dielectric constant was then converted to density via the Clausius-Mossotti equation,

$$\rho=\frac{3M}{4\pi p}\left(\frac{\epsilon-1}{\epsilon+2}\right), \tag{29}$$

where ϵ is the dielectric constant, M is the molecular weight, and p is the molar polarizability. Roach assumed p to a constant of 0.1230 cm³/g. An experimental measurement of p for helium [43] indicates p is a function of density

$$p=0.123396-0.0014\rho, \tag{30}$$

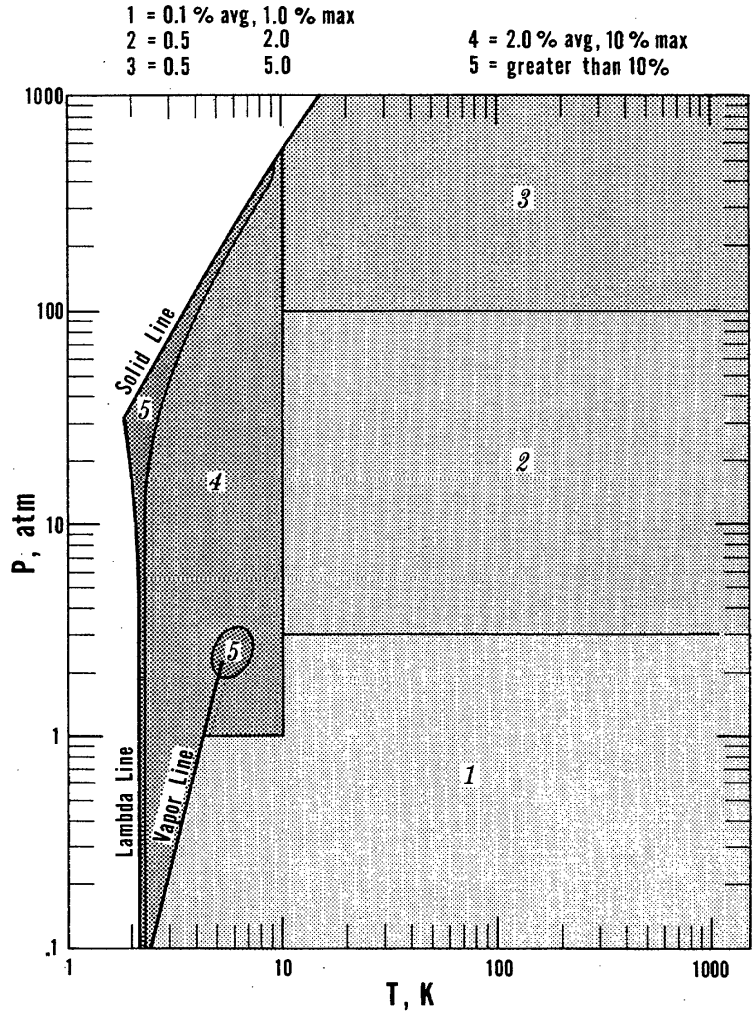

FIGURE 28. Estimates of uncertainty in C_v's calculated using the equation of state

where ρ is in g/cm³. All of Roach's experimental densities were adjusted to reflect the p of equation (30). Roach's P–V–T data contain 38 points on the saturation curve between 5.0041 K on the vapor side to 4.9332 K on the liquid side. Figure 29 is a plot of Roach's data with the temperatures adjusted by equation (3). The solid lines represent Roach's data and the dashed line is from the equation of state (equation (17)). Edwards [19] and others have also measured P–V–T of helium in the critical region. Roach's data were chosen because of the large number of measurements made over essentially the entire critical region. Roach's saturated liquid and saturated vapor densities disagree with those of el Hadi [23] in their small region of overlap by a little over 1 percent. At first thought this would seem excessive; however, translated into temperature the disagreement becomes about three millidegrees. A 3 millidegree disagreement is not large and one would have to say that they agree to with the precision of the measurements. On this same basis of comparison, Edwards is also in agreement with the other two sources.

The maximum difference between pressures from equation (17) and those of Roach is 0.3 percent. The average difference is 0.08 percent. The difference between the calculated and experimental densities, however, may be as much as 7 percent.

The equations for the density of the saturated liquid and vapor phases (equations (4) and (5)) as well as the vapor pressure equation (1) do not have the correct functional form to be consistent with the scaling laws. According to scaling law theory the equation for the saturated liquid and vapor densities as a function of temperature should not contain the term which has the exponent of 2/3. Equations (31) and (32) have been fit to the same data as equations (4) and (5) but the term with the 2/3 power has been left out and the β was determined from Roach's [67] data above.

$$\rho_g = \rho_c + A_g(1 - T/T_c)^{\beta_g} + \sum_{i=2}^{6} SC_{g_i}(1 - T/T_c)^{\left(1+\frac{i-2}{3}\right)}, \qquad (31)$$

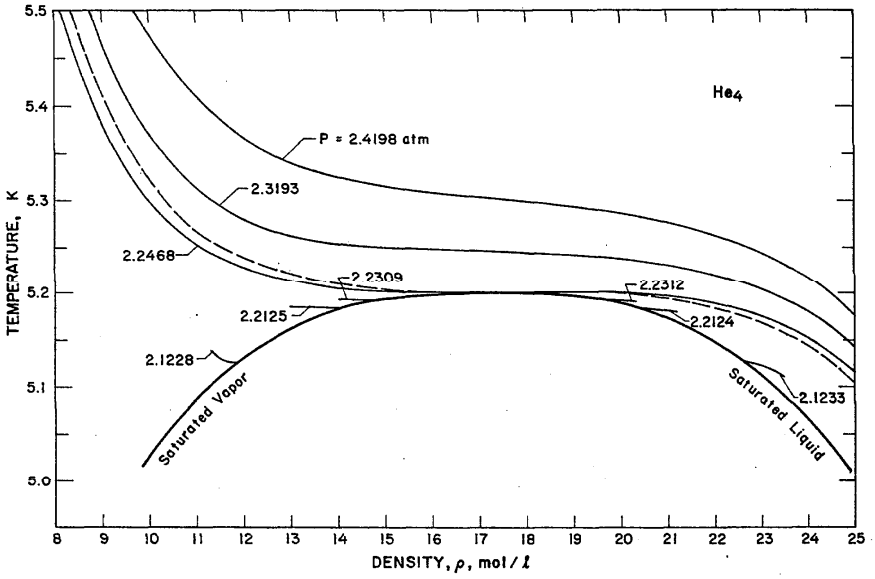

FIGURE 29. A temperature-density plot of Roach's experimental $P-V-T$ data for helium-4 in the near critical region

and

$$\rho_l = \rho_c + A_l(1-T/T_c)^{\beta_l} + \sum_{i=2}^{6} SC_{l_i}(1-T/T_c)^{\left(1+\frac{i-2}{3}\right)}, \qquad (32)$$

where $\beta_g = \beta_l = 0.355444213$ and the SC_{g_i} and SC_{l_i} are given in table 11. The temperature scale used in equations (4), (5), (31) and (32) is the 1958 helium vapor pressure scale adjusted by equation (3). The deviations between experimental densities and those calculated from equations (31) and (32) are almost identical to those shown in figure 3.

TABLE 11. Coefficients for equations (31) and (32)

$A_g = -9.242639719 \times 10^{-2}$	$A_L = 1.0914951199 \times 10^{-1}$
$SC_{g_2} = -1.7283968156 \times 10^{-1}$	$SC_{l_2} = -5.7354057366 \times 10^{-1}$
$SC_{g_3} = 6.2888605651 \times 10^{-1}$	$SC_{l_3} = 2.8890961508$
$SC_{g_4} = -9.6729472221 \times 10^{-1}$	$SC_{l_4} = -5.8442373556$
$SC_{g_5} = 7.8552645724 \times 10^{-1}$	$SC_{l_5} = 5.4230756349$
$SC_{g_6} = -2.5054802998 \times 10^{-1}$	$SC_{l_6} = -1.9428808351$

The equation for the vapor pressure of helium between the critical temperature and the lambda point, equation (1), is based on the 1958 helium-vapor-pressure temperature scale. It seemed worthwhile to preserve this representation of that temperature scale even though the functional form is known to be incorrect. The segment of the vapor pressure curve from the normal boiling point was re-fit to a functional form consistent with scaling law theory utilizing new information by Kierstead [46] about the shape of the vapor pressure curve at the critical point. Equation (33) has been constrained to the points listed in table 1 except the dP/dT at 5.1994 K is 1289200.0 μm Hg/K, Kierstead [46], and the constraint to the lambda point was omitted. The temperature scale is handled exactly as is reported in section 3.

$$\ln P = A_{P_1}(1-T/T_c)^{\alpha} + \sum_{i=2}^{9} A_{P_i}(T/T_c)^{(i-3)}, \qquad (33)$$

where P is in μm Hg, T is in K, $T_c = 5.1994$ K, and α is 1.9. The A_{P_i} are given in table 12. The deviations between the 1958 helium scale and equation (33) are about the same as those encountered with equation (1).

TABLE 12. Coefficients for equation (33)

$A_{p_1} = 3.3091363152 \times 10^{1}$	$A_{p_6} = 2.3721292437 \times 10^{5}$
$A_{p_2} = 3.7434535255 \times 10^{3}$	$A_{p_7} = -1.6478097574 \times 10^{5}$
$A_{p_3} = -3.0462038761 \times 10^{4}$	$A_{p_8} = 6.3552729819 \times 10^{4}$
$A_{p_4} = 1.0603013575 \times 10^{5}$	$A_{p_9} = -1.0499388807 \times 10^{4}$
$A_{p_5} = -2.0478248349 \times 10^{5}$	

9.2. Specific Heat in the Critical Regions

The behavior of the specific heat at constant volume, C_v, in the critical region has been the subject of both experimental and theoretical investigation in recent years. Theoretically the scaling laws predict C_v to become discontinuous and very large as the critical point is approached. The C_v data taken by Moldover [60] have been extensively studied in conjunction with the scaling laws. Figure 30 shows the experimental C_v data for helium-4 taken by Moldover [60]. The experimental temperatures have been adjusted by equation (3).

The specific heat at constant pressure, C_p, is usually obtained by using experimental measurements of C_v and the relationship

$$C_p = C_v + T(\partial P/\partial T)_\rho^2/\rho^2(\partial P/\partial \rho)_T. \quad (34)$$

The C_p's shown in figure 31 were obtained by using Moldover's [60] C_v data and the derivatives $(\partial P/\partial T)_\rho$ and $(\partial P/\partial \rho)_T$ calculated from equation (17). The experimental temperatures have been adjusted by equation (3).

TABLE 13. C_v for helium-4 along the λ curve

ρ g/cm³	C_v J/mol·K	T K
1.50	46.7	2.15
1.55	43.8	2.12
1.60	40.8	2.08
1.65	37.5	2.03
1.70	33.8	1.96
1.75	29.8	1.88
1.80	25.1	1.77

Lounasmaa reports these values of C_v to be estimates rather than measured values.

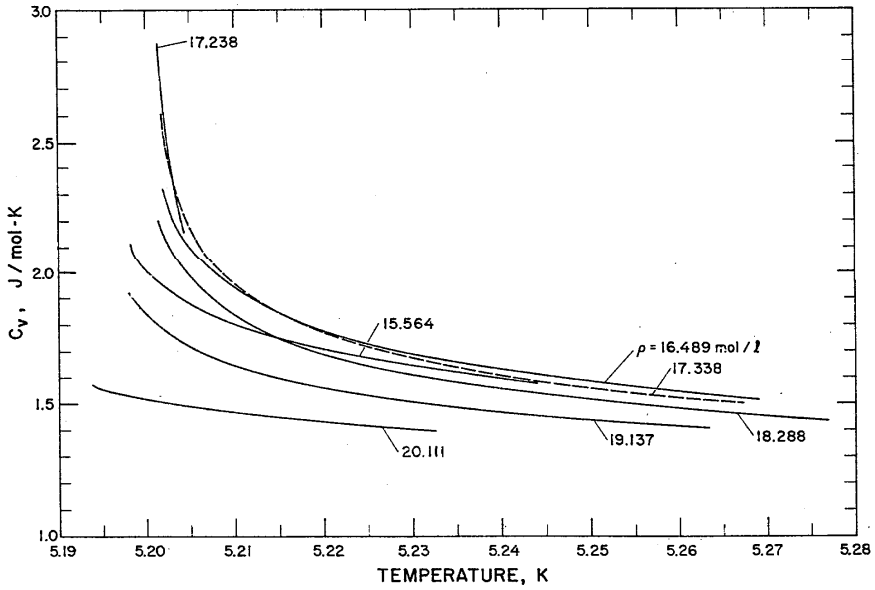

FIGURE 30. C_v in the near critical region of helium-4

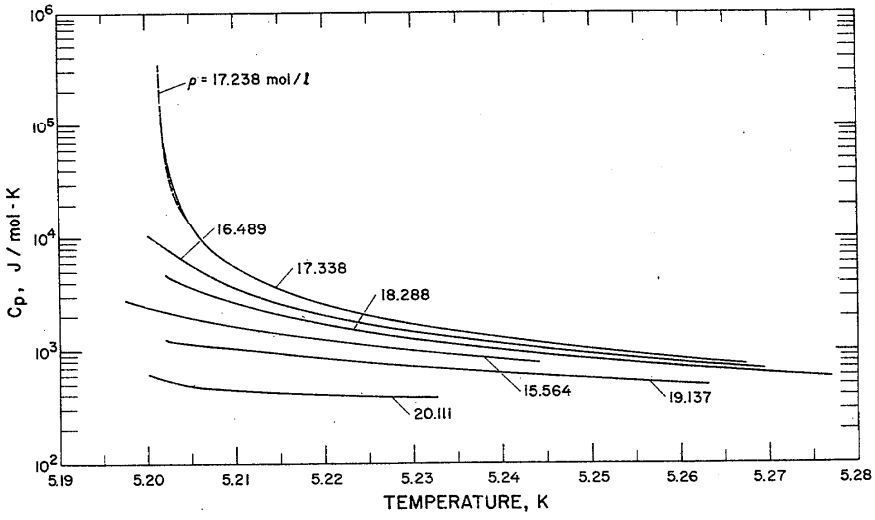

FIGURE 31. C_p in the near critical region of helium-4

9.3. Speed of Sound in the Critical Region

The behavior of the speed of sound near the critical point was investigated by Barmatz [3].

The divergence of the constant-volume specific heat C_v, which has been observed in several fluids near the critical point, see figure 30, implies the vanishing of the isentropic sound velocity [18]. In previous measurements of the ultrasonic velocity near the critical point [78], the behavior of the speed of sound very near the critical point was obscured by effects of gravity or dispersion. Barmatz [3] used low frequencies, 1–5 to 50 kHz, and an improved experimental design of the resonator to minimize the effects of gravity and dispersion. His results are given in figure (32).

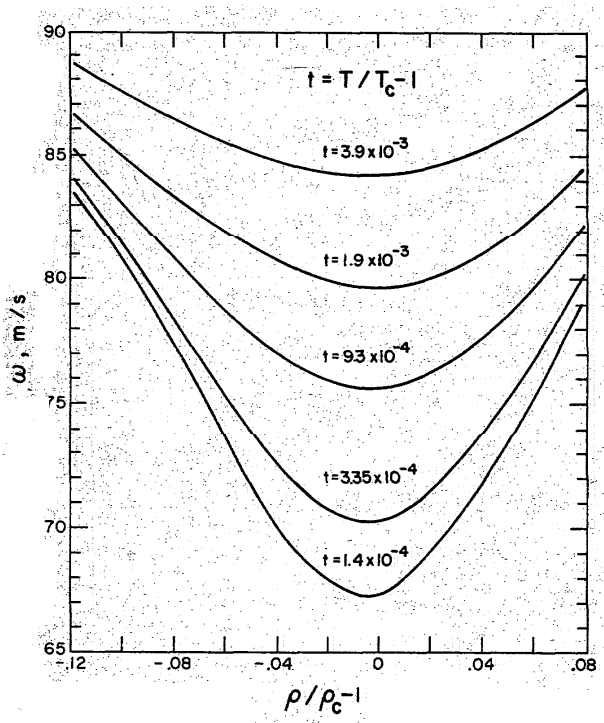

FIGURE 32. Speed of sound for helium-4 in the near critical region

10. Thermodynamic Properties Near the Lambda Line

The lambda line for helium-4 is the boundary between the two phases of helium known as helium I and helium II. Figure 9 shows the lambda line on a P–T diagram. The so-called lambda phase transition which occurs at pressures and temperatures to the left of the lambda line and above the vapor pressure curve, is the superfluid phase of helium-4. The superfluid region will not be considered here at all. The lambda line may be described in terms of one state variable as a function of another state variable. Two such equations are given below. These equations are from Keirstead [47].

$$P_\lambda = b_0 + b_1 x + b_2 x^2 + b_3 x^3 + b_4 x^4 + b_5 \exp\,(b_6 x), \tag{35}$$

where P_λ is in atmospheres and $x = T_\lambda - 2.172$, T_λ in kelvin on the T_{58} temperature scale, and

$$\rho_\lambda = d_0 + d_1 x + d_2 x^2 + d_3 x^3 + d_4 x^4 + d_5 \exp\,(d_6 x), \tag{36}$$

where ρ_λ is in g/cm³ and x is the same as above.

The coefficients for equations (35) and (36) are given in table 14.

TABLE 14. Coefficients of equations for P_λ and ρ_λ

$b_0 =$ 0.42800749	$d_0 =$ 0.14841388
$b_1 =$ − 95.0719	$d_1 =$ − 0.150735
$b_2 =$ − 86.417	$d_2 =$ − 0.3298225
$b_3 =$ − 103.341	$d_3 =$ − 0.53031333
$b_4 =$ − 77.52175	$d_4 =$ − 0.383035
$b_5 =$ − 0.37827065	$d_5 =$ − 0.00226388
$b_6 =$ 42.2507	$d_6 =$ 36.7348

The equation of state in section 6 predicts reasonable densities for a P–T input on the lambda line. If a ρ–T input from the lambda line is chosen, the pressure predicted by the equation of state will disagree with the above pressures by several percent. This occurs because of a very large $(\partial p/\partial \rho)_v$ and about a 0.3 percent uncertainty in ρ. All of the values in table 15 have been calculated from equations (35) and (36), except the upper lambda point value which comes from Kierstead [47].

TABLE 15. P–ρ–T of the lambda line

Temp. K	Pressure [eq (35)] atm	Density [eq (17)] g/cm³	Density [eq (36)] g/cm³
2.1720	0.04974	0.14615	0.14624
2.15	2.33	0.15057	0.15082
2.10	6.84	0.15758	0.15769
2.05	10.91	0.16275	0.16257
2.00	14.68	0.16694	0.16650
1.95	18.22	0.17049	0.16987
1.90	21.55	0.17359	0.17288
1.85	24.70	0.17634	0.17568
1.80	27.67	0.17881	0.17840
1.7633	29.74	0.18044	0.18041

Lounasmaa [49] published thermodynamic properties of helium-4 along the λ curve. The C_v values tabulated in table 13 are taken from Lounasmaa's [49] paper. The equation of state given in section 6 does predict an increase in C_v as the lambda line is approached, but the increase is too small and the C_v has been omitted in the tables of Appendix D where the state point is too close to the lambda line. If C_v's are required near the lambda line they may be obtained by interpolating between the C_v's given in table 13 and the C_v's in the tables of Appendix D. The temperatures in table 13 are on the T_{58} scale.

The partial derivative $(\partial P/\partial T)$, for isochores crossing the lambda line also shows anomalous behavior. An example from Lounasmaa and Kaunisto [51] is shown below in figure 33.

The speed of sound measurements by Atkins and Stasior [1] exhibit a slight anomalous behavior along the lambda line. An example is given in figure 34 which is taken from Atkins and Stasior [1].

11. The Melting Curve

The melting curve for helium has been measured by many experimenters. For the purposes of this correlation, the measurements of Mills and Grilly [59] have been used. These measurements extend from the upper lambda point to 30.77 K where the pressure is 3555.6 kg/cm². Mills and Grilly [59] give values of $a=-17.80$, $b=17.31457$ and $c=1.555414$ to the Simon melting equation:

$$P=a+bT^c, \qquad (37)$$

where P is in kg/cm² and T is in kelvin. The range of validity for this equation is reported to be 37 to 3500 kg/cm².

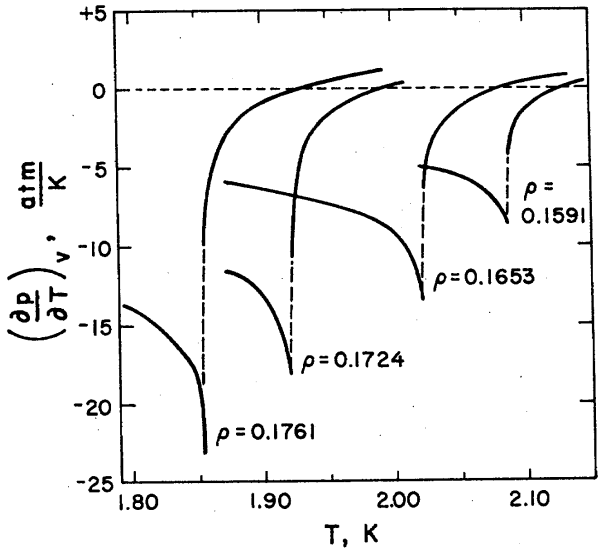

FIGURE 33. Pressure coefficient, $(\partial P/\partial T)_\rho$, for helium across the lambda line

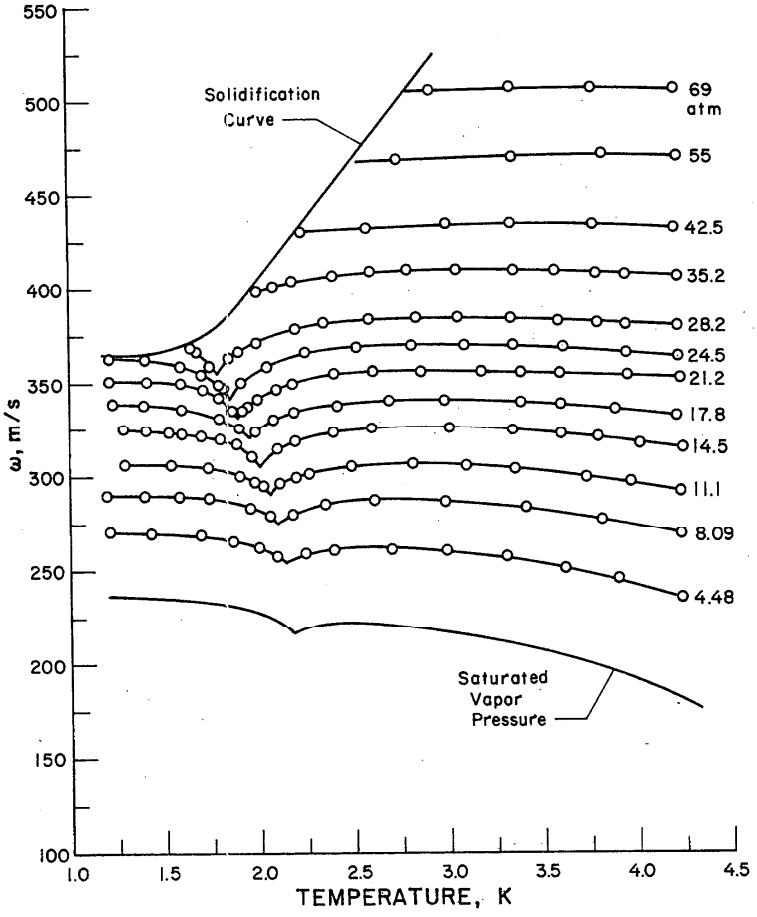

FIGURE 34. Speed of sound for liquid helium

In a later publication [28], the equation:

$$P = A + BT + CT^2 + DT^3 + ET^4, \qquad (38)$$

was used for the range of temperature from 1.8 to 5.2 K. P again is in kg/cm² and temperature is in kelvin. The reported rms deviation for this equation is 0.23 kg/cm². The constants appearing in equation (38) are given in table 16.

Table 17 shows the properties of helium-4 along the melting line. The equation of state, equation (17), predicts erroneous values of C_v along the melting line for temperatures below about 10 K. These erroneous values of C_v have been left out of the tables in Appendix D. If C_v is needed in the region near the melting curve where they have been omitted in Appendix D, they should be obtained by interpolation between the values given in table 17 and those in the tables of Appendix D. The pressures in table 17 have been calculated from equations (37) and (38). The densities listed in table 17 have been calculated using the equation of state, equation (17) and the adjacent P–T input. Above 10 K the C_v's in table 17 have been calculated with the equation of state. For temperatures below 10 K the C_v's in table 17 are from Dugdale and Franck [16].

TABLE 16. Parameters for equation (38)

A	=	33.280
B	=	44.156
C	=	31.749
D	=	−4.8159
E	=	0.30313

TABLE 17. Melting line for helium-4

Temperature K	Pressure atm	Liquid density mol/l	Liquid C_v J/mol·K
2.0	37.25	46.18	
2.5	56.35	48.67	
3.0	78.91	50.97	
3.5	103.83	52.94	
4.0	130.49	54.63	5.77
5.0	188.67	57.54	6.44
6.0	254.77	60.25	7.08
7.0	328.47	62.85	7.70
8.0	408.27	65.30	8.29
9.0	493.81	67.63	8.60
10.0	584.82	69.85	8.84
12.0	782.21	73.91	9.15
14.0	998.83	77.37	9.37
16.0	1233.37	80.43	10.43
18.0	1484.81	83.34	10.85
20.0	1752.29	86.07	11.18
22.0	2035.05	88.67	11.43
24.0	2332.48	91.17	11.65
26.0	2644.01	93.60	11.85
28.0	2969.14	95.98	12.03
30.0	3307.44	98.34	12.21

12. Joule-Thomson Inversion Curve

The Joule-Thomson coefficient for a fluid is defined as

$$J = (\partial T/\partial P)_H.$$

The locus of points where $J = 0$ is called the Joule-Thomson inversion curve. The inversion curve for helium using the relationship

$$T(\partial P/\partial T)_\rho = \rho(\partial P/\partial \rho)_T$$

as calculated from the equation of state equation (17) is given in table 18. Roebuck and Osterberg [68] measured the Joule-Thomson coefficient for helium. They later published corrections to these data (Roebuck and Osterberg [69]). A sample comparison between their data and values calculated from equation (16) is given in table 19. The equation

$$J = \frac{1}{C_p}\left[T\left(\frac{\partial V}{\partial T}\right) - v\right], \qquad (39)$$

TABLE 18. Joule-Thomson inversion curve

Temperature K	Pressure atm	Density mol/l
4.5	1.821	30.83
5	3.768	30.68
6	7.266	30.03
7	10.74	29.53
8	14.10	28.99
9	17.31	28.43
10	20.36	27.86
12	25.57	26.42
14	29.29	24.72
16	32.07	23.07
18	34.44	21.61
20	36.18	20.20
22	37.33	18.82
24	37.93	17.48
26	37.98	16.15
28	37.48	14.83
30	36.40	13.49
32	34.71	12.13
34	32.32	10.71
36	29.13	9.194
38	24.89	7.527
40	19.11	5.567
42	9.80	2.780
43	.03	.009

TABLE 19. Comparison of Joule-Thomson coefficients at 1 atmosphere

Temperature K	Joule-Thomson coefficient in K/atm	
	$-J_{exp}$	$-J_{calc.\ [eq.\ (17)]}$
83.15	0.0380	0.0433
93.15	0.0412	0.0476
118.15	0.0503	0.0545
133.15	0.0540	0.0571
173.15	0.0584	0.0612
223.15	0.0606	0.0635
273.15	0.0616	0.0644
575.15	0.0573	0.0633

was used to calculate the Joule-Thomson coefficient from equation (17). Figure 35 shows the J–T inversion curve for helium. The Joule-Thomson coefficients calculated from equation (17) are in the author's opinion more correct than the experimental values listed in table 19.

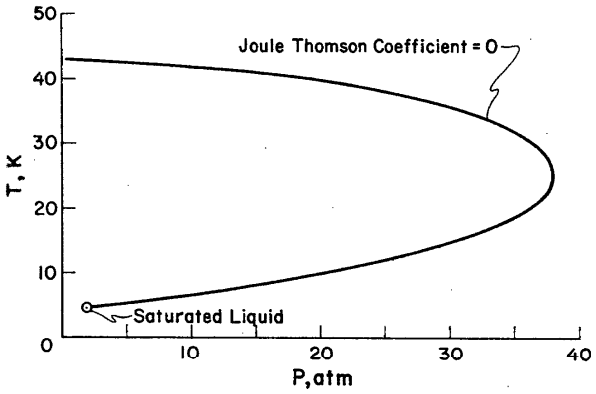

FIGURE 35. Joule-Thomson inversion curve calculated from equation of state

This work has been funded by the Office of Standard Reference Data, the National Aeronautics and Space Administration and the DOC/NBS Presidential Initiative Program in Cryogenics for the Electrical Industry. Many of my friends and colleagues have contributed significantly to this work by their continued support, encouragement and suggestions during a particularly long and at times frustrating job. I wish to acknowledge special gratitude to Hans Roder, Victor Johnson, R. B. Stewart and Neil Olien without whose help and support this job would not have been possible.

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Appendix A

Temperature-Entropy Diagrams

The temperature-entropy diagrams for helium in three temperature ranges are given in figures 36–38.

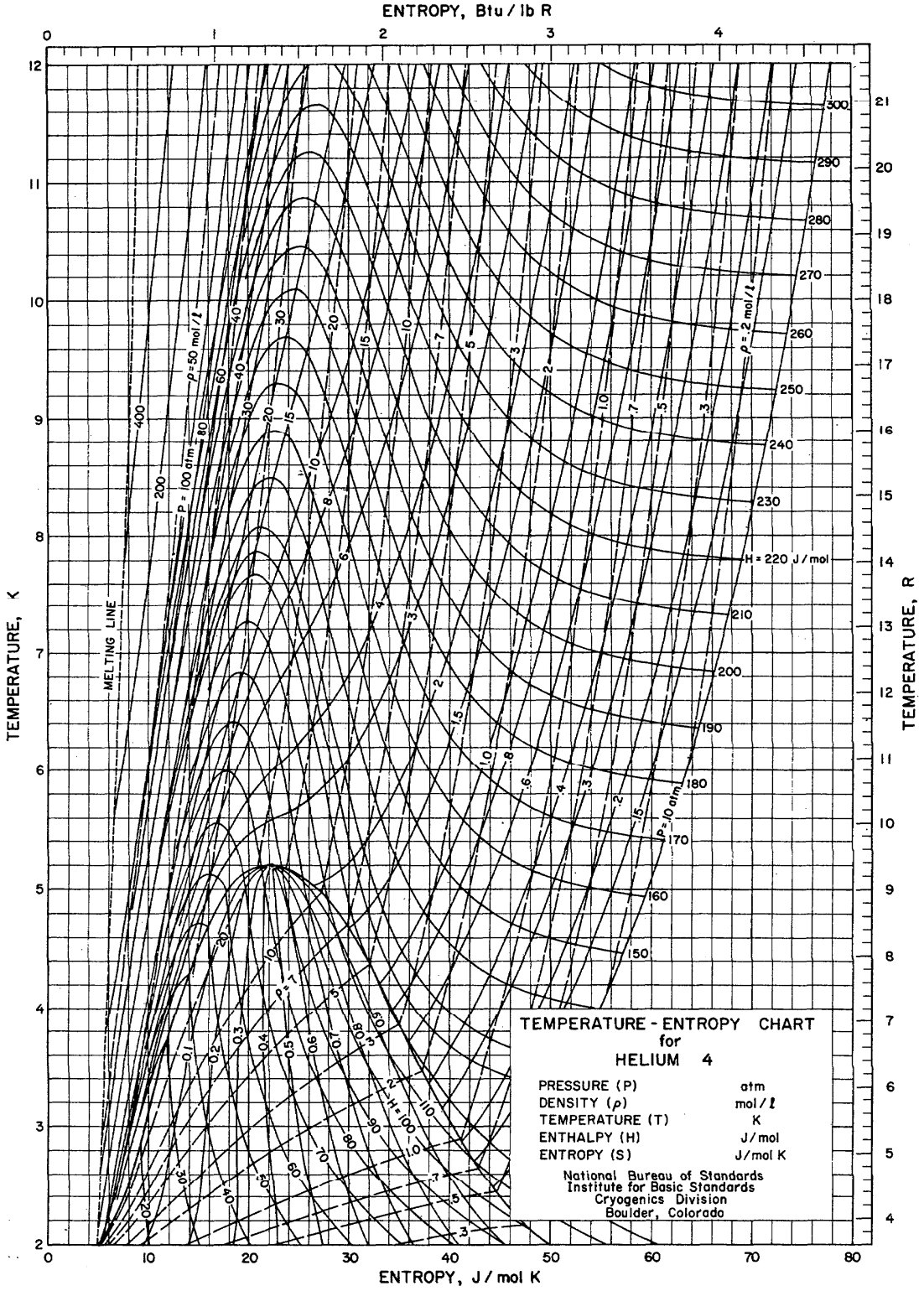

FIGURE 36. Temperature-entropy diagram for helium for temperatures from 2 to 12 K

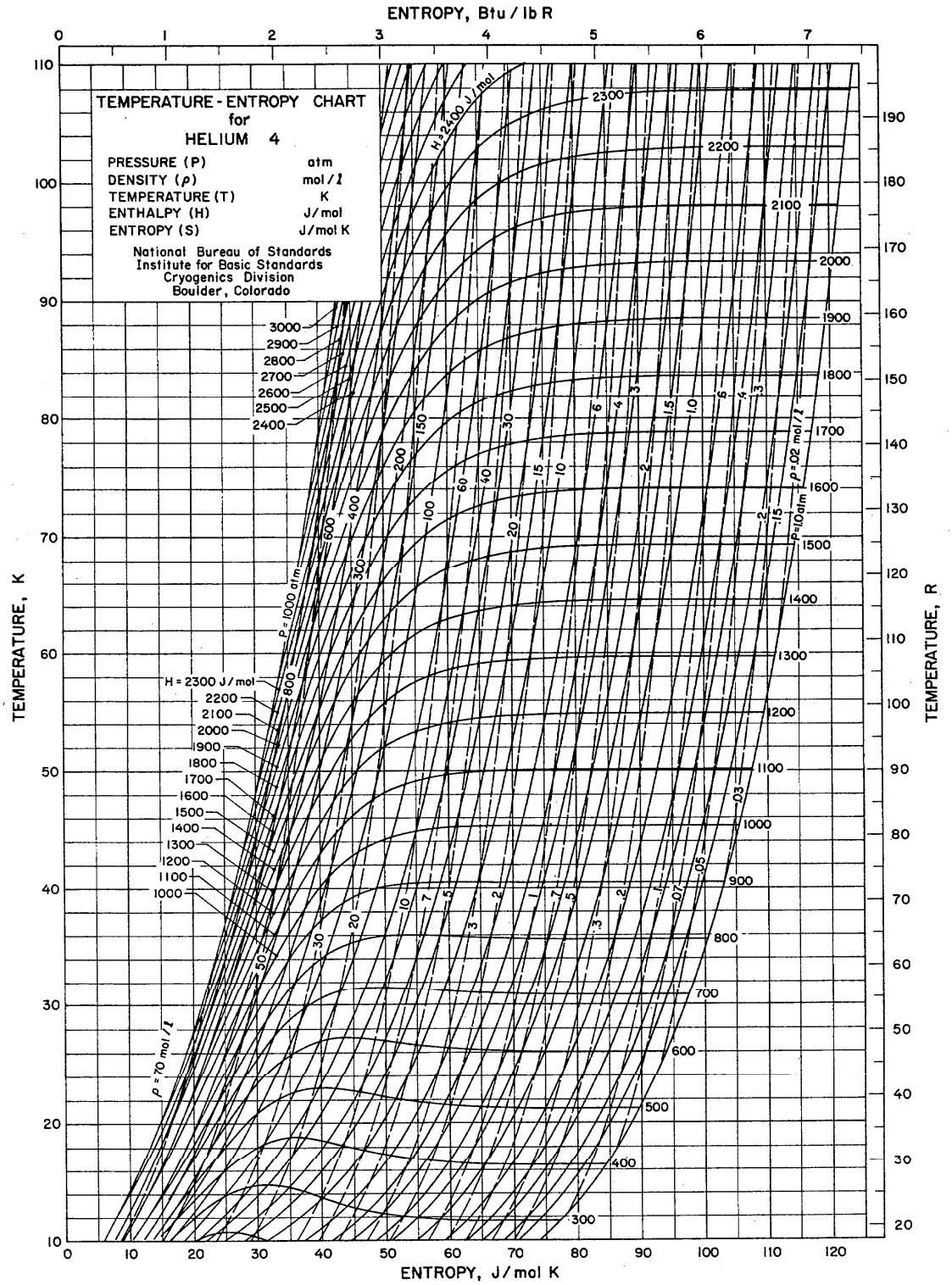

FIGURE 37. Temperature-entropy diagram for helium between 10 and 110 K

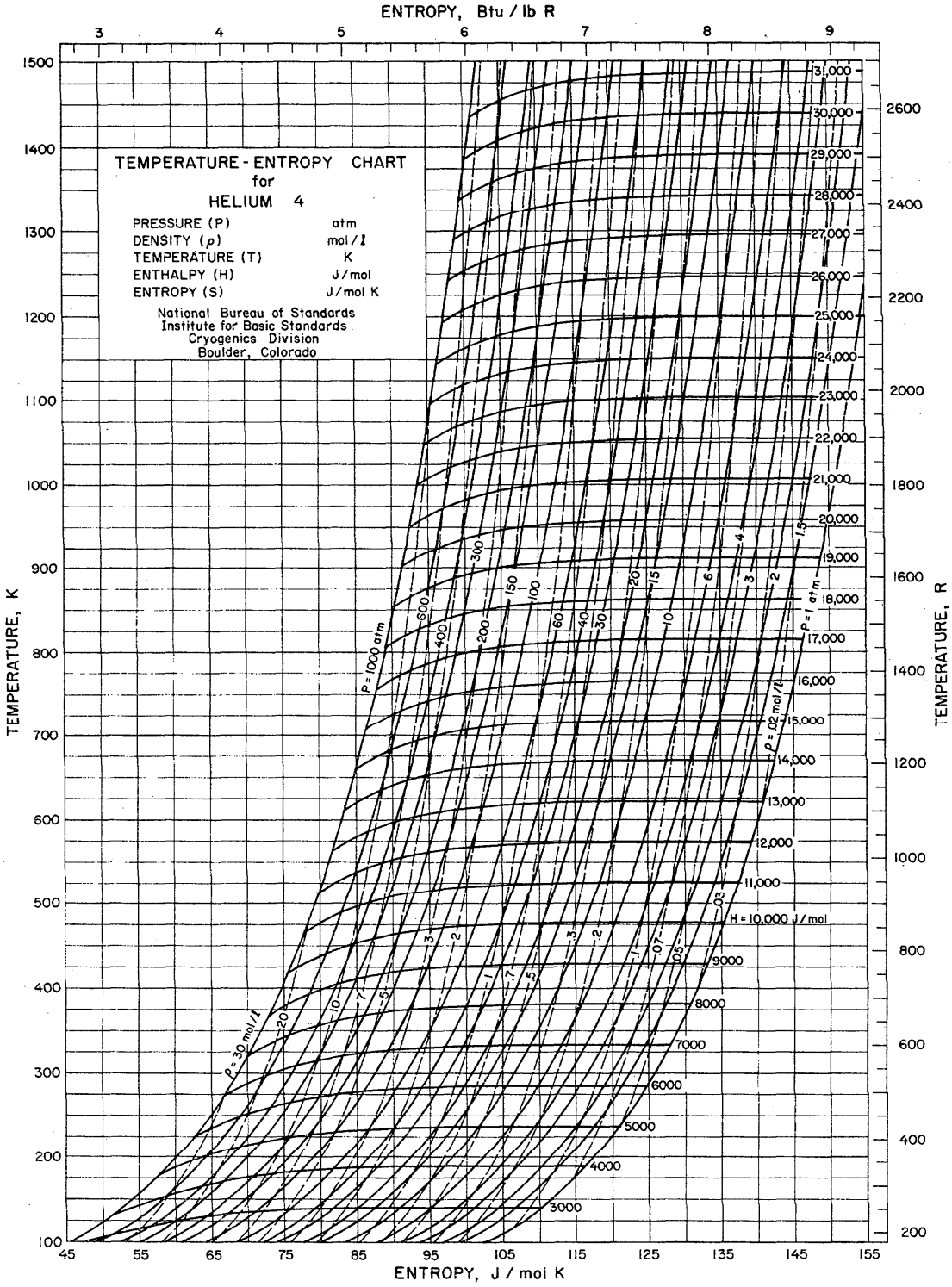

FIGURE 38. Temperature-entropy diagram for helium between 100 and 1500 K

Appendix B

Symbols

Nomenclature

P – absolute pressure
T – absolute temperature
V – specific volume
ρ – density (specific or molar)
R – universal gas constant
Z – compressibility factor PV/RT
U – internal energy
H – enthalpy
S – entropy
C_p – heat capacity at constant pressure
C_v – heat capacity at constant volume
J – Joule-Thomson coefficient
B – second virial coefficient
G – Gibbs energy
W – velocity of sound
β – critical parameter
α – critical parameter
ϵ – dielectric constant
p – molar polarizability
M – molecular weight

Superscripts

° – ideal gas property
* – real or ideal gas property at very low pressure
l – saturated liquid property
g – saturated vapor property
c – critical point
λ – lambda point, or line
o – reference state property
sat – property at saturation
t – triple point
expr – experimentally determined property value
calc – calculated property value
melt – melting line property

Subscripts on partial derivatives and integrals indicate which property is being held constant.

Appendix C

Conversion Factors and Fixed Points

Conversions and Physical Constants

1 thermochemical calorie = 4.184 joules
0 °C = 273.15 K (triple point of water = 273.16 K)
Gas constant, $R = 0.0820558$ l·atm/mol·K
Molecular weight of helium = 4.0026 g/mol (based on the carbon − 12 scale)
1 bar = 10^5 Pa
1 atmosphere = 1.01325×10^5 Pa
1 micrometer of Hg = 133.322 Pa
1 liter = 10^{-3} m^3

Fixed Points for Helium

Critical pressure = 2.2746×10^5 Pa (2.2449 atm)*
Critical temperature = 5.2014 K*
Critical density = 69.64 Kg/m^3 (17.399 mol/l)*
Normal boiling point = 4.224 K
Lambda point temperature = 2.177 K
Lambda point pressure = 0.05035×10^5 Pa (0.0497 atm)
Lambda point density (liquid) = 146.15 Kg/m^3 (36.514 mol/l)

*The equation of state (equation (17)) was constrained to these critical point parameters. More recent work suggests the critical temperature is 2 or 3 millidegrees lower and the critical pressure slightly greater by 1 or 2 mm Hg. (See the discussion and references in section 3.)

Appendix D

Thermodynamic Properties of Coexisting Liquid and Gaseous Phases of Helium-4

Thermodynamic properties of coexisting gaseous and liquid helium

Temperature K	Pressure 10^5 Pa	Density kg/m³	Isotherm derivative 10^5m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg/K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
*2.177	0.05035	146.2								
*2.177	0.05035	1.177	0.0403	0.0249	6.400	10.68	12.03	3.20	5.61	84.10
2.20	0.05326	146.1	0.459	1.60	−11.49	−11.45	1.782	3.10	3.16	216.1
2.20	0.05326	1.235	0.0405	0.0261	6.458	10.77	11.96	3.20	5.63	84.45
2.25	0.05994	146.0	0.455	1.83	−11.34	−11.30	1.849	2.73	2.81	216.4
2.25	0.05994	1.365	0.0411	0.0289	6.582	10.97	11.82	3.20	5.66	85.19
2.30	0.06717	145.8	0.451	2.05	−11.20	−11.16	1.907	2.46	2.56	216.7
2.30	0.06717	1.503	0.0416	0.0319	6.705	11.17	11.68	3.21	5.69	85.91
2.35	0.07497	145.6	0.447	2.23	−11.08	−11.03	1.960	2.25	2.38	217.1
2.35	0.07497	1.649	0.0421	0.0350	6.825	11.37	11.56	3.21	5.73	86.61
2.40	0.08337	145.3	0.442	2.40	−10.97	−10.91	2.008	2.10	2.25	217.4
2.40	0.08337	1.805	0.0425	0.0384	6.944	11.56	11.43	3.22	5.77	87.29
2.45	0.09241	145.1	0.436	2.55	−10.86	−10.79	2.053	2.00	2.17	217.7
2.45	0.09241	1.970	0.0429	0.0419	7.062	11.75	11.31	3.22	5.81	87.95
2.50	0.1021	144.8	0.430	2.68	−10.75	−10.68	2.097	1.93	2.13	217.9
2.50	0.1021	2.144	0.0433	0.0457	7.177	11.94	11.20	3.22	5.85	88.59
2.55	0.1125	144.5	0.424	2.79	−10.65	−10.57	2.138	1.88	2.11	217.9
2.55	0.1125	2.327	0.0436	0.0497	7.290	12.12	11.09	3.23	5.89	89.22
2.60	0.1235	144.2	0.417	2.90	−10.54	−10.46	2.179	1.85	2.10	217.7
2.60	0.1235	2.521	0.0440	0.0539	7.401	12.30	10.98	3.23	5.93	89.82
2.65	0.1353	143.8	0.410	2.99	−10.44	−10.34	2.219	1.84	2.12	217.4
2.65	0.1353	2.725	0.0443	0.0583	7.510	12.48	10.87	3.24	5.98	90.40
2.70	0.1479	143.5	0.403	3.08	−10.33	−10.23	2.258	1.84	2.14	216.9
2.70	0.1479	2.939	0.0445	0.0630	7.617	12.65	10.77	3.24	6.02	90.97
2.75	0.1612	143.1	0.395	3.15	−10.23	−10.11	2.297	1.84	2.18	216.3
2.75	0.1612	3.164	0.0447	0.0679	7.721	12.82	10.67	3.24	6.07	91.51
2.80	0.1753	142.8	0.388	3.22	−10.12	−9.99	2.336	1.85	2.22	215.5
2.80	0.1753	3.401	0.0449	0.0731	7.824	12.98	10.58	3.25	6.13	92.04
2.85	0.1903	142.4	0.380	32.8	−10.01	−9.883	2.375	1.87	2.27	214.7
2.85	0.1903	3.648	0.0451	0.0785	7.924	13.14	10.48	3.25	6.18	92.56
2.90	0.2060	142.0	0.371	3.34	−9.904	−9.759	2.414	1.88	2.31	213.7
2.90	0.2060	3.908	0.0452	0.0842	8.021	13.29	10.39	3.26	6.24	93.05
2.95	0.2227	141.6	0.363	3.39	−9.790	−9.633	2.454	1.90	2.37	212.6
2.95	0.2227	4.179	0.0453	0.0902	8.116	13.44	10.30	3.26	6.30	93.53
3.00	0.2402	141.1	0.355	3.44	−9.673	−9.503	2.493	1.92	2.42	211.5
3.00	0.2402	4.463	0.0453	0.0965	8.209	13.59	10.22	3.26	6.36	93.99
3.05	0.2587	140.7	0.346	3.49	−9.554	−9.370	2.533	1.94	2.48	210.3
3.05	0.2587	4.760	0.0454	0.103	8.299	13.73	10.13	3.27	6.42	94.44

Thermodynamic properties of coexisting gaseous and liquid helium—Continued

Temperature K	Pressure 10^5 Pa	Density kg/m³	Isotherm derivative 10^5 m³ · Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg · K	C_v kJ/kg · K	C_p kJ/kg · K	Velocity of sound m/s
3.10	0.2780	140.2	0.337	3.53	−9.432	−9.234	2.573	1.96	2.54	209.1
3.10	0.2780	5.070	0.0453	0.110	8.386	13.87	10.05	3.27	6.49	94.87
3.15	0.2984	139.8	0.329	3.56	−9.308	−9.094	2.613	1.98	2.60	207.08
3.15	0.2984	5.394	0.0453	0.117	8.470	14.00	9.97	3.27	6.56	95.28
3.20	0.3197	139.3	0.320	3.60	−9.180	−8.951	2.653	2.00	2.67	206.5
3.20	0.3197	5.731	0.0452	0.125	8.551	14.13	9.884	3.28	6.64	95.68
3.25	0.3421	138.8	0.311	3.63	−9.051	−8.804	2.693	2.02	2.73	205.2
3.25	0.3421	6.084	0.0451	0.133	8.630	14.25	9.805	3.28	6.72	96.06
3.30	0.3655	138.3	0.302	3.66	−8.918	−8.654	2.734	2.04	2.80	203.8
3.30	0.3655	6.452	0.0449	0.141	8.705	14.37	9.727	3.28	6.80	96.42
3.35	0.3899	137.7	0.293	3.68	−8.782	−8.499	2.775	2.06	2.87	202.4
3.35	0.3899	6.835	0.0447	0.150	8.778	14.48	9.650	3.29	6.89	96.77
3.40	0.4155	137.2	0.284	3.71	−8.644	−8.341	2.817	2.07	2.95	201.0
3.40	0.4155	7.235	0.0445	0.159	8.847	14.59	9.574	3.29	7.98	97.10
3.45	0.4421	136.6	0.275	3.73	−8.503	−8.179	2.858	2.09	3.02	199.5
3.45	0.4421	7.651	0.0442	0.168	8.912	14.69	9.499	3.29	7.08	97.41
3.50	0.4699	136.0	0.266	3.74	−8.358	−8.013	2.900	2.11	3.10	198.0
3.50	0.4699	8.085	0.0439	0.178	8.974	14.79	9.425	3.30	7.18	97.71
3.55	0.4988	135.4	0.258	3.76	−8.210	−7.842	2.943	2.13	3.19	196.5
3.55	0.4988	8.537	0.0435	0.189	9.033	14.88	9.352	3.30	7.29	98.00
3.60	0.5289	134.8	0.249	3.77	−8.059	−7.667	2.985	2.14	3.28	194.9
3.60	0.5289	9.008	0.0431	0.200	9.088	14.96	9.279	3.30	7.40	98.27
3.65	0.5602	134.1	0.240	3.78	−7.905	−7.487	3.029	2.16	3.37	193.4
3.65	0.5602	9.498	0.0427	0.211	9.139	15.04	9.207	3.31	7.52	98.52
3.70	0.5927	133.5	0.231	3.79	−7.747	−7.303	3.072	2.18	3.47	191.7
3.70	0.5927	10.01	0.0422	0.223	9.186	15.11	9.136	3.31	7.66	98.75
3.75	0.6264	132.8	0.222	3.79	−7.585	−7.113	3.116	2.19	3.57	190.1
3.75	0.6264	10.54	0.0417	0.235	9.229	15.17	9.065	3.31	7.79	98.97
3.80	0.6614	132.1	0.213	3.79	−7.419	−6.919	3.161	2.21	3.68	188.4
3.80	0.6614	11.09	0.0411	0.248	9.268	15.23	8.994	3.32	7.94	99.17
3.85	0.6977	131.4	0.205	3.79	−7.250	−6.719	3.206	2.23	3.80	186.7
3.85	0.6977	11.67	0.0405	0.262	9.302	15.28	8.924	3.32	8.10	99.36
3.90	0.7354	130.6	0.196	3.79	−7.076	6.513	3.251	2.25	3.92	184.9
3.90	0.7354	12.28	0.0398	0.276	9.332	15.32	8.854	3.33	8.27	99.5
3.95	0.7743	129.8	0.187	3.78	−6.898	−6.302	3.298	2.26	4.05	183.1
3.95	0.7743	12.90	0.0391	0.291	9.356	15.36	8.784	3.33	8.45	99.7
4.00	0.8147	129.0	0.179	3.77	−6.716	−6.084	3.345	2.28	4.19	181.2
4.00	0.8147	13.56	0.0384	0.306	9.376	15.38	8.714	3.33	8.65	99.8
4.05	0.8564	128.2	0.170	3.76	−6.529	−5.860	3.392	2.30	4.35	179.2
4.05	0.8654	14.24	0.0376	0.323	9.390	15.40	8.644	3.34	8.87	99.9

Thermodynamic properties of coexisting gaseous and liquid helium—Continued

Temperature K	Pressure 10^5 Pa	Density kg/m^3	Isotherm derivative 10^5m^3 · Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg · K	C_v kJ/kg · K	C_p kJ/kg · K	Velocity of sound m/s
4.10	0.8995	127.3	0.162	3.74	−6.336	−5.630	3.440	2.32	4.51	177.2
4.10	0.8995	14.96	0.0367	0.340	9.399	15.41	8.574	3.34	9.10	100.0
4.15	0.9441	126.4	0.153	3.72	−6.139	−5.392	3.490	2.34	4.69	175.2
4.15	0.9441	15.71	0.0358	0.358	9.401	15.41	8.503	3.34	9.35	100.1
4.20	0.9902	125.4	0.145	3.70	−5.936	−5.146	3.540	2.36	4.88	173.0
4.20	0.9902	16.49	0.0349	0.377	9.397	15.40	8.432	3.35	9.63	100.1
4.224	1.013	125.0	0.141	3.69	−5.834	−5.023	3.564	2.37	4.98	172.0
4.224	1.013	16.89	0.0344	0.386	9.393	15.39	8.397	3.35	9.78	100.2
4.25	1.038	124.5	0.136	3.67	−5.726	−4.893	3.591	2.38	5.09	170.8
4.25	1.038	17.32	0.0338	0.397	9.387	15.38	8.361	3.35	9.94	100.2
4.30	1.087	123.5	0.128	3.64	−5.511	−4.631	3.643	2.40	5.32	168.6
4.30	1.087	18.18	0.0328	0.418	9.368	15.35	8.288	3.35	10.3	100.2
4.35	1.138	122.4	0.120	3.61	−5.289	−4.360	3.696	2.42	5.58	166.2
4.35	1.138	19.09	0.0316	0.440	9.342	15.30	8.215	3.36	10.7	100.2
4.40	1.190	121.3	0.112	3.58	−5.059	−4.078	3.750	2.44	5.86	163.8
4.40	1.190	20.05	0.0304	0.463	9.307	15.24	8.140	3.36	11.1	100.1
4.45	1.244	120.2	0.104	3.54	−4.822	−3.787	3.806	2.47	6.18	161.3
4.45	1.244	21.06	0.0291	0.488	9.262	15.17	8.064	3.36	11.6	100.1
4.50	1.299	118.9	0.0957	3.49	−4.576	−3.484	3.863	2.49	6.55	158.6
4.50	1.299	22.13	0.0278	0.514	9.207	15.08	7.986	3.37	12.1	100.0
4.55	1.357	117.7	0.0878	3.45	−4.320	−3.168	3.923	2.51	6.96	155.9
4.55	1.357	23.27	0.0264	0.543	9.140	14.97	7.907	3.37	12.8	99.9
4.60	1.416	116.3	0.0800	3.40	−4.055	−2.838	3.984	2.54	7.44	153.1
4.60	1.416	24.49	0.0248	0.573	9.060	14.84	7.825	3.37	13.5	99.7
4.65	1.476	114.9	0.0723	3.34	−3.777	−2.492	4.047	2.57	8.01	150.2
4.65	1.476	25.79	0.0233	0.605	8.965	14.69	7.740	3.38	14.4	99.6
4.70	1.539	113.4	0.0647	3.28	−3.486	−2.129	4.113	2.59	8.68	147.1
4.70	1.539	27.19	0.0216	0.641	8.853	14.51	7.651	3.38	15.5	99.38
4.75	1.603	111.8	0.0572	3.22	−3.180	−1.746	4.182	2.62	9.51	144.0
4.75	1.603	28.71	0.0198	0.679	8.722	14.31	7.558	3.38	16.8	99.16
4.80	1.670	110.1	0.0499	3.15	−2.856	−1.339	4.255	2.66	10.5	140.7
4.80	1.670	30.37	0.0179	0.721	8.566	14.06	7.461	3.38	18.5	98.91
4.85	1.738	108.2	0.0427	3.07	−2.510	−0.9042	4.332	2.69	11.9	137.3
4.85	1.738	32.21	0.0160	0.768	8.382	13.78	7.356	3.39	20.7	98.65
4.90	1.808	106.1	0.0357	2.99	−2.138	−0.4345	4.415	2.73	13.6	133.7
4.90	1.808	34.25	0.0139	0.820	8.163	13.44	7.244	3.39	23.6	98.37
4.95	1.880	103.7	0.0289	2.90	−1.733	0.07862	4.505	2.76	16.1	129.9
4.95	1.880	36.58	0.0117	0.880	7.897	13.04	7.120	3.39	27.9	98.09
5.00	1.954	101.1	0.0224	2.80	−1.283	0.6496	4.605	2.81	19.9	126.0
5.00	1.954	39.30	0.00937	0.950	7.570	12.54	6.982	3.39	34.6	97.83
5.05	2.031	97.96	0.0162	2.68	−0.7706	1.302	4.720	2.86	26.1	121.8
5.05	2.031	42.58	0.00697	1.04	7.152	11.92	6.821	3.38	46.2	97.64

Thermodynamic properties of coexisting gaseous and liquid helium—Continued

Temperature K	Pressure 10^5 Pa	Density kg/m^3	Isotherm derivative 10^5m^3·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
5.10	2.109	94.09	0.0104	2.54	−0.1582	2.083	1.858	2.92	38.5	117.3
5.10	2.109	46.80	0.00450	1.15	6.589	11.10	6.624	3.37	71.5	97.61
*5.201	2.275	69.54								
*5.201	2.275	69.64								

*Lambda point and critical point.

Appendix E

Isobaric Tables of the Thermodynamic Properties of Helium-4

Thermodynamic properties of helium 4

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
				0.1 × 10^{+5} pascal Isobar					
* 2.177	146.3								
* 2.489	144.8	0.432	2.65	−10.77	−10.70	2.088	1.940	2.133	217.8
* 2.489	2.106	0.0432	0.0449	7.153	11.90	11.22	3.223	5.837	88.46
2.5	2.095	0.0435	0.0446	7.190	11.96	11.25	3.221	5.828	88.70
3.0	1.692	0.0559	0.0356	8.885	14.79	12.28	3.163	5.543	98.94
3.5	1.427	0.0675	0.0299	10.52	17.53	13.12	3.138	5.415	107.9
4.0	1.236	0.0787	0.0258	12.13	20.22	13.84	3.126	5.347	116.0
4.5	1.092	0.0897	0.0228	13.72	22.88	14.47	3.120	5.307	123.5
5.0	0.9783	0.101	0.0204	15.31	25.53	15.03	3.118	5.281	130.5
5.1	0.9584	0.103	0.0200	15.62	26.06	15.13	3.117	5.277	131.9
5.2	0.9393	0.105	0.0196	15.94	26.58	15.23	3.117	5.274	133.2
5.3	0.9210	0.107	0.0192	16.25	27.11	15.33	3.117	5.270	134.5
5.4	0.9034	0.109	0.0188	16.57	27.64	15.43	3.116	5.267	135.9
5.5	0.8865	0.111	0.0185	16.88	28.16	15.53	3.116	5.264	137.1
5.6	0.8702	0.114	0.0181	17.20	28.69	15.62	3.116	5.261	138.4
5.7	0.8545	0.116	0.0178	17.51	29.22	15.72	3.116	5.259	139.7
5.8	0.8394	0.118	0.0175	17.83	29.74	15.81	3.116	5.256	141.0
5.9	0.8248	0.120	0.0172	18.14	30.27	15.90	3.116	5.254	142.2
6.0	0.8107	0.122	0.0169	18.46	30.79	15.99	3.115	5.252	143.4
6.5	0.7470	0.133	0.0156	20.03	33.42	16.41	3.115	5.242	149.4
7.0	0.6927	0.143	0.0144	21.60	36.04	16.80	3.115	5.235	155.2
7.5	0.6458	0.154	0.0135	23.17	38.65	17.16	3.115	5.230	160.7
8.0	0.6048	0.164	0.0126	24.73	41.27	17.49	3.115	5.225	166.1
8.5	0.5688	0.175	0.0118	26.30	43.88	17.81	3.115	5.222	171.3
9.0	0.5369	0.186	0.0112	27.86	46.49	18.11	3.115	5.219	176.3
9.5	0.5084	0.196	0.0106	29.43	49.10	18.39	3.115	5.216	181.2
10.0	0.4828	0.207	0.0101	30.99	51.70	18.66	3.115	5.214	185.9
11.0	0.4386	0.228	0.00913	34.11	56.92	19.16	3.116	5.210	195.0
12.0	0.4018	0.248	0.00836	37.24	62.12	19.61	3.116	5.208	203.8
13.0	0.3708	0.269	0.00772	40.36	67.33	20.03	3.116	5.206	212.1
14.0	0.3442	0.290	0.00716	43.48	72.54	20.41	3.116	5.204	220.2
15.0	0.3212	0.311	0.00668	46.60	77.74	20.77	3.116	5.203	227.9
16.0	0.3011	0.332	0.00626	49.72	82.94	21.11	3.116	5.202	235.4
17.0	0.2833	0.353	0.00589	52.84	88.14	21.42	3.116	5.201	242.6
18.0	0.2675	0.374	0.00556	55.96	93.34	21.72	3.116	5.200	249.7
19.0	0.2534	0.395	0.00527	59.08	98.54	22.00	3.116	5.199	256.5
20.0	0.2407	0.415	0.00501	62.20	103.7	22.27	3.116	5.199	263.2
21.0	0.2293	0.436	0.00477	65.32	108.9	22.52	3.116	5.198	269.7
22.0	0.2188	0.457	0.00455	68.44	114.1	22.76	3.116	5.198	276.1
23.0	0.2093	0.478	0.00435	71.56	119.3	22.99	3.116	5.197	282.3
24.0	0.2006	0.499	0.00417	74.67	124.5	23.21	3.116	5.197	288.3
25.0	0.1925	0.519	0.00400	77.79	129.7	23.43	3.116	5.197	294.3
26.0	0.1851	0.540	0.00385	80.91	134.9	23.63	3.116	5.196	300.1
28.0	0.1719	0.582	0.00357	87.14	145.3	24.01	3.116	5.196	311.4
30.0	0.1604	0.623	0.00334	93.38	155.7	24.37	3.116	5.196	322.4
32.0	0.1504	0.665	0.00313	99.6	166.1	24.71	3.116	5.195	332.9
34.0	0.1416	0.707	0.00294	105.8	176.5	25.02	3.116	5.195	343.2
36.0	0.1337	0.748	0.00278	112.1	186.9	25.32	3.116	5.195	353.1
38.0	0.1267	0.790	0.00263	118.3	197.3	25.60	3.116	5.195	362.8
40.0	0.1203	0.831	0.00250	124.5	207.7	25.87	3.116	5.194	372.2
45.0	0.1070	0.935	0.00222	140.1	233.6	26.48	3.116	5.194	394.8
50.0	0.09626	1.04	0.00200	155.7	259.6	27.03	3.116	5.194	416.1
55.0	0.08751	1.14	0.00182	171.3	285.6	27.52	3.116	5.194	436.4
60.0	0.08022	1.25	0.00167	186.9	311.5	27.97	3.116	5.194	455.8
65.0	0.07405	1.35	0.00154	202.5	337.5	28.39	3.116	5.194	474.4
70.0	0.06876	1.45	0.00143	218.0	363.5	28.77	3.116	5.193	492.4
75.0	0.06418	1.56	0.00133	233.6	389.4	29.13	3.116	5.193	509.6
80.0	0.06017	1.66	0.00125	249.2	415.4	29.47	3.116	5.193	526.3

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
90.0	0.05348	1.87	0.00111	280.4	467.3	30.08	3.116	5.193	558.3
100.0	0.04813	2.08	0.00100	311.5	519.3	30.63	3.116	5.193	588.4
125.0	0.03851	2.60	0.000800	389.4	649.1	31.79	3.116	5.193	657.9
150.0	0.03209	3.12	0.000667	467.3	778.9	32.73	3.116	5.193	720.6
175.0	0.02751	3.64	0.000571	545.2	908.8	33.53	3.116	5.193	778.4
200.0	0.02407	4.16	0.000500	623.1	1039.0	34.23	3.116	5.193	832.1
225.0	0.02139	4.67	0.000444	701.0	1168.0	34.84	3.116	5.193	882.6
250.0	0.01926	5.19	0.000400	778.9	1298.0	35.38	3.116	5.193	930.3
275.0	0.01750	5.71	0.000364	856.8	1428.0	35.88	3.116	5.193	975.7
300.0	0.01605	6.23	0.000333	934.7	1558.0	36.33	3.116	5.193	1019.0
350.0	0.01375	7.27	0.000286	1090.0	1818.0	37.13	3.116	5.193	1101.0
400.0	0.01203	8.31	0.000250	1246.0	2077.0	37.83	3.116	5.193	1177.0
450.0	0.01070	9.35	0.000222	1402.0	2337.0	38.44	3.116	5.193	1248.0
500.0	0.009628	10.4	0.000200	1558.0	2596.0	38.98	3.116	5.193	1316.0
600.0	0.008023	12.5	0.000167	1869.0	3116.0	39.93	3.116	5.193	1441.0
700.0	0.006877	14.5	0.000143	2181.0	3635.0	40.73	3.116	5.193	1557.0
800.0	0.006018	16.6	0.000125	2493.0	4154.0	41.43	3.116	5.193	1664.0
900.0	0.005349	18.7	0.000111	2804.0	4674.0	42.04	3.116	5.193	1765.0
1000.0	0.004814	20.8	0.000100	3116.0	5193.0	42.58	3.116	5.193	1861.0
1100.0	0.004376	22.8	0.0000909	3427.0	5712.0	43.08	3.116	5.193	1951.0
1200.0	0.004012	24.9	0.0000833	3739.0	6232.0	43.53	3.116	5.193	2038.0
1300.0	0.003703	27.0	0.0000769	4051.0	6751.0	43.95	3.116	5.193	2121.0
1400.0	0.003439	29.1	0.0000714	4362.0	7270.0	44.33	3.116	5.193	2201.0
1500.0	0.003209	31.2	0.0000667	4674.0	7790.0	44.69	3.116	5.193	2279.0

$0.2 \times 10^{+5}$ pascal Isobar

* 2.176	146.6								
2.5	145.0	0.436	2.68	−10.76	−10.62	2.092	1.921	2.116	219.2
* 2.881	142.1	0.374	3.32	−9.947	−9.806	2.400	1.876	2.296	214.1
* 2.881	3.809	0.0452	0.0820	7.985	13.24	10.43	3.254	6.215	92.87
3.0	3.607	0.0486	0.0773	8.420	13.97	10.67	3.229	6.067	95.53
3.5	2.973	0.0619	0.0630	10.17	16.89	11.58	3.168	5.704	105.5
4.0	2.545	0.0741	0.0536	11.84	19.70	12.33	3.140	5.533	114.3
4.5	2.231	0.0859	0.0468	13.48	22.44	12.97	3.127	5.438	122.2
5.0	1.989	0.0973	0.0417	15.09	25.14	13.54	3.120	5.379	129.5
5.1	1.947	0.100	0.0408	15.41	25.68	13.65	3.119	5.371	130.9
5.2	1.907	0.102	0.0400	15.73	26.22	13.75	3.119	5.362	132.3
5.3	1.869	0.104	0.0391	16.05	26.75	13.86	3.118	5.355	133.6
5.4	1.832	0.106	0.0384	16.37	27.29	13.96	3.117	5.347	135.0
5.5	1.796	0.108	0.0376	16.69	27.82	14.05	3.117	5.341	136.3
5.6	1.762	0.111	0.0369	17.01	28.36	14.15	3.117	5.335	137.6
5.7	1.730	0.113	0.0362	17.33	28.89	14.24	3.116	5.329	138.9
5.8	1.698	0.115	0.0355	17.65	29.42	14.34	3.116	5.324	140.2
5.9	1.668	0.117	0.0349	17.96	29.95	14.43	3.116	5.319	141.5
6.0	1.639	0.119	0.0343	18.28	30.49	14.52	3.115	5.314	142.7
6.5	1.507	0.130	0.0315	19.87	33.14	14.94	3.115	5.294	148.9
7.0	1.395	0.141	0.0292	21.45	35.78	15.33	3.114	5.279	154.7
7.5	1.299	0.152	0.0271	23.03	38.42	15.70	3.114	5.268	160.4
8.0	1.216	0.163	0.0254	24.60	41.05	16.04	3.114	5.258	165.8
8.5	1.143	0.173	0.0239	26.17	43.68	16.36	3.115	5.251	171.0
9.0	1.078	0.184	0.0225	27.75	46.30	16.66	3.115	5.245	176.1
9.5	1.020	0.195	0.0213	29.32	48.92	16.94	3.115	5.239	181.0
10.0	0.9683	0.205	0.0202	30.88	51.54	17.21	3.115	5.235	185.8
11.0	0.8791	0.227	0.0183	34.02	56.77	17.71	3.115	5.228	195.0
12.0	0.8050	0.248	0.0168	37.15	62.00	18.16	3.116	5.223	203.7
13.0	0.7425	0.269	0.0155	40.28	67.22	18.58	3.116	5.218	212.1
14.0	0.6891	0.290	0.0144	43.41	72.43	18.97	3.116	5.215	220.2
15.0	0.6428	0.311	0.0134	46.53	77.65	19.33	3.116	5.212	227.9

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
16.0	0.6024	0.332	0.0125	49.66	82.86	19.66	3.116	5.210	235.4
17.0	0.5668	0.353	0.0118	52.78	88.07	19.98	3.116	5.208	242.7
18.0	0.5352	0.373	0.0111	55.91	93.27	20.28	3.116	5.207	249.8
19.0	0.5070	0.394	0.0106	59.03	98.48	20.56	3.116	5.205	256.6
20.0	0.4815	0.415	0.0100	62.15	103.7	20.82	3.116	5.204	263.3
21.0	0.4586	0.436	0.00955	65.27	108.9	21.08	3.116	5.203	269.8
22.0	0.4377	0.457	0.00911	68.39	114.1	21.32	3.116	5.202	276.2
23.0	0.4186	0.478	0.00871	71.51	119.3	21.55	3.116	5.201	282.4
24.0	0.4011	0.499	0.00835	74.63	124.5	21.77	3.116	5.201	288.5
25.0	0.3851	0.519	0.00801	77.75	129.7	21.98	3.116	5.200	294.4
26.0	0.3702	0.540	0.00770	80.87	134.9	22.19	3.116	5.200	300.2
28.0	0.3438	0.582	0.00715	87.11	145.3	22.57	3.116	5.199	311.6
30.0	0.3208	0.624	0.00667	93.35	155.7	22.93	3.116	5.198	322.5
32.0	0.3008	0.665	0.00626	99.6	166.1	23.27	3.116	5.197	333.1
34.0	0.2831	0.707	0.00589	105.8	176.5	23.58	3.116	5.197	343.3
36.0	0.2673	0.748	0.00556	112.1	186.9	23.88	3.116	5.196	353.3
38.0	0.2533	0.790	0.00527	118.3	197.3	24.16	3.116	5.196	362.9
40.0	0.2406	0.832	0.00500	124.5	207.7	24.43	3.116	5.196	372.3
45.0	0.2139	0.936	0.00445	140.1	233.6	25.04	3.116	5.195	394.9
50.0	0.1925	1.04	0.00400	155.7	259.6	25.59	3.116	5.195	416.3
55.0	0.1750	1.14	0.00364	171.3	285.6	26.08	3.116	5.194	436.6
60.0	0.1604	1.25	0.00333	186.9	311.5	26.53	3.116	5.194	456.0
65.0	0.1481	1.35	0.00308	202.4	337.5	26.95	3.116	5.194	474.6
70.0	0.1375	1.46	0.00286	218.0	363.5	27.33	3.116	5.194	492.5
75.0	0.1283	1.56	0.00267	233.6	389.5	27.69	3.116	5.194	509.7
80.0	0.1203	1.66	0.00250	249.2	415.4	28.03	3.116	5.194	526.4
90.0	0.1069	1.87	0.00222	280.3	467.4	28.64	3.116	5.194	558.3
100.0	0.09625	2.08	0.00200	311.5	519.3	29.19	3.116	5.193	588.5
125.0	0.07701	2.60	0.00160	389.4	649.1	30.35	3.116	5.193	658.0
150.0	0.06418	3.12	0.00133	467.3	779.0	31.29	3.116	5.193	720.7
175.0	0.05501	3.64	0.00114	545.2	908.8	32.09	3.116	5.193	778.4
200.0	0.04813	4.16	0.00100	623.1	1039.0	32.79	3.116	5.193	832.2
225.0	0.04279	4.67	0.000889	701.0	1168.0	33.40	3.116	5.193	882.6
250.0	0.03851	5.19	0.000800	778.9	1298.0	33.95	3.116	5.193	930.4
275.0	0.03501	5.71	0.000727	856.8	1428.0	34.44	3.116	5.193	975.8
300.0	0.03209	6.23	0.000667	934.7	1558.0	34.89	3.116	5.193	1019.0
350.0	0.02751	7.27	0.000571	1090.0	1818.0	35.69	3.116	5.193	1101.0
400.0	0.02407	8.31	0.000500	1246.0	2077.0	36.39	3.116	5.193	1177.0
450.0	0.02139	9.35	0.000444	1402.0	2337.0	37.00	3.116	5.193	1248.0
500.0	0.01926	10.4	0.000400	1558.0	2597.0	37.54	3.116	5.193	1316.0
600.0	0.01605	12.5	0.000333	1869.0	3116.0	38.49	3.116	5.193	1441.0
700.0	0.01375	14.5	0.000286	2181.0	3635.0	39.29	3.116	5.193	1557.0
800.0	0.01203	16.6	0.000250	2493.0	4154.0	39.99	3.116	5.193	1664.0
900.0	0.01070	18.7	0.000222	2804.0	4674.0	40.60	3.116	5.193	1765.0
1000.0	0.009628	20.8	0.000200	3116.0	5193.0	41.14	3.116	5.193	1861.0
1100.0	0.008753	22.9	0.000182	3427.0	5712.0	41.64	3.116	5.193	1951.0
1200.0	0.008023	24.9	0.000167	3739.0	6232.0	42.09	3.116	5.193	2038.0
1300.0	0.007406	27.0	0.000154	4051.0	6751.0	42.51	3.116	5.193	2121.0
1400.0	0.006877	29.1	0.000143	4362.0	7270.0	42.89	3.116	5.193	2201.0
1500.0	0.006419	31.2	0.000133	4674.0	7790.0	43.25	3.116	5.193	2279.0
				$0.3 \times 10^{+5}$ pascal Isobar					
* 2.175	146.8								
2.5	145.3	0.442	2.68	−10.77	−10.57	2.088	1.915	2.107	220.5
3.0	141.3	0.358	3.45	−9.684	−9.472	2.489	1.919	2.418	212.4
* 3.154	139.7	0.328	3.57	−9.298	−9.083	2.616	1.982	2.608	207.7
* 3.154	5.419	0.0453	0.118	8.476	14.01	9.96	3.273	6.567	95.31
3.5	4.673	0.0558	0.100	9.774	16.19	10.62	3.206	6.092	103.0

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
4.0	3.939	0.0693	0.0836	11.53	19.15	11.40	3.158	5.759	112.4
4.5	3.424	0.0819	0.0723	13.22	21.98	12.07	3.135	5.588	120.8
5.0	3.036	0.0939	0.0640	14.86	24.75	12.66	3.124	5.488	128.4
5.1	2.969	0.0962	0.0625	15.19	25.29	12.76	3.123	5.473	129.8
5.2	2.906	0.0985	0.0612	15.52	25.84	12.87	3.121	5.459	131.3
5.3	2.845	0.101	0.0599	15.84	26.39	12.97	3.120	5.447	132.7
5.4	2.787	0.103	0.0586	16.17	26.93	13.08	3.119	5.435	134.1
5.5	2.731	0.105	0.0574	16.49	27.47	13.18	3.118	5.424	135.4
5.6	2.678	0.108	0.0563	16.81	28.02	13.27	3.118	5.414	136.8
5.7	2.627	0.110	0.0552	17.14	28.56	13.37	3.117	5.405	138.1
5.8	2.578	0.112	0.0542	17.46	29.10	13.46	3.117	5.396	139.5
5.9	2.530	0.115	0.0532	17.78	29.64	13.55	3.116	5.388	140.8
6.0	2.485	0.117	0.0522	18.10	30.17	13.65	3.116	5.380	142.1
6.5	2.281	0.128	0.0479	19.70	32.86	14.07	3.114	5.349	148.3
7.0	2.109	0.139	0.0442	21.30	35.52	14.47	3.114	5.325	154.3
7.5	1.961	0.150	0.0411	22.88	38.18	14.84	3.114	5.307	160.0
8.0	1.833	0.161	0.0384	24.47	40.83	15.18	3.114	5.292	165.5
8.5	1.722	0.172	0.0360	26.05	43.47	15.50	3.114	5.281	170.7
9.0	1.623	0.183	0.0340	27.63	46.11	15.80	3.114	5.271	175.9
9.5	1.535	0.194	0.0321	29.20	48.75	16.09	3.115	5.263	180.8
10.0	1.457	0.204	0.0305	30.78	51.37	16.36	3.115	5.256	185.6
11.0	1.321	0.226	0.0276	33.92	56.62	16.86	3.115	5.246	194.9
12.0	1.209	0.247	0.0253	37.06	61.87	17.31	3.116	5.237	203.7
13.0	1.115	0.268	0.0233	40.20	67.10	17.73	3.116	5.231	212.1
14.0	1.035	0.289	0.0216	43.33	72.33	18.12	3.116	5.226	220.2
15.0	0.9650	0.310	0.0201	46.46	77.55	18.48	3.116	5.222	228.0
16.0	0.9042	0.331	0.0189	49.59	82.77	18.82	3.116	5.219	235.5
17.0	0.8506	0.352	0.0177	52.72	87.99	19.13	3.116	5.216	242.8
18.0	0.8031	0.373	0.0167	55.85	93.20	19.43	3.117	5.213	249.8
19.0	0.7606	0.394	0.0159	58.97	98.42	19.71	3.117	5.211	256.7
20.0	0.7224	0.415	0.0151	62.10	103.6	19.98	3.117	5.210	263.4
21.0	0.6879	0.436	0.0143	65.22	108.8	20.23	3.117	5.208	269.9
22.0	0.6565	0.457	0.0137	68.35	114.0	20.48	3.117	5.207	276.3
23.0	0.6279	0.478	0.0131	71.47	119.2	20.71	3.117	5.206	282.5
24.0	0.6017	0.499	0.0125	74.59	124.5	20.93	3.117	5.204	288.6
25.0	0.5775	0.520	0.0120	77.71	129.7	21.14	3.117	5.204	294.5
26.0	0.5553	0.540	0.0116	80.83	134.9	21.34	3.117	5.203	300.3
28.0	0.5156	0.582	0.0107	87.07	145.3	21.73	3.117	5.201	311.7
30.0	0.4812	0.624	0.0100	93.31	155.7	22.09	3.117	5.200	322.6
32.0	0.4511	0.666	0.00939	99.6	166.1	22.42	3.117	5.199	333.2
34.0	0.4245	0.707	0.00883	105.8	176.5	22.74	3.117	5.199	343.4
36.0	0.4009	0.749	0.00834	112.0	186.9	23.04	3.116	5.198	353.4
38.0	0.3798	0.790	0.00790	118.3	197.3	23.32	3.116	5.198	363.0
40.0	0.3608	0.832	0.00751	124.5	207.6	23.58	3.116	5.197	372.5
45.0	0.3207	0.936	0.00667	140.1	233.6	24.20	3.116	5.196	395.0
50.0	0.2887	1.04	0.00600	155.7	259.6	24.74	3.116	5.196	416.4
55.0	0.2624	1.14	0.00546	171.3	285.6	25.24	3.116	5.195	436.7
60.0	0.2406	1.25	0.00500	186.8	311.6	25.69	3.116	5.195	456.1
65.0	0.2221	1.35	0.00462	202.4	337.5	26.11	3.116	5.194	474.7
70.0	0.2062	1.46	0.00429	218.0	363.5	26.49	3.116	5.194	492.6
75.0	0.1925	1.56	0.00400	233.6	389.5	26.85	3.116	5.194	509.8
80.0	0.1804	1.66	0.00375	249.2	415.4	27.19	3.116	5.194	526.5
90.0	0.1604	1.87	0.00333	280.3	467.4	27.80	3.116	5.194	558.4
100.0	0.1444	2.08	0.00300	311.5	519.3	28.34	3.116	5.194	588.6
125.0	0.1155	2.60	0.00240	389.4	649.2	29.50	3.116	5.193	658.0
150.0	0.09625	3.12	0.00200	467.3	779.0	30.45	3.116	5.193	720.8
175.0	0.08251	3.64	0.00171	545.2	908.8	31.25	3.116	5.193	778.5
200.0	0.07220	4.16	0.00150	623.1	1039.0	31.94	3.116	5.193	832.2
225.0	0.06418	4.68	0.00133	701.0	1168.0	32.56	3.116	5.193	882.7
250.0	0.05776	5.19	0.00120	778.9	1298.0	33.10	3.116	5.193	930.4

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
275.0	0.05251	5.71	0.00109	856.8	1428.0	33.60	3.116	5.193	975.8
300.0	0.04813	6.23	0.00100	934.7	1558.0	34.05	3.116	5.193	1019.0
350.0	0.04126	7.27	0.000857	1090.0	1818.0	34.85	3.116	5.193	1101.0
400.0	0.03610	8.31	0.000750	1246.0	2077.0	35.54	3.116	5.193	1177.0
450.0	0.03209	9.35	0.000667	1402.0	2337.0	36.16	3.116	5.193	1248.0
500.0	0.02888	10.4	0.000600	1558.0	2597.0	36.70	3.116	5.193	1316.0
600.0	0.02407	12.5	0.000500	1869.0	3116.0	37.65	3.116	5.193	1441.0
700.0	0.02063	14.5	0.000429	2181.0	3635.0	38.45	3.116	5.193	1557.0
800.0	0.01805	16.6	0.000375	2493.0	4154.0	39.14	3.116	5.193	1664.0
900.0	0.01605	18.7	0.000333	2804.0	4674.0	39.75	3.116	5.193	1765.0
1000.0	0.01444	20.8	0.000300	3116.0	5193.0	40.30	3.116	5.193	1861.0
1100.0	0.01313	22.9	0.000273	3427.0	5712.0	40.80	3.116	5.193	1951.0
1200.0	0.01203	24.9	0.000250	3739.0	6232.0	41.25	3.116	5.193	2038.0
1300.0	0.01111	27.0	0.000231	4051.0	6751.0	41.66	3.116	5.193	2121.0
1400.0	0.01032	29.1	0.000214	4362.0	7270.0	42.05	3.116	5.193	2201.0
1500.0	0.009628	31.2	0.000200	4674.0	7790.0	42.41	3.116	5.193	2279.0

$0.4 \times 10^{+5}$ pascal Isobar

*	2.174	147.0							
	2.5	145.5	0.448	2.68	−10.78	−10.51	2.084	1.909	2.098	221.8
	3.0	141.6	0.364	3.45	−9.702	−9.420	2.483	1.918	2.408	213.9
*	3.370	137.5	0.290	3.69	−8.727	−8.437	2.792	2.064	2.903	201.8
*	3.370	6.993	0.0446	0.153	8.806	14.53	9.620	3.288	6.922	96.90
	3.5	6.581	0.0491	0.143	9.328	15.41	9.876	3.255	6.639	100.0
	4.0	5.437	0.0642	0.117	11.20	18.55	10.72	3.180	6.040	110.5
	4.5	4.677	0.0777	0.0995	12.94	21.50	11.41	3.146	5.763	119.3
	5.0	4.122	0.0904	0.0873	14.63	24.34	12.01	3.129	5.610	127.3
	5.1	4.027	0.0928	0.0852	14.96	24.90	12.12	3.127	5.587	128.8
	5.2	3.938	0.0953	0.0833	15.30	25.45	12.23	3.125	5.567	130.3
	5.3	3.852	0.0977	0.0814	15.63	26.01	12.33	3.123	5.548	131.7
	5.4	3.771	0.100	0.0797	15.96	26.56	12.44	3.122	5.530	133.2
	5.5	3.693	0.102	0.0780	16.29	27.12	12.54	3.121	5.514	134.6
	5.6	3.619	0.105	0.0764	16.61	27.67	12.64	3.119	5.500	136.0
	5.7	3.547	0.107	0.0749	16.94	28.22	12.74	3.118	5.486	137.3
	5.8	3.479	0.110	0.0734	17.27	28.76	12.83	3.118	5.473	138.7
	5.9	3.413	0.112	0.0720	17.59	29.31	12.92	3.117	5.462	140.0
	6.0	3.350	0.114	0.0706	17.92	29.86	13.02	3.116	5.451	141.3
	6.5	3.069	0.126	0.0646	19.53	32.57	13.45	3.114	5.406	147.7
	7.0	2.832	0.137	0.0596	21.14	35.26	13.85	3.113	5.372	153.8
	7.5	2.631	0.148	0.0553	22.74	37.94	14.22	3.113	5.347	159.6
	8.0	2.457	0.159	0.0516	24.33	40.61	14.56	3.113	5.327	165.1
	8.5	2.306	0.170	0.0484	25.92	43.27	14.89	3.113	5.311	170.5
	9.0	2.172	0.181	0.0456	27.51	45.92	15.19	3.114	5.298	175.6
	9.5	2.054	0.192	0.0431	29.09	48.57	15.48	3.114	5.287	180.6
	10.0	1.948	0.203	0.0408	30.67	51.21	15.75	3.114	5.278	185.5
	11.0	1.766	0.225	0.0370	33.83	56.48	16.25	3.115	5.263	194.8
	12.0	1.615	0.246	0.0338	36.97	61.74	16.71	3.116	5.252	203.6
	13.0	1.489	0.267	0.0311	40.12	66.98	17.13	3.116	5.244	212.1
	14.0	1.381	0.289	0.0289	43.26	72.22	17.52	3.116	5.237	220.2
	15.0	1.288	0.310	0.0269	46.39	77.46	17.88	3.116	5.232	228.0
	16.0	1.206	0.331	0.0252	49.53	82.69	18.21	3.117	5.227	235.5
	17.0	1.135	0.352	0.0237	52.66	87.91	18.53	3.117	5.223	242.8
	18.0	1.071	0.373	0.0224	55.79	93.13	18.83	3.117	5.220	249.9
	19.0	1.014	0.394	0.0212	58.92	98.35	19.11	3.117	5.217	256.8
	20.0	0.9633	0.415	0.0201	62.05	103.6	19.38	3.117	5.215	263.5
	21.0	0.9172	0.436	0.0191	65.17	108.8	19.63	3.117	5.213	270.0
	22.0	0.8754	0.457	0.0183	68.30	114.0	19.88	3.117	5.211	276.4
	23.0	0.8372	0.478	0.0175	71.42	119.2	20.11	3.117	5.210	282.6

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
24.0	0.8022	0.499	0.0167	74.55	124.4	20.33	3.117	5.208	288.7
25.0	0.7700	0.520	0.0160	77.67	129.6	20.54	3.117	5.207	294.6
26.0	0.7403	0.541	0.0154	80.79	134.8	20.75	3.117	5.206	300.5
28.0	0.6873	0.582	0.0143	87.04	145.2	21.13	3.117	5.204	311.8
30.0	0.6414	0.624	0.0134	93.28	155.6	21.49	3.117	5.203	322.7
32.0	0.6013	0.666	0.0125	99.5	166.0	21.83	3.117	5.202	333.3
34.0	0.5659	0.707	0.0118	105.8	176.4	22.14	3.117	5.201	343.6
36.0	0.5344	0.749	0.0111	112.0	186.8	22.44	3.117	5.200	353.5
38.0	0.5063	0.791	0.0105	118.2	197.2	22.72	3.117	5.199	363.2
40.0	0.4810	0.832	0.0100	124.5	207.6	22.99	3.117	5.198	372.6
45.0	0.4275	0.936	0.00890	140.1	233.6	23.60	3.117	5.197	395.2
50.0	0.3848	1.04	0.00801	155.7	259.6	24.15	3.116	5.196	416.5
55.0	0.3498	1.14	0.00728	171.3	285.6	24.64	3.116	5.196	436.8
60.0	0.3207	1.25	0.00667	186.8	311.6	25.09	3.116	5.195	456.2
65.0	0.2960	1.35	0.00616	202.4	337.5	25.51	3.116	5.195	474.8
70.0	0.2749	1.46	0.00572	218.0	363.5	25.89	3.116	5.195	492.7
75.0	0.2566	1.56	0.00533	233.6	389.5	26.25	3.116	5.194	509.9
80.0	0.2405	1.66	0.00500	249.2	415.5	26.59	3.116	5.194	526.6
90.0	0.2138	1.87	0.00444	280.3	467.4	27.20	3.116	5.194	558.5
100.0	0.1925	2.08	0.00400	311.5	519.3	27.75	3.116	5.194	588.7
125.0	0.1540	2.60	0.00320	389.4	649.2	28.91	3.116	5.193	658.1
150.0	0.1283	3.12	0.00267	467.3	779.0	29.85	3.116	5.193	720.9
175.0	0.1100	3.64	0.00229	545.2	908.8	30.65	3.116	5.193	778.6
200.0	0.09625	4.16	0.00200	623.1	1039.0	31.35	3.116	5.193	832.3
225.0	0.08556	4.68	0.00178	701.0	1169.0	31.96	3.116	5.193	882.7
250.0	0.07701	5.20	0.00160	778.9	1298.0	32.51	3.116	5.193	930.5
275.0	0.07001	5.71	0.00145	856.8	1428.0	33.00	3.116	5.193	975.9
300.0	0.06418	6.23	0.00133	934.7	1558.0	33.45	3.116	5.193	1019.0
350.0	0.05501	7.27	0.00114	1090.0	1818.0	34.25	3.116	5.193	1101.0
400.0	0.04813	8.31	0.00100	1246.0	2077.0	34.95	3.116	5.193	1177.0
450.0	0.04279	9.35	0.000889	1402.0	2337.0	35.56	3.116	5.193	1248.0
500.0	0.03851	10.4	0.000800	1558.0	2597.0	36.10	3.116	5.193	1316.0
600.0	0.03209	12.5	0.000667	1869.0	3116.0	37.05	3.116	5.193	1441.0
700.0	0.02751	14.5	0.000571	2181.0	3635.0	37.85	3.116	5.193	1557.0
800.0	0.02407	16.6	0.000500	2493.0	4154.0	38.55	3.116	5.193	1664.0
900.0	0.02139	18.7	0.000444	2804.0	4674.0	39.16	3.116	5.193	1765.0
1000.0	0.01926	20.8	0.000400	3116.0	5193.0	39.70	3.116	5.193	1861.0
1100.0	0.01751	22.9	0.000364	3427.0	5712.0	40.20	3.116	5.193	1951.0
1200.0	0.01605	24.9	0.000333	3739.0	6232.0	40.65	3.116	5.193	2038.0
1300.0	0.01481	27.0	0.000308	4051.0	6751.0	41.07	3.116	5.193	2121.0
1400.0	0.01375	29.1	0.000286	4362.0	7270.0	41.45	3.116	5.193	2201.0
1500.0	0.01284	31.2	0.000267	4674.0	7790.0	41.81	3.116	5.193	2279.0

$0.5 \times 10^{+5}$ pascal Isobar

*	2.173	147.2							
	2.5	145.7	0.454	2.68	−10.79	−10.45	2.079	1.903	2.089	223.1
	3.0	141.9	0.370	3.46	−9.720	−9.368	2.477	1.917	2.399	215.3
	3.5	136.1	0.268	3.75	−8.367	−8.000	2.898	2.109	3.098	198.5
*	3.552	135.4	0.257	3.76	−8.204	−7.835	2.944	2.127	3.192	196.4
*	3.552	8.556	0.0435	0.189	9.035	14.88	9.349	3.301	7.292	98.01
	4.0	7.062	0.0588	0.153	10.83	17.91	10.15	3.206	6.396	108.3
	4.5	5.999	0.0735	0.129	12.66	20.99	10.88	3.158	5.968	117.8
	5.0	5.250	0.0868	0.112	14.39	23.91	11.50	3.135	5.746	126.1
	5.1	5.125	0.0894	0.109	14.73	24.49	11.61	3.132	5.714	127.7
	5.2	5.006	0.0919	0.106	15.07	25.06	11.72	3.129	5.685	129.2
	5.3	4.893	0.0945	0.104	15.41	25.62	11.83	3.127	5.659	130.7
	5.4	4.786	0.0970	0.102	15.74	26.19	11.93	3.125	5.635	132.2
	5.5	4.684	0.0994	0.0994	16.08	26.75	12.04	3.123	5.613	133.7

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
5.6	4.586	0.102	0.0972	16.41	27.31	12.14	3.122	5.592	135.1
5.7	4.493	0.104	0.0952	16.74	27.87	12.24	3.120	5.574	136.5
5.8	4.403	0.107	0.0933	17.07	28.43	12.33	3.119	5.557	137.9
5.9	4.318	0.109	0.0914	17.40	28.98	12.43	3.118	5.541	139.3
6.0	4.236	0.112	0.0897	17.73	29.53	12.52	3.117	5.526	140.6
6.5	3.871	0.123	0.0818	19.36	32.28	12.96	3.114	5.465	147.2
7.0	3.567	0.135	0.0753	20.99	35.00	13.36	3.113	5.422	153.3
7.5	3.310	0.146	0.0698	22.60	37.70	13.74	3.113	5.388	159.2
8.0	3.088	0.158	0.0650	24.20	40.39	14.08	3.113	5.362	164.8
8.5	2.895	0.169	0.0609	25.80	43.07	14.41	3.113	5.342	170.2
9.0	2.726	0.180	0.0573	27.39	45.73	14.71	3.113	5.325	175.4
9.5	2.576	0.191	0.0541	28.98	48.39	15.00	3.114	5.311	180.5
10.0	2.441	0.202	0.0513	30.57	51.05	15.27	3.114	5.299	185.3
11.0	2.212	0.224	0.0464	33.73	56.33	15.78	3.115	5.281	194.7
12.0	2.022	0.245	0.0424	36.88	61.61	16.24	3.115	5.268	203.6
13.0	1.863	0.267	0.0390	40.03	66.87	16.66	3.116	5.257	212.1
14.0	1.728	0.288	0.0362	43.18	72.12	17.05	3.116	5.248	220.2
15.0	1.611	0.309	0.0337	46.32	77.36	17.41	3.117	5.241	228.0
16.0	1.509	0.330	0.0316	49.46	82.60	17.75	3.117	5.236	235.6
17.0	1.419	0.352	0.0297	52.60	87.83	18.06	3.117	5.231	242.9
18.0	1.339	0.373	0.0280	55.73	93.06	18.36	3.117	5.227	250.0
19.0	1.268	0.394	0.0265	58.86	98.29	18.64	3.117	5.223	256.9
20.0	1.204	0.415	0.0252	61.99	103.5	18.91	3.117	5.220	263.6
21.0	1.147	0.436	0.0239	65.12	108.7	19.17	3.117	5.218	270.1
22.0	1.094	0.457	0.0228	68.25	113.9	19.41	3.117	5.216	276.5
23.0	1.046	0.478	0.0218	71.38	119.2	19.64	3.117	5.214	282.7
24.0	1.003	0.499	0.0209	74.51	124.4	19.86	3.117	5.212	288.8
25.0	0.9624	0.520	0.0201	77.63	129.6	20.08	3.117	5.211	294.7
26.0	0.9253	0.541	0.0193	80.76	134.8	20.28	3.117	5.209	300.6
28.0	0.8590	0.583	0.0179	87.00	145.2	20.67	3.117	5.207	311.9
30.0	0.8016	0.624	0.0167	93.25	155.6	21.03	3.117	5.205	322.9
32.0	0.7515	0.666	0.0157	99.49	166.0	21.36	3.117	5.204	333.4
34.0	0.7072	0.708	0.0147	105.7	176.4	21.68	3.117	5.202	343.7
36.0	0.6679	0.749	0.0139	112.0	186.8	21.97	3.117	5.201	353.6
38.0	0.6327	0.791	0.0132	118.2	197.2	22.26	3.117	5.200	363.3
40.0	0.6011	0.833	0.0125	124.5	207.6	22.52	3.117	5.200	372.7
45.0	0.5343	0.937	0.0111	140.1	233.6	23.13	3.117	5.198	395.3
50.0	0.4809	1.04	0.0100	155.6	259.6	23.68	3.117	5.197	416.6
55.0	0.4372	1.14	0.00910	171.2	285.6	24.18	3.117	5.196	436.9
60.0	0.4008	1.25	0.00834	186.8	311.6	24.63	3.116	5.196	456.3
65.0	0.3699	1.35	0.00770	202.4	337.6	25.05	3.116	5.195	474.9
70.0	0.3435	1.46	0.00715	218.0	363.5	25.43	3.116	5.195	492.8
75.0	0.3207	1.56	0.00667	233.6	389.5	25.79	3.116	5.195	510.0
80.0	0.3006	1.66	0.00625	249.2	415.5	26.12	3.116	5.194	526.7
90.0	0.2672	1.87	0.00556	280.3	467.4	26.74	3.116	5.194	558.6
100.0	0.2405	2.08	0.00500	311.5	519.4	27.28	3.116	5.194	588.8
125.0	0.1925	2.60	0.00400	389.4	649.2	28.44	3.116	5.194	658.2
150.0	0.1604	3.12	0.00333	467.3	779.0	29.39	3.116	5.193	720.9
175.0	0.1375	3.64	0.00286	545.2	908.9	30.19	3.116	5.193	778.6
200.0	0.1203	4.16	0.00250	623.1	1039.0	30.88	3.116	5.193	832.3
225.0	0.1069	4.68	0.00222	701.0	1169.0	31.49	3.116	5.193	882.8
250.0	0.09625	5.20	0.00200	778.9	1298.0	32.04	3.116	5.193	930.5
275.0	0.08751	5.72	0.00182	856.8	1428.0	32.54	3.116	5.193	975.9
300.0	0.08022	6.23	0.00167	934.7	1558.0	32.99	3.116	5.193	1019.0
350.0	0.06876	7.27	0.00143	1090.0	1818.0	33.79	3.116	5.193	1101.0
400.0	0.06017	8.31	0.00125	1246.0	2077.0	34.48	3.116	5.193	1177.0
450.0	0.05348	9.35	0.00111	1402.0	2337.0	35.09	3.116	5.193	1248.0
500.0	0.04813	10.4	0.00100	1558.0	2597.0	35.64	3.116	5.193	1316.0
600.0	0.04011	12.5	0.000833	1869.0	3116.0	36.59	3.116	5.193	1441.0
700.0	0.03438	14.5	0.000714	2181.0	3635.0	37.39	3.116	5.193	1557.0

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
800.0	0.03009	16.6	0.000625	2493.0	4155.0	38.08	3.116	5.193	1664.0
900.0	0.02674	18.7	0.000556	2804.0	4674.0	38.69	3.116	5.193	1765.0
1000.0	0.02407	20.8	0.000500	3116.0	5193.0	39.24	3.116	5.193	1861.0
1100.0	0.02188	22.9	0.000455	3427.0	5712.0	39.74	3.116	5.193	1951.0
1200.0	0.02006	24.9	0.000417	3739.0	6232.0	40.19	3.116	5.193	2038.0
1300.0	0.01852	27.0	0.000385	4051.0	6751.0	40.60	3.116	5.193	2121.0
1400.0	0.01719	29.1	0.000357	4362.0	7270.0	40.99	3.116	5.193	2201.0
1500.0	0.01605	31.2	0.000333	4674.0	7790.0	41.35	3.116	5.193	2279.0
				0.6 × 10^{+5} pascal Isobar					
* 2.172	147.4								
2.5	146.0	0.459	2.68	−10.80	−10.39	2.075	1.897	2.080	224.4
3.0	142.2	0.376	3.47	−9.737	−9.315	2.471	1.915	2.390	216.7
3.5	136.5	0.275	3.77	−8.396	−7.956	2.889	2.107	3.076	200.3
* 3.711	133.3	0.229	3.79	−7.711	−7.261	3.082	2.181	3.490	191.4
* 3.711	10.12	0.0421	0.225	9.196	15.12	9.120	3.312	7.685	98.80
4.0	8.851	0.0530	0.194	10.43	17.21	9.662	3.238	6.863	106.0
4.5	7.403	0.0690	0.160	12.35	20.46	10.43	3.173	6.211	116.2
5.0	6.427	0.0832	0.138	14.14	23.48	11.06	3.142	5.899	124.9
5.1	6.266	0.0859	0.134	14.49	24.06	11.18	3.138	5.855	126.6
5.2	6.114	0.0885	0.131	14.83	24.65	11.29	3.134	5.816	128.2
5.3	5.971	0.0912	0.127	15.18	25.23	11.40	3.131	5.781	129.7
5.4	5.835	0.0938	0.124	15.52	25.80	11.51	3.129	5.749	131.3
5.5	5.705	0.0963	0.122	15.86	26.38	11.62	3.126	5.720	132.8
5.6	5.582	0.0989	0.119	16.20	26.95	11.72	3.124	5.693	134.2
5.7	5.465	0.101	0.116	16.53	27.51	11.82	3.123	5.669	135.7
5.8	5.353	0.104	0.114	16.87	28.08	11.92	3.121	5.646	137.1
5.9	5.245	0.106	0.112	17.21	28.64	12.02	3.120	5.625	138.5
6.0	5.143	0.109	0.109	17.54	29.21	12.11	3.119	5.606	139.9
6.5	4.689	0.121	0.0994	19.19	31.99	12.56	3.115	5.529	146.6
7.0	4.314	0.133	0.0913	20.83	34.74	12.96	3.113	5.473	152.9
7.5	3.997	0.145	0.0845	22.45	37.46	13.34	3.112	5.431	158.8
8.0	3.726	0.156	0.0787	24.07	40.17	13.69	3.112	5.399	164.5
8.5	3.490	0.167	0.0736	25.67	42.86	14.01	3.113	5.373	170.0
9.0	3.284	0.179	0.0692	27.27	45.54	14.32	3.113	5.353	175.2
9.5	3.101	0.190	0.0653	28.87	48.22	14.61	3.113	5.336	180.3
10.0	2.938	0.201	0.0619	30.46	50.88	14.88	3.114	5.321	185.2
11.0	2.660	0.223	0.0559	33.63	56.19	15.39	3.115	5.299	194.6
12.0	2.431	0.244	0.0511	36.80	61.48	15.85	3.115	5.283	203.5
13.0	2.239	0.266	0.0470	39.95	66.75	16.27	3.116	5.270	212.1
14.0	2.075	0.287	0.0435	43.10	72.01	16.66	3.116	5.260	220.2
15.0	1.934	0.309	0.0405	46.25	77.27	17.02	3.117	5.251	228.1
16.0	1.811	0.330	0.0379	49.39	82.52	17.36	3.117	5.244	235.7
17.0	1.703	0.351	0.0357	52.53	87.76	17.68	3.117	5.239	243.0
18.0	1.608	0.373	0.0336	55.67	92.99	17.98	3.117	5.234	250.1
19.0	1.522	0.394	0.0318	58.81	98.23	18.26	3.117	5.230	257.0
20.0	1.445	0.415	0.0302	61.94	103.5	18.53	3.117	5.226	263.7
21.0	1.376	0.436	0.0288	65.07	108.7	18.79	3.117	5.223	270.2
22.0	1.313	0.457	0.0274	68.21	113.9	19.03	3.117	5.220	276.6
23.0	1.256	0.478	0.0262	71.33	119.1	19.26	3.117	5.218	282.8
24.0	1.203	0.499	0.0251	74.46	124.3	19.48	3.117	5.216	288.9
25.0	1.155	0.520	0.0241	77.59	129.5	19.70	3.117	5.214	294.9
26.0	1.110	0.541	0.0232	80.72	134.8	19.90	3.117	5.212	300.7
28.0	1.031	0.583	0.0215	86.97	145.2	20.29	3.117	5.210	312.0
30.0	0.9618	0.625	0.0201	93.22	155.6	20.65	3.117	5.208	323.0
32.0	0.9016	0.666	0.0188	99.46	166.0	20.98	3.117	5.206	333.5
34.0	0.8485	0.708	0.0177	105.7	176.4	21.30	3.117	5.204	343.8
36.0	0.8013	0.750	0.0167	112.0	186.8	21.59	3.117	5.203	353.7

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative $10^5 Pa/K$	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
38.0	0.7591	0.791	0.0158	118.2	197.2	21.88	3.117	5.202	363.4
40.0	0.7211	0.833	0.0150	124.4	207.6	22.14	3.117	5.201	372.8
45.0	0.6410	0.937	0.0133	140.0	233.6	22.76	3.117	5.199	395.4
50.0	0.5769	1.04	0.0120	155.6	259.6	23.30	3.117	5.198	416.7
55.0	0.5245	1.15	0.0109	171.2	285.6	23.80	3.117	5.197	437.0
60.0	0.4808	1.25	0.0100	186.8	311.6	24.25	3.117	5.196	456.4
65.0	0.4439	1.35	0.00924	202.4	337.6	24.67	3.117	5.196	475.0
70.0	0.4122	1.46	0.00857	218.0	363.6	25.05	3.116	5.195	492.9
75.0	0.3847	1.56	0.00800	233.6	389.5	25.41	3.116	5.195	510.1
80.0	0.3607	1.67	0.00750	249.2	415.5	25.75	3.116	5.195	526.8
90.0	0.3206	1.87	0.00667	280.3	467.5	26.36	3.116	5.194	558.7
100.0	0.2886	2.08	0.00600	311.5	519.4	26.90	3.116	5.194	588.9
125.0	0.2309	2.60	0.00480	389.4	649.2	28.06	3.116	5.194	658.3
150.0	0.1924	3.12	0.00400	467.3	779.1	29.01	3.116	5.193	721.0
175.0	0.1650	3.64	0.00343	545.2	908.9	29.81	3.116	5.193	778.7
200.0	0.1444	4.16	0.00300	623.1	1039.0	30.50	3.116	5.193	832.4
225.0	0.1283	4.68	0.00267	701.0	1169.0	31.12	3.116	5.193	882.9
250.0	0.1155	5.20	0.00240	778.9	1298.0	31.66	3.116	5.193	930.6
275.0	0.1050	5.72	0.00218	856.8	1428.0	32.16	3.116	5.193	976.0
300.0	0.09625	6.24	0.00200	934.7	1558.0	32.61	3.116	5.193	1019.0
350.0	0.08251	7.27	0.00171	1090.0	1818.0	33.41	3.116	5.193	1101.0
400.0	0.07220	8.31	0.00150	1246.0	2077.0	34.10	3.116	5.193	1177.0
450.0	0.06418	9.35	0.00133	1402.0	2337.0	34.72	3.116	5.193	1248.0
500.0	0.05776	10.4	0.00120	1558.0	2597.0	35.26	3.116	5.193	1316.0
600.0	0.04813	12.5	0.00100	1869.0	3116.0	36.21	3.116	5.193	1441.0
700.0	0.04126	14.5	0.000857	2181.0	3635.0	37.01	3.116	5.193	1557.0
800.0	0.03610	16.6	0.000750	2493.0	4155.0	37.70	3.116	5.193	1664.0
900.0	0.03209	18.7	0.000667	2804.0	4674.0	38.31	3.116	5.193	1765.0
1000.0	0.02888	20.8	0.000600	3116.0	5193.0	38.86	3.116	5.193	1861.0
1100.0	0.02626	22.9	0.000545	3427.0	5712.0	39.36	3.116	5.193	1951.0
1200.0	0.02407	24.9	0.000500	3739.0	6232.0	39.81	3.116	5.193	2038.0
1300.0	0.02222	27.0	0.000462	4051.0	6751.0	40.22	3.116	5.193	2121.0
1400.0	0.02063	29.1	0.000429	4362.0	7270.0	40.61	3.116	5.193	2201.0
1500.0	0.01926	31.2	0.000400	4674.0	7790.0	40.97	3.116	5.193	2279.0
				$0.7 \times 10^{+5}$ pascal Isobar					
* 2.171	147.6								
2.5	146.2	0.465	2.68	−10.81	−10.33	2.071	1.891	2.071	225.7
3.0	142.5	0.382	3.47	−9.754	−9.262	2.465	1.914	2.381	218.0
3.5	136.9	0.281	3.78	−8.424	−7.912	2.881	2.105	3.055	202.0
* 3.853	131.3	0.204	3.79	−7.239	−6.706	3.209	2.230	3.804	186.6
* 3.853	11.71	0.0404	0.263	9.304	15.28	8.920	3.322	8.111	99.37
4.0	10.86	0.0466	0.241	9.98	16.43	9.211	3.277	7.507	103.3
4.5	8.904	0.0643	0.194	12.03	19.89	10.03	3.190	6.503	114.5
5.0	7.657	0.0794	0.165	13.88	23.02	10.69	3.150	6.072	123.7
5.1	7.456	0.0823	0.160	14.23	23.62	10.81	3.145	6.014	125.4
5.2	7.267	0.0851	0.156	14.59	24.22	10.92	3.140	5.963	127.1
5.3	7.088	0.0878	0.152	14.94	24.82	11.04	3.137	5.916	128.7
5.4	6.920	0.0905	0.148	15.29	25.41	11.15	3.133	5.875	130.3
5.5	6.760	0.0932	0.145	15.64	25.99	11.25	3.130	5.837	131.8
5.6	6.609	0.0959	0.141	15.98	26.57	11.36	3.128	5.803	133.3
5.7	6.465	0.0985	0.138	16.32	27.15	11.46	3.126	5.771	134.8
5.8	6.328	0.101	0.135	16.67	27.73	11.56	3.124	5.742	136.3
5.9	6.197	0.104	0.132	17.01	28.30	11.66	3.122	5.716	137.8
6.0	6.073	0.106	0.130	17.34	28.87	11.76	3.120	5.692	139.2
6.5	5.523	0.119	0.118	19.02	31.69	12.21	3.115	5.595	146.0
7.0	5.072	0.131	0.108	20.67	34.47	12.62	3.113	5.526	152.4
7.5	4.693	0.143	0.100	22.30	37.22	13.00	3.112	5.475	158.4

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
8.0	4.370	0.154	0.0925	23.93	39.95	13.35	3.112	5.436	164.2
8.5	4.090	0.166	0.0865	25.54	42.66	13.68	3.112	5.406	169.7
9.0	3.846	0.177	0.0813	27.15	45.35	13.99	3.113	5.381	175.0
9.5	3.630	0.188	0.0766	28.75	48.04	14.28	3.113	5.360	180.1
10.0	3.438	0.200	0.0725	30.35	50.71	14.55	3.114	5.343	185.1
11.0	3.110	0.222	0.0655	33.53	56.04	15.06	3.114	5.317	194.5
12.0	2.841	0.244	0.0598	36.71	61.35	15.52	3.115	5.298	203.5
13.0	2.615	0.265	0.0550	39.87	66.63	15.95	3.116	5.283	212.1
14.0	2.424	0.287	0.0509	43.03	71.91	16.34	3.116	5.271	220.2
15.0	2.258	0.308	0.0474	46.18	77.17	16.70	3.117	5.261	228.1
16.0	2.115	0.330	0.0444	49.33	82.43	17.04	3.117	5.253	235.7
17.0	1.988	0.351	0.0417	52.47	87.68	17.36	3.117	5.246	243.0
18.0	1.876	0.372	0.0393	55.61	92.92	17.66	3.117	5.240	250.1
19.0	1.776	0.393	0.0372	58.75	98.16	17.94	3.118	5.236	257.0
20.0	1.687	0.415	0.0353	61.89	103.4	18.21	3.118	5.232	263.8
21.0	1.606	0.436	0.0336	65.03	108.6	18.46	3.118	5.228	270.3
22.0	1.532	0.457	0.0320	68.16	113.9	18.71	3.118	5.225	276.7
23.0	1.465	0.478	0.0306	71.29	119.1	18.94	3.118	5.222	282.9
24.0	1.404	0.499	0.0293	74.42	124.3	19.16	3.118	5.220	289.0
25.0	1.347	0.520	0.0282	77.55	129.5	19.37	3.118	5.218	295.0
26.0	1.295	0.541	0.0271	80.68	134.7	19.58	3.118	5.216	300.8
28.0	1.202	0.583	0.0251	86.93	145.2	19.97	3.118	5.213	312.2
30.0	1.122	0.625	0.0234	93.19	155.6	20.32	3.118	5.210	323.1
32.0	1.052	0.667	0.0219	99.43	166.0	20.66	3.117	5.208	333.7
34.0	0.9897	0.708	0.0206	105.7	176.4	20.98	3.117	5.206	343.9
36.0	0.9346	0.750	0.0195	111.9	186.8	21.27	3.117	5.205	353.9
38.0	0.8854	0.792	0.0185	118.2	197.2	21.56	3.117	5.203	363.5
40.0	0.8411	0.834	0.0175	124.4	207.6	21.82	3.117	5.202	372.9
45.0	0.7477	0.938	0.0156	140.0	233.6	22.43	3.117	5.200	395.5
50.0	0.6729	1.04	0.0140	155.6	259.6	22.98	3.117	5.199	416.8
55.0	0.6118	1.15	0.0127	171.2	285.6	23.48	3.117	5.198	437.1
60.0	0.5608	1.25	0.0117	186.8	311.6	23.93	3.117	5.197	456.5
65.0	0.5177	1.35	0.0108	202.4	337.6	24.35	3.117	5.196	475.1
70.0	0.4808	1.46	0.0100	218.0	363.6	24.73	3.117	5.196	493.0
75.0	0.4487	1.56	0.00934	233.6	389.6	25.09	3.117	5.195	510.2
80.0	0.4207	1.67	0.00875	249.2	415.5	25.43	3.116	5.195	526.9
90.0	0.3740	1.87	0.00778	280.3	467.5	26.04	3.116	5.195	558.8
100.0	0.3366	2.08	0.00700	311.5	519.4	26.58	3.116	5.194	589.0
125.0	0.2694	2.60	0.00560	389.4	649.3	27.74	3.116	5.194	658.3
150.0	0.2245	3.12	0.00467	467.3	779.1	28.69	3.116	5.193	721.1
175.0	0.1924	3.64	0.00400	545.2	908.9	29.49	3.116	5.193	778.8
200.0	0.1684	4.16	0.00350	623.1	1039.0	30.18	3.116	5.193	832.5
225.0	0.1497	4.68	0.00311	701.0	1169.0	30.80	3.116	5.193	882.9
250.0	0.1347	5.20	0.00280	778.9	1298.0	31.34	3.116	5.193	930.6
275.0	0.1225	5.72	0.00255	856.8	1428.0	31.84	3.116	5.193	976.0
300.0	0.1123	6.24	0.00233	934.7	1558.0	32.29	3.116	5.193	1019.0
350.0	0.09626	7.27	0.00200	1091.0	1818.0	33.09	3.116	5.193	1101.0
400.0	0.08423	8.31	0.00175	1246.0	2077.0	33.78	3.116	5.193	1177.0
450.0	0.07487	9.35	0.00156	1402.0	2337.0	34.40	3.116	5.193	1248.0
500.0	0.06738	10.4	0.00140	1558.0	2597.0	34.94	3.116	5.193	1316.0
600.0	0.05616	12.5	0.00117	1869.0	3116.0	35.89	3.116	5.193	1441.0
700.0	0.04814	14.5	0.00100	2181.0	3635.0	36.69	3.116	5.193	1557.0
800.0	0.04212	16.6	0.000875	2493.0	4155.0	37.38	3.116	5.193	1664.0
900.0	0.03744	18.7	0.000778	2804.0	4674.0	37.99	3.116	5.193	1765.0
1000.0	0.03370	20.8	0.000700	3116.0	5193.0	38.54	3.116	5.193	1861.0
1100.0	0.03063	22.9	0.000636	3427.0	5712.0	39.04	3.116	5.193	1951.0
1200.0	0.02808	24.9	0.000583	3739.0	6232.0	39.49	3.116	5.193	2038.0
1300.0	0.02592	27.0	0.000538	4051.0	6751.0	39.90	3.116	5.193	2121.0
1400.0	0.02407	29.1	0.000500	4362.0	7270.0	40.29	3.116	5.193	2201.0
1500.0	0.02246	31.2	0.000467	4674.0	7790.0	40.65	3.116	5.193	2279.0

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative: 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
				0.8 × 10^{+5} pascal Isobar					
* 2.171	147.8								
2.5	146.4	0.471	2.67	−10.82	−10.27	2.067	1.885	2.063	226.9
3.0	142.7	0.388	3.48	−9.770	−9.209	2.460	1.913	2.372	219.4
3.5	137.3	0.287	3.80	−8.451	−7.868	2.873	2.103	3.036	203.7
* 3.982	129.3	0.182	3.77	−6.782	−6.163	3.328	2.275	4.142	181.9
* 3.982	13.32	0.0386	0.301	9.370	15.38	8.739	3.331	8.580	99.8
4.0	13.18	0.0395	0.297	9.460	15.53	8.778	3.324	8.468	100.3
4.5	10.52	0.0594	0.231	11.68	19.28	9.663	3.210	6.862	112.7
5.0	8.948	0.0756	0.194	13.60	22.54	10.35	3.159	6.270	122.4
5.1	8.700	0.0785	0.188	13.97	23.17	10.47	3.153	6.194	124.2
5.2	8.468	0.0815	0.183	14.34	23.78	10.59	3.147	6.127	125.9
5.3	8.250	0.0844	0.178	14.70	24.39	10.71	3.143	6.067	127.6
5.4	8.045	0.0872	0.173	15.05	25.00	10.82	3.138	6.014	129.3
5.5	7.852	0.0900	0.169	15.41	25.60	10.93	3.135	5.966	130.9
5.6	7.669	0.0928	0.165	15.76	26.19	11.04	3.132	5.922	132.4
5.7	7.496	0.0955	0.161	16.11	26.78	11.14	3.129	5.883	134.0
5.8	7.332	0.0982	0.157	16.46	27.37	11.25	3.126	5.847	135.5
5.9	7.176	0.101	0.154	16.80	27.95	11.35	3.124	5.814	137.0
6.0	7.027	0.103	0.151	17.14	28.53	11.44	3.122	5.784	138.4
6.5	6.374	0.116	0.136	18.84	31.39	11.90	3.116	5.665	145.4
7.0	5.843	0.129	0.124	20.51	34.20	12.32	3.113	5.582	151.9
7.5	5.399	0.141	0.115	22.16	36.97	12.70	3.112	5.521	158.0
8.0	5.022	0.153	0.107	23.79	39.72	13.06	3.112	5.475	163.9
8.5	4.696	0.164	0.100	25.42	42.45	13.39	3.112	5.438	169.4
9.0	4.412	0.176	0.0935	27.03	45.16	13.70	3.112	5.409	174.8
9.5	4.162	0.187	0.0881	28.64	47.86	13.99	3.113	5.386	179.9
10.0	3.940	0.198	0.0833	30.24	50.55	14.26	3.113	5.366	184.9
11.0	3.562	0.221	0.0752	33.44	55.89	14.77	3.114	5.336	194.4
12.0	3.252	0.243	0.0686	36.62	61.22	15.24	3.115	5.313	203.5
13.0	2.993	0.265	0.0630	39.79	66.52	15.66	3.116	5.296	212.0
14.0	2.773	0.286	0.0583	42.95	71.80	16.05	3.117	5.282	220.3
15.0	2.583	0.308	0.0543	46.11	77.08	16.42	3.117	5.271	228.2
16.0	2.418	0.329	0.0508	49.26	82.35	16.76	3.117	5.262	235.8
17.0	2.273	0.351	0.0477	52.41	87.60	17.08	3.118	5.254	243.1
18.0	2.145	0.372	0.0450	55.56	92.85	17.38	3.118	5.247	250.2
19.0	2.030	0.393	0.0426	58.70	98.10	17.66	3.118	5.242	257.1
20.0	1.928	0.415	0.0404	61.84	103.3	17.93	3.118	5.237	263.9
21.0	1.835	0.436	0.0384	64.98	108.6	18.18	3.118	5.233	270.4
22.0	1.751	0.457	0.0367	68.11	113.8	18.43	3.118	5.229	276.8
23.0	1.674	0.478	0.0350	71.25	119.0	18.66	3.118	5.226	283.0
24.0	1.604	0.499	0.0336	74.38	124.3	18.88	3.118	5.224	289.1
25.0	1.539	0.520	0.0322	77.51	129.5	19.10	3.118	5.221	295.1
26.0	1.480	0.541	0.0309	80.64	134.7	19.30	3.118	5.219	300.9
28.0	1.374	0.583	0.0287	86.90	145.1	19.69	3.118	5.215	312.3
30.0	1.282	0.625	0.0268	93.15	155.6	20.05	3.118	5.212	323.2
32.0	1.202	0.667	0.0251	99.40	166.0	20.38	3.118	5.210	333.8
34.0	1.131	0.709	0.0236	105.7	176.4	20.70	3.118	5.208	344.0
36.0	1.068	0.750	0.0223	111.9	186.8	21.00	3.118	5.206	354.0
38.0	1.012	0.792	0.0211	118.1	197.2	21.28	3.117	5.205	363.7
40.0	0.9611	0.834	0.0200	124.4	207.6	21.54	3.117	5.204	373.1
45.0	0.8543	0.938	0.0178	140.0	233.6	22.16	3.117	5.201	395.6
50.0	0.7689	1.04	0.0160	155.6	259.6	22.70	3.117	5.200	416.9
55.0	0.6990	1.15	0.0146	171.2	285.6	23.20	3.117	5.198	437.2
60.0	0.6408	1.25	0.0133	186.8	311.6	23.65	3.117	5.197	456.6
65.0	0.5916	1.35	0.0123	202.4	337.6	24.07	3.117	5.197	475.2
70.0	0.5494	1.46	0.0114	218.0	363.6	24.45	3.117	5.196	493.1
75.0	0.5128	1.56	0.0107	233.6	389.6	24.81	3.117	5.196	510.3

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
80.0	0.4807	1.67	0.0100	249.1	415.6	25.15	3.117	5.195	527.0
90.0	0.4274	1.87	0.00889	280.3	467.5	25.76	3.116	5.195	558.9
100.0	0.3847	2.08	0.00800	311.5	519.4	26.31	3.116	5.194	589.0
125.0	0.3078	2.60	0.00640	389.4	649.3	27.47	3.116	5.194	658.4
150.0	0.2565	3.12	0.00533	467.3	779.1	28.41	3.116	5.194	721.1
175.0	0.2199	3.64	0.00457	545.2	909.0	29.21	3.116	5.193	778.8
200.0	0.1925	4.16	0.00400	623.1	1039.0	29.91	3.116	5.193	832.5
225.0	0.1711	4.68	0.00356	701.0	1169.0	30.52	3.116	5.193	883.0
250.0	0.1540	5.20	0.00320	778.9	1298.0	31.07	3.116	5.193	930.7
275.0	0.1400	5.72	0.00291	856.8	1428.0	31.56	3.116	5.193	976.1
300.0	0.1283	6.24	0.00267	934.7	1558.0	32.01	3.116	5.193	1019.0
350.0	0.1100	7.27	0.00229	1091.0	1818.0	32.81	3.116	5.193	1101.0
400.0	0.09626	8.31	0.00200	1246.0	2077.0	33.51	3.116	5.193	1177.0
450.0	0.08556	9.35	0.00178	1402.0	2337.0	34.12	3.116	5.193	1248.0
500.0	0.07701	10.4	0.00160	1558.0	2597.0	34.67	3.116	5.193	1316.0
600.0	0.06418	12.5	0.00133	1869.0	3116.0	35.61	3.116	5.193	1441.0
700.0	0.05501	14.5	0.00114	2181.0	3635.0	36.41	3.116	5.193	1557.0
800.0	0.04814	16.6	0.00100	2493.0	4155.0	37.11	3.116	5.193	1664.0
900.0	0.04279	18.7	0.000889	2804.0	4674.0	37.72	3.116	5.193	1765.0
1000.0	0.03851	20.8	0.000800	3116.0	5193.0	38.26	3.116	5.193	1861.0
1100.0	0.03501	22.9	0.000727	3427.0	5713.0	38.76	3.116	5.193	1951.0
1200.0	0.03209	24.9	0.000667	3739.0	6232.0	39.21	3.116	5.193	2038.0
1300.0	0.02962	27.0	0.000615	4051.0	6751.0	39.63	3.116	5.193	2121.0
1400.0	0.02751	29.1	0.000571	4362.0	7270.0	40.01	3.116	5.193	2202.0
1500.0	0.02567	31.2	0.000533	4674.0	7790.0	40.37	3.116	5.193	2279.0

$0.9 \times 10^{+5}$ pascal Isobar

*	2.170	148.0							
	2.5	146.6	0.476	2.67	−10.83	−10.22	2.063	1.880	2.054	228.1
	3.0	143.0	0.394	3.49	−9.786	−9.156	2.454	1.911	2.364	220.7
	3.5	137.6	0.294	3.81	−8.477	−7.823	2.865	2.102	3.017	205.3
	4.0	129.5	0.185	3.79	−6.758	−6.063	3.334	2.279	4.140	183.1
*	4.101	127.3	0.161	3.74	−6.334	−5.627	3.441	2.319	4.512	177.2
*	4.101	14.97	0.0367	0.340	9.399	15.41	8.573	3.339	9.102	100.0
	4.5	12.28	0.0542	0.272	11.29	18.62	9.322	3.232	7.315	110.7
	5.0	10.31	0.0716	0.225	13.31	22.05	10.04	3.170	6.497	121.1
	5.1	10.00	0.0747	0.218	13.70	22.69	10.17	3.162	6.398	123.0
	5.2	9.723	0.0778	0.211	14.07	23.33	10.29	3.155	6.312	124.8
	5.3	9.461	0.0808	0.205	14.44	23.95	10.41	3.149	6.236	126.5
	5.4	9.215	0.0838	0.200	14.81	24.57	10.53	3.144	6.168	128.2
	5.5	8.984	0.0867	0.194	15.17	25.19	10.64	3.140	6.107	129.9
	5.6	8.766	0.0896	0.189	15.53	25.80	10.75	3.136	6.053	131.5
	5.7	8.561	0.0924	0.185	15.89	26.40	10.86	3.133	6.004	133.1
	5.8	8.366	0.0952	0.180	16.24	27.00	10.96	3.130	5.960	134.6
	5.9	8.182	0.0980	0.176	16.59	27.59	11.06	3.127	5.920	136.2
	6.0	8.006	0.101	0.172	16.94	28.18	11.16	3.125	5.883	137.7
	6.5	7.243	0.114	0.155	18.66	31.08	11.63	3.117	5.739	144.8
	7.0	6.626	0.127	0.142	20.34	33.93	12.05	3.113	5.640	151.4
	7.5	6.114	0.139	0.130	22.01	36.73	12.44	3.112	5.568	157.6
	8.0	5.680	0.151	0.121	23.65	39.50	12.79	3.111	5.514	163.5
	8.5	5.308	0.163	0.113	25.29	42.24	13.13	3.111	5.472	169.2
	9.0	4.983	0.174	0.106	26.91	44.97	13.44	3.112	5.438	174.6
	9.5	4.698	0.186	0.100	28.53	47.68	13.73	3.112	5.411	179.8
	10.0	4.445	0.197	0.0942	30.14	50.38	14.01	3.113	5.388	184.8
	11.0	4.016	0.220	0.0850	33.34	55.75	14.52	3.114	5.354	194.4
	12.0	3.665	0.242	0.0774	36.53	61.09	14.99	3.115	5.329	203.4
	13.0	3.371	0.264	0.0711	39.70	66.40	15.41	3.116	5.309	212.0
	14.0	3.122	0.286	0.0658	42.87	71.70	15.80	3.117	5.294	220.3

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
15.0	2.908	0.307	0.0612	46.04	76.98	16.17	3.117	5.281	228.2
16.0	2.722	0.329	0.0573	49.19	82.26	16.51	3.117	5.270	235.8
17.0	2.558	0.350	0.0538	52.35	87.53	16.83	3.118	5.262	243.2
18.0	2.414	0.372	0.0507	55.50	92.78	17.13	3.118	5.254	250.3
19.0	2.285	0.393	0.0480	58.64	98.03	17.41	3.118	5.248	257.2
20.0	2.169	0.414	0.0455	61.79	103.3	17.68	3.118	5.243	263.9
21.0	2.065	0.436	0.0433	64.93	108.5	17.94	3.118	5.238	270.5
22.0	1.970	0.457	0.0413	68.07	113.8	18.18	3.118	5.234	276.9
23.0	1.883	0.478	0.0395	71.20	119.0	18.41	3.118	5.230	283.1
24.0	1.804	0.499	0.0378	74.34	124.2	18.64	3.118	5.227	289.2
25.0	1.732	0.520	0.0363	77.47	129.4	18.85	3.118	5.225	295.2
26.0	1.665	0.541	0.0348	80.60	134.7	19.05	3.118	5.222	301.0
28.0	1.545	0.583	0.0323	86.86	145.1	19.44	3.118	5.218	312.4
30.0	1.442	0.625	0.0301	93.12	155.5	19.80	3.118	5.215	323.3
32.0	1.352	0.667	0.0282	99.37	166.0	20.14	3.118	5.212	333.9
34.0	1.272	0.709	0.0266	105.6	176.4	20.45	3.118	5.210	344.2
36.0	1.201	0.751	0.0251	111.9	186.8	20.75	3.118	5.208	354.1
38.0	1.138	0.793	0.0237	118.1	197.2	21.03	3.118	5.206	363.8
40.0	1.081	0.834	0.0226	124.4	207.6	21.30	3.118	5.205	373.2
45.0	0.9608	0.939	0.0200	140.0	233.6	21.91	3.117	5.202	395.7
50.0	0.8648	1.04	0.0180	155.6	259.7	22.46	3.117	5.200	417.1
55.0	0.7862	1.15	0.0164	171.2	285.7	22.96	3.117	5.199	437.3
60.0	0.7208	1.25	0.0150	186.8	311.6	23.41	3.117	5.198	456.7
65.0	0.6654	1.36	0.0139	202.4	337.6	23.82	3.117	5.197	475.3
70.0	0.6179	1.46	0.0129	218.0	363.6	24.21	3.117	5.197	493.2
75.0	0.5768	1.56	0.0120	233.5	389.6	24.57	3.117	5.196	510.4
80.0	0.5407	1.67	0.0113	249.1	415.6	24.90	3.117	5.196	527.1
90.0	0.4807	1.87	0.0100	280.3	467.5	25.51	3.117	5.195	559.0
100.0	0.4327	2.08	0.00900	311.5	519.5	26.06	3.116	5.195	589.1
125.0	0.3462	2.60	0.00720	389.4	649.3	27.22	3.116	5.194	658.5
150.0	0.2886	3.12	0.00600	467.3	779.2	28.17	3.116	5.194	721.2
175.0	0.2474	3.64	0.00514	545.2	909.0	28.97	3.116	5.193	778.9
200.0	0.2165	4.16	0.00450	623.1	1039.0	29.66	3.116	5.193	832.6
225.0	0.1925	4.68	0.00400	701.0	1169.0	30.27	3.116	5.193	883.0
250.0	0.1732	5.20	0.00360	778.9	1298.0	30.82	3.116	5.193	930.7
275.0	0.1575	5.72	0.00327	856.8	1428.0	31.32	3.116	5.193	976.1
300.0	0.1444	6.24	0.00300	934.7	1558.0	31.77	3.116	5.193	1019.0
350.0	0.1237	7.28	0.00257	1091.0	1818.0	32.57	3.116	5.193	1101.0
400.0	0.1083	8.31	0.00225	1246.0	2077.0	33.26	3.116	5.193	1177.0
450.0	0.09626	9.35	0.00200	1402.0	2337.0	33.87	3.116	5.193	1248.0
500.0	0.08663	10.4	0.00180	1558.0	2597.0	34.42	3.116	5.193	1316.0
600.0	0.07220	12.5	0.00150	1869.0	3116.0	35.37	3.116	5.193	1441.0
700.0	0.06189	14.5	0.00129	2181.0	3635.0	36.17	3.116	5.193	1557.0
800.0	0.05415	16.6	0.00112	2493.0	4155.0	36.86	3.116	5.193	1664.0
900.0	0.04814	18.7	0.00100	2804.0	4674.0	37.47	3.116	5.193	1765.0
1000.0	0.04332	20.8	0.000900	3116.0	5193.0	38.02	3.116	5.193	1861.0
1100.0	0.03938	22.9	0.000818	3427.0	5713.0	38.51	3.116	5.193	1951.0
1200.0	0.03610	24.9	0.000750	3739.0	6232.0	38.97	3.116	5.193	2038.0
1300.0	0.03333	27.0	0.000692	4051.0	6751.0	39.38	3.116	5.193	2121.0
1400.0	0.03095	29.1	0.000643	4362.0	7270.0	39.77	3.116	5.193	2202.0
1500.0	0.02888	31.2	0.000600	4674.0	7790.0	40.13	3.116	5.193	2279.0
				$1.0 \times 10^{+5}$ pascal Isobar					
* 2.169	148.2								
2.5	146.8	0.482	2.67	−10.84	−10.16	2.059	1.874	2.046	229.3
3.0	143.3	0.400	3.49	−9.801	−9.103	2.448	1.910	2.356	222.0
3.5	138.0	0.300	3.83	−8.502	−7.777	2.857	2.100	2.998	206.9
4.0	130.0	0.191	3.82	−6.805	−6.036	3.321	2.275	4.082	185.3

Thermodynamic properties of helium 4—Continued

	Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
*	4.210	125.2	0.143	3.69	−5.892	−5.094	3.550	2.362	4.923	172.6
*	4.210	16.66	0.0346	0.381	9.396	15.40	8.417	3.347	9.693	100.2
	4.5	14.23	0.0485	0.319	10.88	17.90	8.994	3.259	7.909	108.5
	5.0	11.75	0.0674	0.258	13.01	21.52	9.758	3.182	6.763	119.7
	5.1	11.38	0.0708	0.249	13.41	22.19	9.890	3.172	6.634	121.6
	5.2	11.04	0.0740	0.241	13.79	22.85	10.02	3.164	6.522	123.5
	5.3	10.73	0.0772	0.234	14.18	23.50	10.14	3.157	6.425	125.4
	5.4	10.43	0.0803	0.227	14.55	24.14	10.26	3.151	6.340	127.1
	5.5	10.16	0.0834	0.221	14.92	24.77	10.38	3.146	6.264	128.9
	5.6	9.903	0.0864	0.215	15.29	25.39	10.49	3.141	6.197	130.5
	5.7	9.661	0.0893	0.209	15.66	26.01	10.60	3.137	6.137	132.2
	5.8	9.433	0.0922	0.204	16.02	26.62	10.70	3.133	6.083	133.8
	5.9	9.218	0.0951	0.199	16.37	27.22	10.81	3.130	6.034	135.4
	6.0	9.014	0.0979	0.195	16.73	27.82	10.91	3.128	5.989	136.9
	6.5	8.131	0.111	0.175	18.47	30.77	11.38	3.118	5.817	144.2
	7.0	7.423	0.124	0.159	20.18	33.65	11.81	3.114	5.700	150.9
	7.5	6.839	0.137	0.146	21.86	36.48	12.20	3.112	5.617	157.2
	8.0	6.347	0.149	0.135	23.51	39.27	12.56	3.111	5.554	163.2
	8.5	5.925	0.161	0.126	25.16	42.04	12.89	3.111	5.506	168.9
	9.0	5.559	0.173	0.118	26.79	44.78	13.21	3.111	5.468	174.4
	9.5	5.238	0.185	0.111	28.41	47.50	13.50	3.112	5.437	179.6
	10.0	4.954	0.196	0.105	30.03	50.22	13.78	3.113	5.411	184.6
	11.0	4.472	0.219	0.0948	33.24	55.60	14.29	3.114	5.373	194.3
	12.0	4.079	0.241	0.0863	36.44	60.95	14.76	3.115	5.344	203.4
	13.0	3.751	0.263	0.0793	39.62	66.28	15.19	3.116	5.322	212.0
	14.0	3.473	0.285	0.0733	42.80	71.59	15.58	3.117	5.305	220.3
	15.0	3.234	0.307	0.0682	45.96	76.89	15.94	3.117	5.291	228.2
	16.0	3.026	0.329	0.0638	49.13	82.17	16.29	3.118	5.279	235.9
	17.0	2.844	0.350	0.0599	52.29	87.45	16.61	3.118	5.269	243.2
	18.0	2.683	0.372	0.0564	55.44	92.71	16.91	3.118	5.261	250.4
	19.0	2.539	0.393	0.0534	58.59	97.97	17.19	3.118	5.254	257.3
	20.0	2.410	0.414	0.0506	61.73	103.2	17.46	3.118	5.248	264.0
	21.0	2.294	0.436	0.0482	64.88	108.5	17.72	3.118	5.243	270.6
	22.0	2.189	0.457	0.0459	68.02	113.7	17.96	3.118	5.238	277.0
	23.0	2.093	0.478	0.0439	71.16	118.9	18.19	3.119	5.235	283.2
	24.0	2.005	0.499	0.0420	74.29	124.2	18.41	3.118	5.231	289.3
	25.0	1.924	0.520	0.0403	77.43	129.4	18.63	3.118	5.228	295.3
	26.0	1.849	0.541	0.0387	80.56	134.6	18.83	3.118	5.225	301.2
	28.0	1.717	0.583	0.0359	86.83	145.1	19.22	3.118	5.221	312.5
	30.0	1.602	0.625	0.0335	93.09	155.5	19.58	3.118	5.217	323.5
	32.0	1.501	0.667	0.0314	99.34	165.9	19.92	3.118	5.214	334.0
	34.0	1.413	0.709	0.0295	105.6	176.4	20.23	3.118	5.212	344.3
	36.0	1.334	0.751	0.0279	111.8	186.8	20.53	3.118	5.210	354.2
	38.0	1.264	0.793	0.0264	118.1	197.2	20.81	3.118	5.208	363.9
	40.0	1.201	0.835	0.0251	124.3	207.6	21.08	3.118	5.206	373.3
	45.0	1.067	0.939	0.0223	140.0	233.6	21.69	3.118	5.203	395.9
	50.0	0.9607	1.04	0.0200	155.6	259.7	22.24	3.117	5.201	417.2
	55.0	0.8734	1.15	0.0182	171.2	285.7	22.74	3.117	5.200	437.5
	60.0	0.8007	1.25	0.0167	186.8	311.7	23.19	3.117	5.198	456.8
	65.0	0.7392	1.36	0.0154	202.4	337.6	23.60	3.117	5.198	475.4
	70.0	0.6864	1.46	0.0143	218.0	363.6	23.99	3.117	5.197	493.3
	75.0	0.6407	1.56	0.0133	233.5	389.6	24.35	3.117	5.196	510.5
	80.0	0.6007	1.67	0.0125	249.1	415.6	24.68	3.117	5.196	527.2
	90.0	0.5341	1.88	0.0111	280.3	467.5	25.30	3.117	5.195	559.1
	100.0	0.4807	2.08	0.0100	311.5	519.5	25.84	3.117	5.195	589.2
	125.0	0.3847	2.60	0.00800	389.4	649.4	27.00	3.116	5.194	658.6
	150.0	0.3206	3.12	0.00667	467.3	779.2	27.95	3.116	5.194	721.3
	175.0	0.2749	3.64	0.00571	545.2	909.0	28.75	3.116	5.193	779.0
	200.0	0.2405	4.16	0.00500	623.1	1039.0	29.44	3.116	5.193	832.6
	225.0	0.2138	4.68	0.00444	701.0	1169.0	30.05	3.116	5.193	883.1

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
250.0	0.1925	5.20	0.00400	778.9	1299.0	30.60	3.116	5.193	930.8
275.0	0.1750	5.72	0.00364	856.8	1428.0	31.10	3.116	5.193	976.1
300.0	0.1604	6.24	0.00333	934.7	1558.0	31.55	3.116	5.193	1020.0
350.0	0.1375	7.28	0.00286	1091.0	1818.0	32.35	3.116	5.193	1101.0
400.0	0.1203	8.31	0.00250	1246.0	2077.0	33.04	3.116	5.193	1177.0
450.0	0.1069	9.35	0.00222	1402.0	2337.0	33.65	3.116	5.193	1248.0
500.0	0.09626	10.4	0.00200	1558.0	2597.0	34.20	3.116	5.193	1316.0
600.0	0.08022	12.5	0.00167	1869.0	3116.0	35.15	3.116	5.193	1441.0
700.0	0.06876	14.5	0.00143	2181.0	3635.0	35.95	3.116	5.193	1557.0
800.0	0.06017	16.6	0.00125	2493.0	4155.0	36.64	3.116	5.193	1664.0
900.0	0.05348	18.7	0.00111	2804.0	4674.0	37.25	3.116	5.193	1765.0
1000.0	0.04814	20.8	0.00100	3116.0	5193.0	37.80	3.116	5.193	1861.0
1100.0	0.04376	22.9	0.000909	3427.0	5713.0	38.30	3.116	5.193	1951.0
1200.0	0.04011	24.9	0.000833	3739.0	6232.0	38.75	3.116	5.193	2038.0
1300.0	0.03703	27.0	0.000769	4051.0	6751.0	39.16	3.116	5.193	2121.0
1400.0	0.03438	29.1	0.000714	4362.0	7270.0	39.55	3.116	5.193	2202.0
1500.0	0.03209	31.2	0.000667	4674.0	7790.0	39.91	3.116	5.193	2279.0
				$1.2 \times 10^{+5}$ pascal Isobar					
• 2.167	148.6								
2.5	147.3	0.493	2.67	−10.86	−10.04	2.052	1.863	2.030	231.7
3.0	143.8	0.411	3.50	−9.831	−8.996	2.438	1.907	2.340	224.6
3.5	138.6	0.312	3.86	−8.551	−7.685	2.842	2.096	2.964	210.1
4.0	131.0	0.205	3.88	−6.893	−5.977	3.297	2.268	3.977	189.5
4.410	121.1	0.110	3.57	−5.014	−4.023	3.761	2.447	5.922	163.3
4.410	20.24	0.0302	0.468	9.299	15.23	8.126	3.361	11.17	100.1
4.5	18.99	0.0356	0.436	9.863	16.18	8.339	3.325	9.97	103.3
5.0	14.92	0.0586	0.333	12.35	20.39	9.228	3.210	7.454	116.6
5.1	14.38	0.0624	0.320	12.78	21.12	9.373	3.196	7.231	118.8
5.2	13.90	0.0661	0.308	13.20	21.83	9.512	3.185	7.045	120.9
5.3	13.45	0.0697	0.297	13.61	22.53	9.644	3.175	6.887	122.9
5.4	13.04	0.0731	0.287	14.01	23.21	9.772	3.166	6.752	124.9
5.5	12.66	0.0765	0.278	14.41	23.88	9.895	3.159	6.636	126.7
5.6	12.31	0.0797	0.270	14.79	24.54	10.01	3.153	6.533	128.5
5.7	11.98	0.0829	0.262	15.18	25.19	10.13	3.147	6.443	130.3
5.8	11.68	0.0860	0.255	15.55	25.83	10.24	3.142	6.364	132.0
5.9	11.39	0.0891	0.249	15.93	26.46	10.35	3.138	6.292	133.7
6.0	11.12	0.0921	0.242	16.30	27.09	10.45	3.134	6.228	135.3
6.5	9.97	0.107	0.216	18.10	30.14	10.94	3.121	5.987	142.9
7.0	9.058	0.120	0.196	19.84	33.09	11.38	3.115	5.830	149.9
7.5	8.319	0.133	0.179	21.55	35.97	11.78	3.112	5.719	156.4
8.0	7.702	0.146	0.165	23.23	38.81	12.14	3.111	5.639	162.6
8.5	7.177	0.158	0.154	24.90	41.62	12.48	3.110	5.577	168.4
9.0	6.724	0.170	0.144	26.55	44.39	12.80	3.111	5.529	173.9
9.5	6.329	0.182	0.135	28.18	47.15	13.10	3.111	5.490	179.2
10.0	5.979	0.194	0.128	29.81	49.88	13.38	3.112	5.458	184.4
11.0	5.391	0.217	0.115	33.05	55.31	13.90	3.113	5.411	194.1
12.0	4.911	0.239	0.104	36.26	60.69	14.37	3.115	5.376	203.3
13.0	4.512	0.262	0.0957	39.46	66.05	14.79	3.116	5.349	212.0
14.0	4.175	0.284	0.0884	42.64	71.38	15.19	3.117	5.328	220.3
15.0	3.886	0.306	0.0822	45.82	76.70	15.56	3.118	5.311	228.3
16.0	3.635	0.328	0.0768	48.99	82.00	15.90	3.118	5.297	236.0
17.0	3.416	0.350	0.0721	52.16	87.29	16.22	3.118	5.285	243.4
18.0	3.221	0.371	0.0679	55.32	92.57	16.52	3.119	5.275	250.5
19.0	3.048	0.393	0.0642	58.48	97.84	16.81	3.119	5.266	257.5
20.0	2.893	0.414	0.0609	61.63	103.1	17.08	3.119	5.259	264.2
21.0	2.753	0.435	0.0579	64.78	108.4	17.33	3.119	5.253	270.8
22.0	2.627	0.457	0.0552	67.92	113.6	17.58	3.119	5.248	277.2

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
23.0	2.511	0.478	0.0528	71.07	118.9	17.81	3.119	5.243	283.4
24.0	2.405	0.499	0.0505	74.21	124.1	18.03	3.119	5.239	289.6
25.0	2.308	0.520	0.0484	77.35	129.3	18.25	3.119	5.235	295.5
26.0	2.219	0.542	0.0465	80.49	134.6	18.45	3.119	5.232	301.4
28.0	2.059	0.584	0.0432	86.76	145.0	18.84	3.119	5.226	312.7
30.0	1.921	0.626	0.0402	93.02	155.5	19.20	3.119	5.222	323.7
32.0	1.801	0.668	0.0377	99.29	165.9	19.54	3.119	5.218	334.3
34.0	1.695	0.710	0.0355	105.5	176.3	19.85	3.119	5.215	344.5
36.0	1.600	0.752	0.0335	111.8	186.8	20.15	3.118	5.213	354.5
38.0	1.516	0.794	0.0317	118.1	197.2	20.43	3.118	5.211	364.1
40.0	1.440	0.835	0.0301	124.3	207.6	20.70	3.118	5.209	373.6
45.0	1.280	0.940	0.0267	139.9	233.7	21.31	3.118	5.205	396.1
50.0	1.152	1.04	0.0240	155.5	259.7	21.86	3.118	5.203	417.4
55.0	1.048	1.15	0.0219	171.1	285.7	22.36	3.118	5.201	437.7
60.0	0.9604	1.25	0.0200	186.7	311.7	22.81	3.117	5.200	457.0
65.0	0.8866	1.36	0.0185	202.3	337.7	23.23	3.117	5.198	475.6
70.0	0.8234	1.46	0.0172	217.9	363.7	23.61	3.117	5.198	493.5
75.0	0.7686	1.56	0.0160	233.5	389.7	23.97	3.117	5.197	510.7
80.0	0.7206	1.67	0.0150	249.1	415.6	24.30	3.117	5.196	527.4
90.0	0.6407	1.88	0.0133	280.3	467.6	24.92	3.117	5.196	559.3
100.0	0.5767	2.08	0.0120	311.5	519.5	25.46	3.117	5.195	589.4
125.0	0.4615	2.60	0.00960	389.4	649.4	26.62	3.117	5.194	658.7
150.0	0.3847	3.12	0.00800	467.3	779.3	27.57	3.116	5.194	721.4
175.0	0.3298	3.64	0.00686	545.2	909.1	28.37	3.116	5.194	779.1
200.0	0.2886	4.16	0.00600	623.1	1039.0	29.06	3.116	5.193	832.8
225.0	0.2566	4.68	0.00533	701.0	1169.0	29.68	3.116	5.193	883.2
250.0	0.2309	5.20	0.00480	778.9	1299.0	30.22	3.116	5.193	930.9
275.0	0.2099	5.72	0.00436	856.8	1428.0	30.72	3.116	5.193	976.2
300.0	0.1925	6.24	0.00400	934.7	1558.0	31.17	3.116	5.193	1020.0
350.0	0.1650	7.28	0.00343	1091.0	1818.0	31.97	3.116	5.193	1101.0
400.0	0.1444	8.32	0.00300	1246.0	2078.0	32.66	3.116	5.193	1177.0
450.0	0.1283	9.35	0.00267	1402.0	2337.0	33.28	3.116	5.193	1248.0
500.0	0.1155	10.4	0.00240	1558.0	2597.0	33.82	3.116	5.193	1316.0
600.0	0.09626	12.5	0.00200	1869.0	3116.0	34.77	3.116	5.193	1441.0
700.0	0.08251	14.5	0.00171	2181.0	3635.0	35.57	3.116	5.193	1557.0
800.0	0.07220	16.6	0.00150	2493.0	4155.0	36.26	3.116	5.193	1664.0
900.0	0.06418	18.7	0.00133	2804.0	4674.0	36.88	3.116	5.193	1765.0
1000.0	0.05776	20.8	0.00120	3116.0	5193.0	37.42	3.116	5.193	1861.0
1100.0	0.05251	22.9	0.00109	3427.0	5713.0	37.92	3.116	5.193	1952.0
1200.0	0.04814	24.9	0.00100	3739.0	6232.0	38.37	3.116	5.193	2038.0
1300.0	0.04443	27.0	0.000923	4051.0	6751.0	38.78	3.116	5.193	2121.0
1400.0	0.04126	29.1	0.000857	4362.0	7271.0	39.17	3.116	5.193	2202.0
1500.0	0.03851	31.2	0.000800	4674.0	7790.0	39.53	3.116	5.193	2279.0
				$1.4 \times 10^{+5}$ pascal Isobar					
* 2.165	149.0								
2.5	147.7	0.504	2.67	−10.87	−9.933	2.044	1.853	2.014	234.0
3.0	144.3	0.423	3.51	−9.859	−8.888	2.427	1.904	2.325	227.1
3.5	139.3	0.324	3.88	−8.597	−7.592	2.828	2.093	2.932	213.1
4.0	131.9	0.218	3.93	−6.975	−5.914	3.275	2.262	3.887	193.5
4.5	119.9	0.104	3.54	−4.673	−3.505	3.840	2.481	6.278	161.9
* 4.587	116.7	0.0820	3.41	−4.125	−2.925	3.968	2.533	7.310	153.8
* 4.587	24.16	0.0252	0.565	9.083	14.88	7.846	3.373	13.30	99.8
5.0	18.65	0.0488	0.423	11.57	19.08	8.727	3.244	8.506	113.1
5.1	17.84	0.0533	0.403	12.06	19.91	8.891	3.225	8.094	115.7
5.2	17.13	0.0575	0.385	12.53	20.70	9.045	3.210	7.770	118.0
5.3	16.50	0.0616	0.369	12.98	21.47	9.190	3.196	7.508	120.3
5.4	15.93	0.0654	0.355	13.42	22.21	9.328	3.185	7.291	122.4

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
5.5	15.41	0.0692	0.343	13.84	22.93	9.460	3.175	7.109	124.4
5.6	14.94	0.0728	0.331	14.25	23.63	9.587	3.166	6.954	126.4
5.7	14.50	0.0762	0.321	14.66	24.32	9.709	3.159	6.820	128.3
5.8	14.09	0.0796	0.311	15.06	24.99	9.827	3.152	6.703	130.1
5.9	13.72	0.0829	0.302	15.45	25.66	9.940	3.147	6.601	131.9
6.0	13.36	0.0862	0.294	15.84	26.31	10.05	3.142	6.510	133.6
6.5	11.89	0.102	0.260	17.70	29.48	10.56	3.125	6.179	141.7
7.0	10.75	0.116	0.234	19.49	32.51	11.01	3.116	5.971	148.9
7.5	9.843	0.129	0.213	21.24	35.46	11.41	3.112	5.830	155.6
8.0	9.090	0.142	0.196	22.95	38.35	11.79	3.110	5.727	161.9
8.5	8.454	0.155	0.182	24.63	41.19	12.13	3.110	5.651	167.9
9.0	7.909	0.167	0.170	26.30	44.00	12.45	3.110	5.591	173.5
9.5	7.434	0.180	0.159	27.95	46.79	12.75	3.111	5.544	178.9
10.0	7.017	0.192	0.150	29.60	49.55	13.04	3.112	5.505	184.1
11.0	6.317	0.215	0.135	32.85	55.01	13.56	3.113	5.449	193.9
12.0	5.749	0.238	0.123	36.08	60.43	14.03	3.115	5.408	203.2
13.0	5.278	0.261	0.112	39.29	65.81	14.46	3.116	5.376	212.0
14.0	4.881	0.283	0.104	42.49	71.17	14.86	3.117	5.351	220.4
15.0	4.541	0.305	0.0963	45.68	76.51	15.23	3.118	5.332	228.4
16.0	4.246	0.327	0.0900	48.86	81.83	15.57	3.118	5.314	236.1
17.0	3.988	0.349	0.0844	52.04	87.14	15.89	3.119	5.300	243.5
18.0	3.760	0.371	0.0795	55.20	92.43	16.19	3.119	5.289	250.7
19.0	3.558	0.392	0.0751	58.37	97.72	16.48	3.119	5.279	257.7
20.0	3.376	0.414	0.0712	61.53	103.0	16.75	3.119	5.270	264.4
21.0	3.213	0.435	0.0677	64.68	108.3	17.01	3.120	5.263	271.0
22.0	3.064	0.457	0.0645	67.83	113.5	17.25	3.120	5.257	277.4
23.0	2.929	0.478	0.0617	70.98	118.8	17.49	3.120	5.251	283.7
24.0	2.806	0.499	0.0590	74.13	124.0	17.71	3.120	5.246	289.8
25.0	2.693	0.521	0.0566	77.27	129.3	17.92	3.120	5.242	295.8
26.0	2.588	0.542	0.0544	80.41	134.5	18.13	3.119	5.238	301.6
28.0	2.402	0.584	0.0504	86.69	145.0	18.52	3.119	5.232	313.0
30.0	2.241	0.626	0.0470	92.96	155.4	18.88	3.119	5.227	323.9
32.0	2.100	0.668	0.0440	99.23	165.9	19.21	3.119	5.223	334.5
34.0	1.976	0.710	0.0414	105.5	176.3	19.53	3.119	5.219	344.8
36.0	1.866	0.752	0.0391	111.7	186.8	19.83	3.119	5.216	354.7
38.0	1.768	0.794	0.0370	118.0	197.2	20.11	3.119	5.214	364.4
40.0	1.680	0.836	0.0351	124.3	207.6	20.38	3.119	5.211	373.8
45.0	1.493	0.941	0.0312	139.9	233.7	20.99	3.118	5.207	396.3
50.0	1.344	1.05	0.0281	155.5	259.7	21.54	3.118	5.204	417.6
55.0	1.222	1.15	0.0255	171.1	285.7	22.04	3.118	5.202	437.9
60.0	1.120	1.25	0.0234	186.7	311.7	22.49	3.118	5.201	457.3
65.0	1.034	1.36	0.0216	202.3	337.7	22.91	3.117	5.199	475.8
70.0	0.9603	1.46	0.0200	217.9	363.7	23.29	3.117	5.198	493.7
75.0	0.8964	1.57	0.0187	233.5	389.7	23.65	3.117	5.198	510.9
80.0	0.8404	1.67	0.0175	249.1	415.7	23.98	3.117	5.197	527.6
90.0	0.7472	1.88	0.0156	280.3	467.6	24.60	3.117	5.196	559.4
100.0	0.6726	2.09	0.0140	311.5	519.6	25.14	3.117	5.195	589.6
125.0	0.5383	2.61	0.0112	389.4	649.5	26.30	3.117	5.194	658.9
150.0	0.4487	3.12	0.00933	467.3	779.3	27.25	3.116	5.194	721.6
175.0	0.3847	3.64	0.00800	545.2	909.2	28.05	3.116	5.194	779.2
200.0	0.3366	4.16	0.00700	623.1	1039.0	28.74	3.116	5.193	832.9
225.0	0.2993	4.68	0.00622	701.0	1169.0	29.36	3.116	5.193	883.3
250.0	0.2694	5.20	0.00560	778.9	1299.0	29.90	3.116	5.193	931.0
275.0	0.2449	5.72	0.00509	856.8	1428.0	30.40	3.116	5.193	976.3
300.0	0.2245	6.24	0.00467	934.7	1558.0	30.85	3.116	5.193	1020.0
350.0	0.1925	7.28	0.00400	1091.0	1818.0	31.65	3.116	5.193	1101.0
400.0	0.1684	8.32	0.00350	1246.0	2078.0	32.34	3.116	5.193	1177.0
450.0	0.1497	9.36	0.00311	1402.0	2337.0	32.96	3.116	5.193	1249.0
500.0	0.1347	10.4	0.00280	1558.0	2597.0	33.50	3.116	5.193	1316.0
600.0	0.1123	12.5	0.00233	1870.0	3116.0	34.45	3.116	5.193	1442.0

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
700.0	0.09626	14.5	0.00200	2181.0	3636.0	35.25	3.116	5.193	1557.0
800.0	0.08423	16.6	0.00175	2493.0	4155.0	35.94	3.116	5.193	1664.0
900.0	0.07487	18.7	0.00156	2804.0	4674.0	36.56	3.116	5.193	1765.0
1000.0	0.06739	20.8	0.00140	3116.0	5193.0	37.10	3.116	5.193	1861.0
1100.0	0.06126	22.9	0.00127	3427.0	5713.0	37.60	3.116	5.193	1952.0
1200.0	0.05616	24.9	0.00117	3739.0	6232.0	38.05	3.116	5.193	2038.0
1300.0	0.05184	27.0	0.00108	4051.0	6751.0	38.46	3.116	5.193	2122.0
1400.0	0.04814	29.1	0.00100	4362.0	7271.0	38.85	3.116	5.193	2202.0
1500.0	0.04493	31.2	0.000933	4674.0	7790.0	39.21	3.116	5.193	2279.0
				$1.6 \times 10^{+5}$ pascal Isobar					
* 2.163	149.4								
2.5	148.1	0.514	2.66	−10.89	−9.816	2.037	1.842	1.999	236.2
3.0	144.8	0.434	3.52	−9.885	−8.780	2.417	1.901	2.311	229.5
3.5	139.9	0.336	3.91	−8.640	−7.497	2.814	2.089	2.903	216.0
4.0	132.8	0.231	3.97	−7.051	−5.846	3.254	2.255	3.806	197.3
4.5	121.6	0.119	3.64	−4.845	−3.529	3.798	2.467	5.858	167.8
* 4.747	111.9	0.0576	3.22	−3.196	−1.766	4.178	2.623	9.460	144.1
* 4.747	28.63	0.0199	0.677	8.729	14.32	7.563	3.382	16.72	99.17
5.0	23.28	0.0377	0.538	10.63	17.51	8.219	3.285	10.36	109.0
5.1	22.00	0.0432	0.505	11.22	18.49	8.415	3.260	9.479	112.0
5.2	20.92	0.0482	0.477	11.76	19.41	8.593	3.239	8.857	114.8
5.3	20.00	0.0528	0.454	12.27	20.27	8.757	3.221	8.391	117.3
5.4	19.19	0.0572	0.434	12.75	21.09	8.910	3.206	8.027	119.7
5.5	18.48	0.0614	0.416	13.22	21.88	9.055	3.193	7.735	122.0
5.6	17.83	0.0654	0.400	13.67	22.64	9.192	3.182	7.495	124.1
5.7	17.25	0.0692	0.386	14.10	23.38	9.323	3.173	7.293	126.2
5.8	16.71	0.0730	0.373	14.53	24.10	9.448	3.164	7.122	128.1
5.9	16.22	0.0766	0.361	14.94	24.80	9.568	3.157	6.975	130.0
6.0	15.77	0.0801	0.350	15.35	25.49	9.684	3.151	6.847	131.9
6.5	13.91	0.0964	0.306	17.29	28.80	10.21	3.129	6.397	140.4
7.0	12.52	0.111	0.274	19.14	31.92	10.68	3.118	6.127	147.9
7.5	11.41	0.125	0.249	20.92	34.94	11.09	3.113	5.948	154.8
8.0	10.51	0.139	0.228	22.66	37.88	11.47	3.110	5.822	161.3
8.5	9.757	0.152	0.211	24.37	40.76	11.82	3.110	5.728	167.3
9.0	9.113	0.165	0.197	26.05	43.61	12.15	3.110	5.656	173.1
9.5	8.556	0.177	0.184	27.72	46.42	12.45	3.110	5.600	178.6
10.0	8.067	0.189	0.173	29.38	49.21	12.74	3.111	5.554	183.8
11.0	7.252	0.213	0.156	32.65	54.72	13.26	3.113	5.488	193.8
12.0	6.593	0.236	0.141	35.90	60.17	13.74	3.114	5.440	203.1
13.0	6.048	0.259	0.129	39.12	65.58	14.17	3.116	5.403	212.0
14.0	5.589	0.282	0.119	42.33	70.96	14.57	3.117	5.375	220.4
15.0	5.197	0.304	0.111	45.53	76.32	14.94	3.118	5.352	228.5
16.0	4.858	0.326	0.103	48.73	81.66	15.28	3.119	5.332	236.2
17.0	4.562	0.348	0.0968	51.91	86.98	15.61	3.119	5.316	243.7
18.0	4.300	0.370	0.0911	55.09	92.29	15.91	3.120	5.303	250.9
19.0	4.068	0.392	0.0861	58.26	97.59	16.20	3.120	5.291	257.8
20.0	3.860	0.414	0.0816	61.42	102.9	16.47	3.120	5.281	264.6
21.0	3.672	0.435	0.0776	64.58	108.2	16.73	3.120	5.273	271.2
22.0	3.502	0.457	0.0739	67.74	113.4	16.97	3.120	5.266	277.6
23.0	3.348	0.478	0.0706	70.89	118.7	17.20	3.120	5.260	283.9
24.0	3.206	0.499	0.0676	74.04	123.9	17.43	3.120	5.254	290.0
25.0	3.077	0.521	0.0648	77.19	129.2	17.64	3.120	5.249	296.0
26.0	2.957	0.542	0.0622	80.33	134.4	17.85	3.120	5.245	301.8
28.0	2.744	0.584	0.0577	86.62	144.9	18.24	3.120	5.237	313.2
30.0	2.560	0.627	0.0538	92.89	155.4	18.60	3.120	5.232	324.2
32.0	2.399	0.669	0.0504	99.17	165.8	18.94	3.120	5.227	334.8
34.0	2.258	0.711	0.0474	105.4	176.3	19.25	3.119	5.223	345.0

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative $10^5 Pa/K$	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
36.0	2.132	0.753	0.0447	111.7	186.7	19.55	3.119	5.219	355.0
38.0	2.020	0.795	0.0423	118.0	197.2	19.83	3.119	5.217	364.6
40.0	1.919	0.837	0.0402	124.2	207.6	20.10	3.119	5.214	374.0
45.0	1.705	0.942	0.0357	139.8	233.7	20.71	3.119	5.209	396.6
50.0	1.535	1.05	0.0321	155.5	259.7	21.26	3.118	5.206	417.9
55.0	1.396	1.15	0.0291	171.1	285.7	21.76	3.118	5.204	438.1
60.0	1.280	1.25	0.0267	186.7	311.7	22.21	3.118	5.202	457.5
65.0	1.181	1.36	0.0246	202.3	337.7	22.63	3.118	5.200	476.0
70.0	1.097	1.46	0.0229	217.9	363.7	23.01	3.118	5.199	493.9
75.0	1.024	1.57	0.0214	233.5	389.7	23.37	3.117	5.198	511.1
80.0	0.9602	1.67	0.0200	249.1	415.7	23.71	3.117	5.198	527.8
90.0	0.8537	1.88	0.0178	280.3	467.7	24.32	3.117	5.196	559.6
100.0	0.7685	2.09	0.0160	311.4	519.7	24.87	3.117	5.196	589.7
125.0	0.6150	2.61	0.0128	389.4	649.5	26.03	3.117	5.195	659.0
150.0	0.5127	3.13	0.0107	467.3	779.4	26.97	3.117	5.194	721.7
175.0	0.4395	3.65	0.00914	545.2	909.2	27.77	3.116	5.194	779.3
200.0	0.3847	4.16	0.00800	623.1	1039.0	28.47	3.116	5.193	833.0
225.0	0.3420	4.68	0.00711	701.0	1169.0	29.08	3.116	5.193	883.4
250.0	0.3078	5.20	0.00640	778.9	1299.0	29.63	3.116	5.193	931.1
275.0	0.2799	5.72	0.00582	856.8	1429.0	30.12	3.116	5.193	976.4
300.0	0.2566	6.24	0.00533	934.7	1558.0	30.57	3.116	5.193	1020.0
350.0	0.2199	7.28	0.00457	1091.0	1818.0	31.37	3.116	5.193	1101.0
400.0	0.1925	8.32	0.00400	1246.0	2078.0	32.07	3.116	5.193	1177.0
450.0	0.1711	9.36	0.00356	1402.0	2337.0	32.68	3.116	5.193	1249.0
500.0	0.1540	10.4	0.00320	1558.0	2597.0	33.23	3.116	5.193	1316.0
600.0	0.1283	12.5	0.00267	1870.0	3116.0	34.17	3.116	5.193	1442.0
700.0	0.1100	14.5	0.00229	2181.0	3636.0	34.97	3.116	5.193	1557.0
800.0	0.09626	16.6	0.00200	2493.0	4155.0	35.67	3.116	5.193	1664.0
900.0	0.08557	18.7	0.00178	2804.0	4674.0	36.28	3.116	5.193	1765.0
1000.0	0.07701	20.8	0.00160	3116.0	5193.0	36.82	3.116	5.193	1861.0
1100.0	0.07001	22.9	0.00145	3427.0	5713.0	37.32	3.116	5.193	1952.0
1200.0	0.06418	24.9	0.00133	3739.0	6232.0	37.77	3.116	5.193	2038.0
1300.0	0.05924	27.0	0.00123	4051.0	6751.0	38.19	3.116	5.193	2122.0
1400.0	0.05501	29.1	0.00114	4362.0	7271.0	38.57	3.116	5.193	2202.0
1500.0	0.05135	31.2	0.00107	4674.0	7790.0	38.93	3.116	5.193	2279.0
				$1.8 \times 10^{+5}$ pascal Isobar					
* 2.161	149.8								
2.5	148.5	0.525	2.66	−10.90	−9.698	2.030	1.832	1.985	238.4
3.0	145.3	0.445	3.53	−9.911	−8.672	2.407	1.899	2.297	231.9
3.5	140.5	0.347	3.93	−8.682	−7.400	2.801	2.085	2.875	218.8
4.0	133.7	0.243	4.02	−7.122	−5.775	3.235	2.250	3.735	200.9
4.5	123.1	0.133	3.72	−4.996	−3.533	3.761	2.454	5.539	173.3
* 4.894	106.3	0.0365	3.00	−2.182	−0.4899	4.405	2.721	13.40	134.1
* 4.894	34.01	0.0141	0.814	8.190	13.48	7.257	3.387	23.25	98.40
5.0	29.80	0.0242	0.703	9.350	15.39	7.643	3.336	14.87	103.8
5.1	27.38	0.0314	0.640	10.15	16.73	7.908	3.301	12.18	107.7
5.2	25.59	0.0377	0.594	10.83	17.86	8.129	3.273	10.71	111.0
5.3	24.17	0.0432	0.557	11.44	18.89	8.323	3.250	9.768	114.0
5.4	22.98	0.0484	0.527	12.00	19.83	8.499	3.230	9.104	116.7
5.5	21.97	0.0531	0.501	12.52	20.71	8.662	3.214	8.607	119.3
5.6	21.09	0.0576	0.479	13.02	21.55	8.813	3.200	8.220	121.7
5.7	20.30	0.0619	0.460	13.49	22.36	8.956	3.188	7.909	123.9
5.8	19.60	0.0660	0.442	13.95	23.14	9.091	3.177	7.653	126.1
5.9	18.96	0.0699	0.426	14.39	23.89	9.220	3.169	7.439	128.1
6.0	18.37	0.0737	0.412	14.83	24.62	9.344	3.161	7.257	130.1
6.5	16.04	0.0912	0.356	16.86	28.08	9.898	3.134	6.646	139.0
7.0	14.35	0.107	0.316	18.77	31.31	10.38	3.121	6.298	146.9

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
7.5	13.03	0.122	0.286	20.59	34.40	10.80	3.114	6.075	154.0
8.0	11.97	0.136	0.261	22.36	37.40	11.19	3.111	5.921	160.6
8.5	11.09	0.149	0.241	24.09	40.33	11.55	3.109	5.809	166.8
9.0	10.34	0.162	0.224	25.80	43.21	11.87	3.109	5.724	172.7
9.5	9.693	0.175	0.210	27.49	46.06	12.18	3.110	5.657	178.2
10.0	9.130	0.187	0.197	29.16	48.87	12.47	3.111	5.604	183.5
11.0	8.195	0.211	0.176	32.45	54.42	13.00	3.112	5.527	193.6
12.0	7.442	0.235	0.160	35.72	59.90	13.48	3.114	5.473	203.1
13.0	6.822	0.258	0.146	38.96	65.34	13.91	3.116	5.431	212.0
14.0	6.301	0.281	0.135	42.18	70.75	14.31	3.117	5.399	220.4
15.0	5.856	0.303	0.125	45.39	76.13	14.68	3.118	5.373	228.6
16.0	5.472	0.326	0.117	48.59	81.49	15.03	3.119	5.350	236.3
17.0	5.136	0.348	0.109	51.78	86.83	15.35	3.120	5.332	243.8
18.0	4.841	0.370	0.103	54.97	92.15	15.66	3.120	5.316	251.0
19.0	4.578	0.392	0.0971	58.15	97.46	15.95	3.120	5.304	258.0
20.0	4.343	0.413	0.0920	61.32	102.8	16.22	3.120	5.293	264.8
21.0	4.132	0.435	0.0875	64.48	108.0	16.48	3.121	5.283	271.4
22.0	3.940	0.457	0.0833	67.64	113.3	16.72	3.121	5.275	277.8
23.0	3.766	0.478	0.0796	70.80	118.6	16.96	3.121	5.268	284.1
24.0	3.607	0.500	0.0761	73.96	123.9	17.18	3.121	5.262	290.2
25.0	3.461	0.521	0.0730	77.11	129.1	17.39	3.121	5.256	296.2
26.0	3.326	0.542	0.0701	80.26	134.4	17.60	3.120	5.251	302.1
28.0	3.086	0.585	0.0650	86.55	144.9	17.99	3.120	5.243	313.5
30.0	2.879	0.627	0.0606	92.83	155.3	18.35	3.120	5.236	324.4
32.0	2.698	0.669	0.0567	99.11	165.8	18.69	3.120	5.231	335.0
34.0	2.539	0.712	0.0533	105.4	176.3	19.01	3.120	5.226	345.3
36.0	2.398	0.754	0.0503	111.6	186.7	19.30	3.120	5.223	355.2
38.0	2.271	0.796	0.0476	117.9	197.2	19.59	3.119	5.219	364.9
40.0	2.157	0.838	0.0452	124.2	207.6	19.85	3.119	5.217	374.3
45.0	1.918	0.942	0.0401	139.8	233.7	20.47	3.119	5.211	396.8
50.0	1.726	1.05	0.0361	155.4	259.7	21.02	3.119	5.208	418.1
55.0	1.569	1.15	0.0328	171.1	285.7	21.51	3.118	5.205	438.4
60.0	1.439	1.26	0.0301	186.7	311.8	21.97	3.118	5.203	457.7
65.0	1.328	1.36	0.0277	202.3	337.8	22.38	3.118	5.201	476.2
70.0	1.234	1.46	0.0257	217.9	363.8	22.77	3.118	5.200	494.1
75.0	1.152	1.57	0.0240	233.5	389.8	23.13	3.118	5.199	511.3
80.0	1.080	1.67	0.0225	249.1	415.8	23.46	3.118	5.198	528.0
90.0	0.9601	1.88	0.0200	280.3	467.7	24.07	3.117	5.197	559.8
100.0	0.8643	2.09	0.0180	311.4	519.7	24.62	3.117	5.196	589.9
125.0	0.6918	2.61	0.0144	389.4	649.6	25.78	3.117	5.195	659.2
150.0	0.5767	3.13	0.0120	467.3	779.4	26.73	3.117	5.194	721.8
175.0	0.4944	3.65	0.0103	545.2	909.3	27.53	3.117	5.194	779.5
200.0	0.4327	4.17	0.00900	623.1	1039.0	28.22	3.116	5.193	833.1
225.0	0.3847	4.68	0.00800	701.0	1169.0	28.83	3.116	5.193	883.5
250.0	0.3463	5.20	0.00720	778.9	1299.0	29.38	3.116	5.193	931.2
275.0	0.3148	5.72	0.00654	856.8	1429.0	29.88	3.116	5.193	976.5
300.0	0.2886	6.24	0.00600	934.7	1558.0	30.33	3.116	5.193	1020.0
350.0	0.2474	7.28	0.00514	1091.0	1818.0	31.13	3.116	5.193	1101.0
400.0	0.2165	8.32	0.00450	1246.0	2078.0	31.82	3.116	5.193	1177.0
450.0	0.1925	9.36	0.00400	1402.0	2337.0	32.43	3.116	5.193	1249.0
500.0	0.1732	10.4	0.00360	1558.0	2597.0	32.98	3.116	5.193	1316.0
600.0	0.1444	12.5	0.00300	1870.0	3116.0	33.93	3.116	5.193	1442.0
700.0	0.1238	14.5	0.00257	2181.0	3636.0	34.73	3.116	5.193	1557.0
800.0	0.1083	16.6	0.00225	2493.0	4155.0	35.42	3.116	5.193	1664.0
900.0	0.09626	18.7	0.00200	2804.0	4674.0	36.03	3.116	5.193	1765.0
1000.0	0.08664	20.8	0.00180	3116.0	5194.0	36.58	3.116	5.193	1861.0
1100.0	0.07876	22.9	0.00164	3427.0	5713.0	37.08	3.116	5.193	1952.0
1200.0	0.07220	24.9	0.00150	3739.0	6232.0	37.53	3.116	5.193	2038.0
1300.0	0.06665	27.0	0.00138	4051.0	6751.0	37.94	3.116	5.193	2122.0
1400.0	0.06189	29.1	0.00129	4362.0	7271.0	38.33	3.116	5.193	2202.0

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
1500.0	0.05776	31.2	0.00120	4674.0	7790.0	38.69	3.116	5.193	2279.0
				$2.0 \times 10^{+5}$ pascal Isobar					
* 2.159	150.2								
2.5	148.9	0.535	2.65	−10.92	−9.581	2.023	1.822	1.970	240.6
3.0	145.7	0.455	3.54	−9.935	−8.563	2.398	1.896	2.284	234.2
3.5	141.1	0.359	3.96	−8.721	−7.303	2.788	2.082	2.849	221.5
4.0	134.5	0.255	4.06	−7.188	−5.701	3.216	2.244	3.671	204.4
4.5	124.4	0.147	3.79	−5.130	−3.523	3.727	2.443	5.287	178.3
5.0	102.5	0.0272	2.86	−1.448	0.5028	4.567	2.791	17.10	129.0
* 5.030	99.28	0.0187	2.73	−0.9850	1.030	4.672	2.836	23.19	123.5
* 5.030	41.18	0.00794	1.00	7.333	12.19	6.889	3.383	40.67	97.71
5.1	35.83	0.0167	0.859	8.542	14.12	7.271	3.350	20.92	102.0
5.2	31.98	0.0254	0.757	9.597	15.85	7.607	3.312	14.79	106.5
5.3	29.47	0.0325	0.692	10.41	17.19	7.862	3.282	12.28	110.2
5.4	27.59	0.0386	0.643	11.09	18.34	8.077	3.257	10.85	113.4
5.5	26.09	0.0442	0.604	11.71	19.38	8.267	3.237	9.912	116.3
5.6	24.83	0.0493	0.572	12.28	20.33	8.439	3.219	9.244	119.0
5.7	23.75	0.0541	0.545	12.81	21.23	8.598	3.205	8.740	121.5
5.8	22.81	0.0587	0.521	13.32	22.08	8.747	3.192	8.346	123.8
5.9	21.97	0.0630	0.500	13.80	22.90	8.887	3.181	8.028	126.1
6.0	21.21	0.0671	0.481	14.26	23.69	9.019	3.172	7.766	128.2
6.5	18.30	0.0858	0.410	16.42	27.34	9.604	3.140	6.933	137.7
7.0	16.26	0.102	0.361	18.39	30.69	10.10	3.123	6.488	145.9
7.5	14.70	0.118	0.324	20.26	33.86	10.54	3.115	6.213	153.2
8.0	13.46	0.132	0.295	22.06	36.92	10.93	3.111	6.027	160.0
8.5	12.44	0.146	0.272	23.82	39.89	11.29	3.109	5.894	166.3
9.0	11.58	0.159	0.252	25.55	42.81	11.63	3.109	5.794	172.2
9.5	10.85	0.172	0.236	27.25	45.69	11.94	3.109	5.717	177.9
10.0	10.21	0.185	0.221	28.94	48.53	12.23	3.110	5.655	183.3
11.0	9.147	0.209	0.198	32.25	54.12	12.76	3.112	5.568	193.5
12.0	8.297	0.233	0.179	35.54	59.64	13.24	3.114	5.506	203.0
13.0	7.600	0.256	0.163	38.79	65.11	13.68	3.116	5.459	212.0
14.0	7.015	0.280	0.150	42.02	70.54	14.08	3.117	5.422	220.5
15.0	6.516	0.302	0.140	45.24	75.94	14.46	3.118	5.393	228.6
16.0	6.087	0.325	0.130	48.46	81.32	14.80	3.119	5.368	236.4
17.0	5.712	0.347	0.122	51.66	86.67	15.13	3.120	5.348	243.9
18.0	5.382	0.369	0.115	54.85	92.01	15.43	3.120	5.330	251.2
19.0	5.089	0.391	0.108	58.03	97.34	15.72	3.121	5.316	258.2
20.0	4.827	0.413	0.103	61.21	102.6	15.99	3.121	5.304	265.0
21.0	4.591	0.435	0.0974	64.38	107.9	16.25	3.121	5.293	271.6
22.0	4.378	0.457	0.0928	67.55	113.2	16.50	3.121	5.284	278.0
23.0	4.184	0.478	0.0886	70.71	118.5	16.73	3.121	5.276	284.3
24.0	4.007	0.500	0.0847	73.87	123.8	16.96	3.121	5.269	290.4
25.0	3.844	0.521	0.0812	77.03	129.1	17.17	3.121	5.263	296.4
26.0	3.695	0.543	0.0780	80.18	134.3	17.38	3.121	5.258	302.3
28.0	3.428	0.585	0.0723	86.48	144.8	17.77	3.121	5.249	313.7
30.0	3.198	0.628	0.0674	92.76	155.3	18.13	3.121	5.241	324.7
32.0	2.997	0.670	0.0631	99.05	165.8	18.47	3.120	5.235	335.2
34.0	2.820	0.712	0.0593	105.3	176.2	18.79	3.120	5.230	345.5
36.0	2.663	0.754	0.0559	111.6	186.7	19.08	3.120	5.226	355.4
38.0	2.522	0.796	0.0529	117.9	197.2	19.37	3.120	5.222	365.1
40.0	2.396	0.839	0.0503	124.1	207.6	19.63	3.120	5.219	374.5
45.0	2.130	0.943	0.0446	139.8	233.7	20.25	3.119	5.213	397.0
50.0	1.917	1.05	0.0401	155.4	259.7	20.80	3.119	5.209	418.3
55.0	1.743	1.15	0.0365	171.0	285.8	21.29	3.119	5.206	438.6
60.0	1.598	1.26	0.0334	186.6	311.8	21.75	3.118	5.204	457.9
65.0	1.475	1.36	0.0308	202.3	337.8	22.16	3.118	5.202	476.5

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
70.0	1.370	1.47	0.0286	217.9	363.8	22.55	3.118	5.201	494.3
75.0	1.279	1.57	0.0267	233.5	389.8	22.91	3.118	5.200	511.5
80.0	1.199	1.67	0.0250	249.1	415.8	23.24	3.118	5.199	528.2
90.0	1.066	1.88	0.0222	280.2	467.8	23.86	3.117	5.197	560.0
100.0	0.9601	2.09	0.0200	311.4	519.8	24.40	3.117	5.196	590.1
125.0	0.7684	2.61	0.0160	389.4	649.6	25.56	3.117	5.195	659.3
150.0	0.6406	3.13	0.0133	467.3	779.5	26.51	3.117	5.194	722.0
175.0	0.5493	3.65	0.0114	545.2	909.3	27.31	3.117	5.194	779.6
200.0	0.4807	4.17	0.0100	623.1	1039.0	28.00	3.117	5.194	833.2
225.0	0.4274	4.69	0.00889	701.0	1169.0	28.62	3.116	5.193	883.6
250.0	0.3847	5.21	0.00800	778.9	1299.0	29.16	3.116	5.193	931.3
275.0	0.3497	5.72	0.00727	856.8	1429.0	29.66	3.116	5.193	976.6
300.0	0.3206	6.24	0.00667	934.7	1559.0	30.11	3.116	5.193	1020.0
350.0	0.2749	7.28	0.00571	1091.0	1818.0	30.91	3.116	5.193	1102.0
400.0	0.2405	8.32	0.00500	1246.0	2078.0	31.60	3.116	5.193	1177.0
450.0	0.2138	9.36	0.00444	1402.0	2337.0	32.21	3.116	5.193	1249.0
500.0	0.1925	10.4	0.00400	1558.0	2597.0	32.76	3.116	5.193	1316.0
600.0	0.1604	12.5	0.00333	1870.0	3116.0	33.71	3.116	5.193	1442.0
700.0	0.1375	14.6	0.00286	2181.0	3636.0	34.51	3.116	5.193	1557.0
800.0	0.1203	16.6	0.00250	2493.0	4155.0	35.20	3.116	5.193	1665.0
900.0	0.1070	18.7	0.00222	2804.0	4674.0	35.81	3.116	5.193	1765.0
1000.0	0.09626	20.8	0.00200	3116.0	5194.0	36.36	3.116	5.193	1861.0
1100.0	0.08751	22.9	0.00182	3427.0	5713.0	36.86	3.116	5.193	1952.0
1200.0	0.08022	24.9	0.00167	3739.0	6232.0	37.31	3.116	5.193	2038.0
1300.0	0.07405	27.0	0.00154	4051.0	6751.0	37.72	3.116	5.193	2122.0
1400.0	0.06876	29.1	0.00143	4362.0	7271.0	38.11	3.116	5.193	2202.0
1500.0	0.06418	31.2	0.00133	4674.0	7790.0	38.47	3.116	5.193	2279.0

$2.1 \times 10^{+5}$ pascal Isobar

*	2.158	150.4								
	2.5	149.1	0.540	2.65	−10.92	−9.522	2.020	1.817	1.963	241.6
	3.0	146.0	0.461	3.54	−9.947	−8.508	2.393	1.894	2.277	235.3
	3.5	141.4	0.364	3.97	−8.740	−7.254	2.782	2.080	2.837	222.9
	4.0	134.8	0.261	4.08	−7.220	−5.662	3.207	2.241	3.641	206.1
	4.5	125.1	0.154	3.83	−5.193	−3.514	3.711	2.437	5.180	180.7
	5.0	105.0	0.0368	2.97	−1.742	0.2566	4.498	2.763	13.63	134.8
*	5.094	94.58	0.0111	2.56	−0.2348	1.985	4.840	2.908	36.54	117.8
*	5.094	46.24	0.00478	1.13	6.664	11.21	6.649	3.373	67.20	97.60
	5.1	45.05	0.00594	1.10	6.889	11.55	6.717	3.371	54.62	98.08
	5.2	36.59	0.0182	0.877	8.736	14.48	7.286	3.332	19.77	103.9
	5.3	32.87	0.0265	0.780	9.759	16.15	7.604	3.299	14.55	108.1
	5.4	30.37	0.0334	0.714	10.56	17.47	7.852	3.271	12.21	111.6
	5.5	28.48	0.0395	0.665	11.25	18.62	8.063	3.249	10.85	114.8
	5.6	26.95	0.0450	0.625	11.87	19.66	8.250	3.230	9.934	117.6
	5.7	25.67	0.0501	0.593	12.44	20.62	8.419	3.213	9.277	120.3
	5.8	24.57	0.0549	0.564	12.97	21.52	8.576	3.200	8.778	122.7
	5.9	23.60	0.0594	0.540	13.48	22.38	8.723	3.188	8.386	125.0
	6.0	22.74	0.0637	0.518	13.96	23.20	8.861	3.177	8.069	127.2
	6.5	19.49	0.0831	0.438	16.18	26.96	9.463	3.142	7.093	137.0
	7.0	17.25	0.100	0.384	18.19	30.37	9.97	3.124	6.591	145.3
	7.5	15.56	0.116	0.344	20.08	33.58	10.41	3.115	6.286	152.8
	8.0	14.22	0.130	0.313	21.91	36.67	10.81	3.111	6.083	159.7
	8.5	13.13	0.144	0.288	23.68	39.67	11.18	3.109	5.938	166.0
	9.0	12.21	0.158	0.267	25.42	42.61	11.51	3.109	5.830	172.0
	9.5	11.43	0.171	0.249	27.13	45.51	11.82	3.109	5.747	177.7
	10.0	10.75	0.184	0.234	28.83	48.36	12.12	3.110	5.681	183.2
	11.0	9.626	0.208	0.208	32.16	53.97	12.65	3.112	5.588	193.4
	12.0	8.727	0.232	0.188	35.44	59.51	13.13	3.114	5.522	202.9

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
13.0	7.990	0.256	0.172	38.71	64.99	13.57	3.116	5.473	212.0
14.0	7.373	0.279	0.158	41.95	70.43	13.98	3.117	5.434	220.5
15.0	6.847	0.302	0.147	45.17	75.84	14.35	3.119	5.404	228.7
16.0	6.395	0.325	0.137	48.39	81.23	14.70	3.119	5.377	236.5
17.0	6.000	0.347	0.128	51.60	86.60	15.02	3.120	5.355	244.0
18.0	5.653	0.369	0.121	54.79	91.94	15.33	3.121	5.337	251.3
19.0	5.345	0.391	0.114	57.98	97.27	15.62	3.121	5.322	258.3
20.0	5.069	0.413	0.108	61.16	102.6	15.89	3.121	5.309	265.1
21.0	4.821	0.435	0.102	64.33	107.9	16.15	3.121	5.298	271.7
22.0	4.597	0.457	0.0975	67.50	113.2	16.39	3.121	5.289	278.1
23.0	4.393	0.478	0.0931	70.67	118.5	16.63	3.121	5.280	284.4
24.0	4.207	0.500	0.0891	73.83	123.7	16.85	3.121	5.273	290.6
25.0	4.036	0.521	0.0854	76.99	129.0	17.07	3.121	5.267	296.6
26.0	3.879	0.543	0.0820	80.14	134.3	17.28	3.121	5.261	302.4
28.0	3.599	0.585	0.0760	86.44	144.8	17.67	3.121	5.251	313.8
30.0	3.357	0.628	0.0708	92.73	155.3	18.03	3.121	5.244	324.8
32.0	3.146	0.670	0.0662	99.02	165.8	18.37	3.121	5.237	335.4
34.0	2.960	0.713	0.0623	105.3	176.2	18.68	3.120	5.232	345.6
36.0	2.795	0.755	0.0588	111.6	186.7	18.98	3.120	5.228	355.6
38.0	2.648	0.797	0.0556	117.8	197.1	19.26	3.120	5.224	365.2
40.0	2.515	0.839	0.0528	124.1	207.6	19.53	3.120	5.221	374.6
45.0	2.236	0.944	0.0469	139.8	233.7	20.15	3.119	5.214	397.2
50.0	2.012	1.05	0.0421	155.4	259.7	20.70	3.119	5.210	418.4
55.0	1.830	1.15	0.0383	171.0	285.8	21.19	3.119	5.207	438.7
60.0	1.678	1.26	0.0351	186.6	311.8	21.65	3.119	5.204	458.0
65.0	1.549	1.36	0.0324	202.2	337.8	22.06	3.118	5.203	476.6
70.0	1.439	1.47	0.0300	217.8	363.8	22.45	3.118	5.201	494.4
75.0	1.343	1.57	0.0280	233.4	389.8	22.81	3.118	5.200	511.6
80.0	1.259	1.67	0.0263	249.0	415.8	23.14	3.118	5.199	528.3
90.0	1.120	1.88	0.0233	280.2	467.8	23.75	3.118	5.197	560.1
100.0	1.008	2.09	0.0210	311.4	519.8	24.30	3.117	5.196	590.2
125.0	0.8068	2.61	0.0168	389.4	649.7	25.46	3.117	5.195	659.4
150.0	0.6726	3.13	0.0140	467.3	779.5	26.41	3.117	5.194	722.0
175.0	0.5767	3.65	0.0120	545.2	909.4	27.21	3.117	5.194	779.7
200.0	0.5047	4.17	0.0105	623.1	1039.0	27.90	3.117	5.194	833.3
225.0	0.4487	4.69	0.00933	701.0	1169.0	28.51	3.116	5.193	883.7
250.0	0.4039	5.21	0.00840	778.9	1299.0	29.06	3.116	5.193	931.3
275.0	0.3672	5.73	0.00764	856.8	1429.0	29.56	3.116	5.193	976.7
300.0	0.3366	6.24	0.00700	934.8	1559.0	30.01	3.116	5.193	1020.0
350.0	0.2886	7.28	0.00600	1091.0	1818.0	30.81	3.116	5.193	1102.0
400.0	0.2526	8.32	0.00525	1246.0	2078.0	31.50	3.116	5.193	1177.0
450.0	0.2245	9.36	0.00467	1402.0	2337.0	32.11	3.116	5.193	1249.0
500.0	0.2021	10.4	0.00420	1558.0	2597.0	32.66	3.116	5.193	1316.0
600.0	0.1684	12.5	0.00350	1870.0	3116.0	33.61	3.116	5.193	1442.0
700.0	0.1444	14.6	0.00300	2181.0	3636.0	34.41	3.116	5.193	1557.0
800.0	0.1263	16.6	0.00262	2493.0	4155.0	35.10	3.116	5.193	1665.0
900.0	0.1123	18.7	0.00233	2804.0	4674.0	35.71	3.116	5.193	1765.0
1000.0	0.1011	20.8	0.00210	3116.0	5194.0	36.26	3.116	5.193	1861.0
1100.0	0.09189	22.9	0.00191	3427.0	5713.0	36.75	3.116	5.193	1952.0
1200.0	0.08423	24.9	0.00175	3739.0	6232.0	37.21	3.116	5.193	2038.0
1300.0	0.07775	27.0	0.00162	4051.0	6752.0	37.62	3.116	5.193	2122.0
1400.0	0.07220	29.1	0.00150	4362.0	7271.0	38.01	3.116	5.193	2202.0
1500.0	0.06739	31.2	0.00140	4674.0	7790.0	38.37	3.116	5.193	2279.0
				$2.2 \times 10^{+5}$ pascal Isobar					
• 2.157	150.5								
2.5	149.3	0.545	2.65	−10.93	−9.463	2.016	1.812	1.956	242.7
3.0	146.2	0.466	3.54	−9.95	−8.453	2.389	1.893	2.271	236.5

Thermodynamic properties of helium 4—Continued

	Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative $10^5 Pa/K$	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
	3.5	141.6	0.370	3.98	−8.758	−7.205	2.775	2.078	2.825	224.2
	4.0	135.2	0.267	4.10	−7.251	−5.624	3.198	2.238	3.612	207.7
	4.5	125.7	0.160	3.86	−5.252	−3.501	3.696	2.432	5.082	183.0
	5.0	107.0	0.0458	3.07	−1.978	0.07602	4.443	2.741	11.70	139.8
	5.1	98.42	0.0208	2.71	−0.6840	1.551	4.735	2.862	21.47	124.9
*	5.156	87.88	0.00446	2.32	0.7814	3.285	5.072	3.005	83.83	111.5
*	5.156	54.03	0.00171	1.34	5.579	9.651	6.307	3.343	188.6	98.16
	5.2	43.94	0.00958	1.07	7.418	12.42	6.843	3.348	35.59	100.9
	5.3	37.19	0.0200	0.892	8.958	14.87	7.310	3.315	18.59	105.8
	5.4	33.65	0.0278	0.799	9.943	16.48	7.611	3.285	14.22	109.8
	5.5	31.18	0.0345	0.734	10.73	17.79	7.850	3.261	12.09	113.2
	5.6	29.29	0.0405	0.685	11.42	18.93	8.056	3.240	10.80	116.2
	5.7	27.75	0.0460	0.645	12.03	19.96	8.239	3.222	9.927	119.0
	5.8	26.46	0.0510	0.612	12.61	20.92	8.406	3.207	9.288	121.5
	5.9	25.34	0.0558	0.583	13.14	21.82	8.560	3.194	8.799	124.0
	6.0	24.35	0.0603	0.558	13.65	22.68	8.704	3.183	8.412	126.3
	6.5	20.71	0.0804	0.468	15.94	26.56	9.326	3.145	7.266	136.3
	7.0	18.26	0.0979	0.408	17.99	30.04	9.842	3.126	6.699	144.8
	7.5	16.43	0.114	0.365	19.91	33.30	10.29	3.116	6.362	152.4
	8.0	15.00	0.129	0.331	21.75	36.42	10.69	3.111	6.140	159.3
	8.5	13.83	0.143	0.304	23.54	39.45	11.06	3.109	5.983	165.8
	9.0	12.85	0.156	0.281	25.29	42.41	11.40	3.108	5.867	171.8
	9.5	12.02	0.170	0.262	27.01	45.32	11.72	3.109	5.778	177.6
	10.0	11.30	0.183	0.246	28.72	48.19	12.01	3.110	5.707	183.0
	11.0	10.11	0.207	0.219	32.06	53.82	12.55	3.111	5.609	193.3
	12.0	9.158	0.231	0.198	35.35	59.37	13.03	3.114	5.539	202.9
	13.0	8.381	0.255	0.181	38.62	64.87	13.47	3.116	5.487	212.0
	14.0	7.731	0.278	0.166	41.87	70.32	13.87	3.117	5.446	220.5
	15.0	7.179	0.301	0.154	45.10	75.74	14.25	3.119	5.414	228.7
	16.0	6.703	0.324	0.144	48.32	81.14	14.60	3.120	5.386	236.6
	17.0	6.288	0.347	0.134	51.53	86.52	14.92	3.120	5.363	244.1
	18.0	5.924	0.369	0.126	54.73	91.87	15.23	3.121	5.344	251.3
	19.0	5.600	0.391	0.119	57.92	97.21	15.52	3.121	5.329	258.4
	20.0	5.311	0.413	0.113	61.11	102.5	15.79	3.121	5.315	265.2
	21.0	5.051	0.435	0.107	64.29	107.8	16.05	3.122	5.303	271.8
	22.0	4.816	0.457	0.102	67.46	113.1	16.30	3.122	5.293	278.2
	23.0	4.602	0.478	0.0976	70.62	118.4	16.53	3.122	5.285	284.5
	24.0	4.407	0.500	0.0934	73.79	123.7	16.76	3.122	5.277	290.7
	25.0	4.228	0.521	0.0895	76.95	129.0	16.97	3.122	5.270	296.7
	26.0	4.063	0.543	0.0859	80.10	134.2	17.18	3.121	5.264	302.5
	28.0	3.770	0.586	0.0796	86.41	144.8	17.57	3.121	5.254	313.9
	30.0	3.516	0.628	0.0742	92.70	155.3	17.93	3.121	5.246	324.9
	32.0	3.295	0.671	0.0694	98.99	165.7	18.27	3.121	5.239	335.5
	34.0	3.101	0.713	0.0653	105.3	176.2	18.59	3.121	5.234	345.7
	36.0	2.928	0.755	0.0616	111.5	186.7	18.88	3.120	5.229	355.7
	38.0	2.773	0.797	0.0583	117.8	197.1	19.17	3.120	5.225	365.4
	40.0	2.635	0.839	0.0553	124.1	207.6	19.44	3.120	5.222	374.8
	45.0	2.342	0.944	0.0491	139.7	233.7	20.05	3.120	5.215	397.3
	50.0	2.108	1.05	0.0442	155.4	259.7	20.60	3.119	5.211	418.6
	55.0	1.917	1.15	0.0401	171.0	285.8	21.10	3.119	5.208	438.8
	60.0	1.757	1.26	0.0367	186.6	311.8	21.55	3.119	5.205	458.1
	65.0	1.622	1.36	0.0339	202.2	337.8	21.97	3.118	5.203	476.7
	70.0	1.507	1.47	0.0315	217.8	363.8	22.35	3.118	5.201	494.5
	75.0	1.407	1.57	0.0294	233.4	389.9	22.71	3.118	5.200	511.7
	80.0	1.319	1.67	0.0275	249.0	415.9	23.04	3.118	5.199	528.4
	90.0	1.173	1.88	0.0245	280.2	467.8	23.66	3.118	5.198	560.2
	100.0	1.056	2.09	0.0220	311.4	519.8	24.20	3.117	5.197	590.3
	125.0	0.8451	2.61	0.0176	389.4	649.7	25.36	3.117	5.195	659.5
	150.0	0.7045	3.13	0.0147	467.3	779.6	26.31	3.117	5.194	722.1
	175.0	0.6041	3.65	0.0126	545.2	909.4	27.11	3.117	5.194	779.7

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
200.0	0.5287	4.17	0.0110	623.1	1039.0	27.81	3.117	5.194	833.3
225.0	0.4700	4.69	0.00978	701.0	1169.0	28.42	3.117	5.193	883.7
250.0	0.4231	5.21	0.00880	778.9	1299.0	28.96	3.116	5.193	931.4
275.0	0.3847	5.73	0.00800	856.9	1429.0	29.46	3.116	5.193	976.7
300.0	0.3527	6.24	0.00733	934.8	1559.0	29.91	3.116	5.193	1020.0
350.0	0.3023	7.28	0.00628	1091.0	1818.0	30.71	3.116	5.193	1102.0
400.0	0.2646	8.32	0.00550	1246.0	2078.0	31.41	3.116	5.193	1178.0
450.0	0.2352	9.36	0.00489	1402.0	2338.0	32.02	3.116	5.193	1249.0
500.0	0.2117	10.4	0.00440	1558.0	2597.0	32.56	3.116	5.193	1316.0
600.0	0.1764	12.5	0.00367	1870.0	3116.0	33.51	3.116	5.193	1442.0
700.0	0.1512	14.6	0.00314	2181.0	3636.0	34.31	3.116	5.193	1557.0
800.0	0.1323	16.6	0.00275	2493.0	4155.0	35.00	3.116	5.193	1665.0
900.0	0.1176	18.7	0.00244	2804.0	4674.0	35.62	3.116	5.193	1765.0
1000.0	0.1059	20.8	0.00220	3116.0	5194.0	36.16	3.116	5.193	1861.0
1100.0	0.09626	22.9	0.00200	3428.0	5713.0	36.66	3.116	5.193	1952.0
1200.0	0.08824	24.9	0.00183	3739.0	6232.0	37.11	3.116	5.193	2038.0
1300.0	0.08146	27.0	0.00169	4051.0	6752.0	37.53	3.116	5.193	2122.0
1400.0	0.07564	29.1	0.00157	4362.0	7271.0	37.91	3.116	5.193	2202.0
1500.0	0.07060	31.2	0.00147	4674.0	7790.0	38.27	3.116	5.193	2279.0
				$2.3 \times 10^{+5}$ pascal Isobar					
2.156	150.7								
2.5	149.5	0.551	2.65	−10.93	−9.405	2.013	1.807	1.950	243.7
3.0	146.4	0.471	3.55	−9.96	−8.398	2.384	1.891	2.265	237.6
3.5	141.9	0.375	3.99	−8.776	−7.155	2.769	2.077	2.813	225.5
4.0	135.6	0.273	4.12	−7.280	−5.584	3.189	2.236	3.585	209.3
4.5	126.3	0.167	3.89	−5.309	−3.487	3.682	2.428	4.992	185.2
5.0	108.8	0.0542	3.15	−2.177	−0.06319	4.397	2.723	10.44	144.2
5.1	101.6	0.0307	2.85	−1.066	1.196	4.646	2.825	15.87	131.3
5.2	84.91	0.00577	2.23	1.293	4.002	5.188	3.036	65.33	111.4
5.3	43.37	0.0128	1.06	7.851	13.15	6.938	3.326	27.90	103.5
5.4	37.68	0.0220	0.904	9.200	15.30	7.340	3.298	17.47	107.8
5.5	34.32	0.0294	0.816	10.15	16.85	7.624	3.272	13.84	111.5
5.6	31.91	0.0359	0.753	10.92	18.13	7.854	3.250	11.93	114.7
5.7	30.04	0.0417	0.703	11.60	19.26	8.054	3.231	10.73	117.7
5.8	28.50	0.0471	0.664	12.21	20.29	8.233	3.215	9.895	120.4
5.9	27.19	0.0521	0.630	12.78	21.24	8.397	3.201	9.279	122.9
6.0	26.06	0.0568	0.601	13.32	22.15	8.549	3.189	8.804	125.3
6.5	21.98	0.0777	0.498	15.69	26.16	9.192	3.148	7.454	135.6
7.0	19.29	0.0956	0.433	17.79	29.71	9.719	3.127	6.814	144.3
7.5	17.32	0.112	0.386	19.74	33.02	10.17	3.116	6.441	152.0
8.0	15.78	0.127	0.349	21.60	36.17	10.58	3.111	6.198	159.0
8.5	14.53	0.141	0.320	23.40	39.23	10.95	3.109	6.029	165.5
9.0	13.49	0.155	0.296	25.16	42.21	11.29	3.108	5.904	171.6
9.5	12.61	0.168	0.276	26.90	45.14	11.61	3.109	5.809	177.4
10.0	11.84	0.181	0.258	28.60	48.02	11.91	3.109	5.734	182.9
11.0	10.59	0.206	0.230	31.95	53.67	12.45	3.111	5.629	193.2
12.0	9.591	0.231	0.208	35.26	59.24	12.93	3.113	5.556	202.9
13.0	8.774	0.254	0.190	38.54	64.75	13.37	3.116	5.501	212.0
14.0	8.091	0.278	0.174	41.79	70.22	13.78	3.117	5.459	220.6
15.0	7.511	0.301	0.162	45.03	75.65	14.15	3.119	5.425	228.8
16.0	7.012	0.324	0.150	48.26	81.06	14.50	3.120	5.395	236.6
17.0	6.577	0.346	0.141	51.47	86.44	14.83	3.121	5.371	244.2
18.0	6.195	0.369	0.132	54.67	91.80	15.13	3.121	5.351	251.4
19.0	5.856	0.391	0.125	57.87	97.14	15.42	3.121	5.335	258.5
20.0	5.553	0.413	0.118	61.06	102.5	15.70	3.122	5.321	265.3
21.0	5.281	0.435	0.112	64.24	107.8	15.95	3.122	5.308	271.9
22.0	5.035	0.457	0.107	67.41	113.1	16.20	3.122	5.298	278.4

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
23.0	4.811	0.478	0.102	70.58	118.4	16.44	3.122	5.289	284.6
24.0	4.607	0.500	0.0977	73.75	123.7	16.66	3.122	5.281	290.8
25.0	4.420	0.521	0.0936	76.91	128.9	16.88	3.122	5.274	296.8
26.0	4.247	0.543	0.0899	80.06	134.2	17.08	3.122	5.267	302.7
28.0	3.941	0.586	0.0833	86.37	144.7	17.47	3.122	5.257	314.1
30.0	3.676	0.628	0.0776	92.67	155.2	17.84	3.121	5.248	325.0
32.0	3.444	0.671	0.0726	98.96	165.7	18.17	3.121	5.241	335.6
34.0	3.241	0.713	0.0683	105.2	176.2	18.49	3.121	5.236	345.9
36.0	3.060	0.755	0.0644	111.5	186.7	18.79	3.121	5.231	355.8
38.0	2.899	0.798	0.0609	117.8	197.1	19.07	3.120	5.227	365.5
40.0	2.754	0.840	0.0579	124.1	207.6	19.34	3.120	5.223	374.9
45.0	2.448	0.945	0.0513	139.7	233.7	19.96	3.120	5.216	397.4
50.0	2.203	1.05	0.0462	155.4	259.8	20.51	3.119	5.212	418.7
55.0	2.003	1.15	0.0419	171.0	285.8	21.00	3.119	5.208	438.9
60.0	1.837	1.26	0.0384	186.6	311.8	21.46	3.119	5.205	458.2
65.0	1.696	1.36	0.0354	202.2	337.9	21.87	3.119	5.203	476.8
70.0	1.575	1.47	0.0329	217.8	363.9	22.26	3.118	5.202	494.6
75.0	1.470	1.57	0.0307	233.4	389.9	22.62	3.118	5.201	511.8
80.0	1.379	1.67	0.0288	249.0	415.9	22.95	3.118	5.199	528.5
90.0	1.226	1.88	0.0256	280.2	467.9	23.56	3.118	5.198	560.3
100.0	1.104	2.09	0.0230	311.4	519.8	24.11	3.117	5.197	590.4
125.0	0.8834	2.61	0.0184	389.4	649.7	25.27	3.117	5.195	659.6
150.0	0.7365	3.13	0.0153	467.3	779.6	26.22	3.117	5.194	722.2
175.0	0.6315	3.65	0.0131	545.2	909.4	27.02	3.117	5.194	779.8
200.0	0.5527	4.17	0.0115	623.1	1039.0	27.71	3.117	5.194	833.4
225.0	0.4914	4.69	0.0102	701.0	1169.0	28.32	3.117	5.193	883.8
250.0	0.4423	5.21	0.00920	778.9	1299.0	28.87	3.116	5.193	931.4
275.0	0.4021	5.73	0.00836	856.9	1429.0	29.37	3.116	5.193	976.8
300.0	0.3687	6.25	0.00767	934.8	1559.0	29.82	3.116	5.193	1020.0
350.0	0.3161	7.28	0.00657	1091.0	1818.0	30.62	3.116	5.193	1102.0
400.0	0.2766	8.32	0.00575	1246.0	2078.0	31.31	3.116	5.193	1178.0
450.0	0.2459	9.36	0.00511	1402.0	2338.0	31.92	3.116	5.193	1249.0
500.0	0.2213	10.4	0.00460	1558.0	2597.0	32.47	3.116	5.193	1316.0
600.0	0.1844	12.5	0.00383	1870.0	3117.0	33.42	3.116	5.193	1442.0
700.0	0.1581	14.6	0.00329	2181.0	3636.0	34.22	3.116	5.193	1557.0
800.0	0.1384	16.6	0.00287	2493.0	4155.0	34.91	3.116	5.193	1665.0
900.0	0.1230	18.7	0.00256	2804.0	4674.0	35.52	3.116	5.193	1765.0
1000.0	0.1107	20.8	0.00230	3116.0	5194.0	36.07	3.116	5.193	1861.0
1100.0	0.1006	22.9	0.00209	3428.0	5713.0	36.57	3.116	5.193	1952.0
1200.0	0.09225	24.9	0.00192	3739.0	6232.0	37.02	3.116	5.193	2038.0
1300.0	0.08516	27.0	0.00177	4051.0	6752.0	37.43	3.116	5.193	2122.0
1400.0	0.07908	29.1	0.00164	4362.0	7271.0	37.82	3.116	5.193	2202.0
1500.0	0.07381	31.2	0.00153	4674.0	7790.0	38.18	3.116	5.193	2279.0

$2.4 \times 10^{+5}$ pascal Isobar

* 2.155	150.9								
2.5	149.7	0.556	2.64	−10.94	−9.346	2.010	1.803	1.943	244.7
3.0	146.6	0.477	3.55	−9.97	−8.343	2.380	1.890	2.259	238.7
3.5	142.2	0.381	4.00	−8.794	−7.106	2.763	2.075	2.801	226.8
4.0	135.9	0.279	4.14	−7.309	−5.544	3.181	2.233	3.559	210.9
4.5	126.8	0.173	3.92	−5.363	−3.471	3.668	2.423	4.909	187.4
5.0	110.3	0.0623	3.22	−2.349	−0.1736	4.357	2.707	9.554	148.3
5.1	104.1	0.0397	2.96	−1.356	0.9494	4.578	2.797	13.15	136.7
5.2	93.45	0.0181	2.54	0.2135	2.782	4.932	2.924	24.12	122.3
5.3	55.45	0.00500	1.38	5.828	10.16	6.333	3.305	68.90	102.1
5.4	43.02	0.0158	1.05	8.245	13.82	7.020	3.306	23.53	106.0
5.5	38.07	0.0241	0.914	9.457	15.76	7.376	3.282	16.46	109.9
5.6	34.90	0.0311	0.830	10.36	17.24	7.642	3.259	13.44	113.3

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
5.7	32.57	0.0374	0.769	11.12	18.49	7.864	3.240	11.74	116.4
5.8	30.72	0.0431	0.720	11.79	19.61	8.058	3.222	10.63	119.2
5.9	29.18	0.0484	0.681	12.40	20.63	8.233	3.208	9.843	121.8
6.0	27.88	0.0533	0.647	12.97	21.58	8.393	3.195	9.254	124.3
6.5	23.29	0.0749	0.531	15.44	25.75	9.060	3.151	7.656	134.9
7.0	20.35	0.0933	0.458	17.58	29.38	9.599	3.129	6.934	143.8
7.5	18.22	0.110	0.407	19.56	32.73	10.06	3.117	6.523	151.6
8.0	16.57	0.125	0.368	21.44	35.92	10.47	3.111	6.259	158.7
8.5	15.24	0.140	0.337	23.26	39.00	10.85	3.109	6.076	165.3
9.0	14.14	0.154	0.311	25.03	42.01	11.19	3.108	5.942	171.4
9.5	13.20	0.167	0.290	26.77	44.95	11.51	3.108	5.841	177.2
10.0	12.40	0.180	0.271	28.49	47.85	11.81	3.109	5.761	182.8
11.0	11.08	0.205	0.241	31.85	53.52	12.35	3.111	5.650	193.2
12.0	10.03	0.230	0.218	35.17	59.11	12.83	3.113	5.573	202.8
13.0	9.167	0.254	0.198	38.45	64.63	13.28	3.115	5.515	212.0
14.0	8.451	0.277	0.182	41.71	70.11	13.68	3.117	5.471	220.6
15.0	7.843	0.301	0.169	44.95	75.55	14.06	3.119	5.435	228.8
16.0	7.321	0.323	0.157	48.19	80.97	14.41	3.120	5.404	236.7
17.0	6.866	0.346	0.147	51.41	86.36	14.74	3.121	5.379	244.2
18.0	6.466	0.369	0.138	54.62	91.73	15.04	3.121	5.358	251.5
19.0	6.112	0.391	0.131	57.81	97.08	15.33	3.122	5.341	258.5
20.0	5.796	0.413	0.124	61.00	102.4	15.60	3.122	5.326	265.4
21.0	5.511	0.435	0.117	64.19	107.7	15.86	3.122	5.313	272.0
22.0	5.254	0.457	0.112	67.36	113.0	16.11	3.122	5.303	278.5
23.0	5.021	0.478	0.107	70.54	118.3	16.35	3.122	5.293	284.8
24.0	4.807	0.500	0.102	73.70	123.6	16.57	3.122	5.285	290.9
25.0	4.612	0.522	0.0978	76.87	128.9	16.79	3.122	5.277	296.9
26.0	4.432	0.543	0.0939	80.03	134.2	16.99	3.122	5.271	302.8
28.0	4.111	0.586	0.0870	86.34	144.7	17.38	3.122	5.260	314.2
30.0	3.835	0.629	0.0810	92.64	155.2	17.75	3.122	5.251	325.1
32.0	3.593	0.671	0.0758	98.93	165.7	18.09	3.121	5.244	335.7
34.0	3.381	0.713	0.0712	105.2	176.2	18.40	3.121	5.237	346.0
36.0	3.193	0.756	0.0672	111.5	186.7	18.70	3.121	5.232	355.9
38.0	3.024	0.798	0.0636	117.8	197.1	18.99	3.121	5.228	365.6
40.0	2.873	0.840	0.0604	124.0	207.6	19.25	3.120	5.225	375.0
45.0	2.553	0.945	0.0536	139.7	233.7	19.87	3.120	5.218	397.5
50.0	2.298	1.05	0.0482	155.3	259.8	20.42	3.120	5.212	418.8
55.0	2.090	1.15	0.0438	171.0	285.8	20.91	3.119	5.209	439.0
60.0	1.916	1.26	0.0401	186.6	311.8	21.37	3.119	5.206	458.3
65.0	1.769	1.36	0.0370	202.2	337.9	21.78	3.119	5.204	476.9
70.0	1.643	1.47	0.0343	217.8	363.9	22.17	3.118	5.202	494.7
75.0	1.534	1.57	0.0320	233.4	389.9	22.53	3.118	5.201	511.9
80.0	1.438	1.68	0.0300	249.0	415.9	22.86	3.118	5.200	528.6
90.0	1.279	1.88	0.0267	280.2	467.9	23.48	3.118	5.198	560.4
100.0	1.151	2.09	0.0240	311.4	519.9	24.02	3.118	5.197	590.4
125.0	0.9217	2.61	0.0192	389.4	649.8	25.18	3.117	5.195	659.7
150.0	0.7684	3.13	0.0160	467.3	779.6	26.13	3.117	5.194	722.3
175.0	0.6589	3.65	0.0137	545.2	909.5	26.93	3.117	5.194	779.8
200.0	0.5767	4.17	0.0120	623.1	1039.0	27.62	3.117	5.194	833.5
225.0	0.5127	4.69	0.0107	701.0	1169.0	28.24	3.117	5.193	883.8
250.0	0.4615	5.21	0.00960	779.0	1299.0	28.78	3.117	5.193	931.5
275.0	0.4196	5.73	0.00873	856.9	1429.0	29.28	3.116	5.193	976.8
300.0	0.3847	6.25	0.00800	934.8	1559.0	29.73	3.116	5.193	1020.0
350.0	0.3298	7.28	0.00686	1091.0	1818.0	30.53	3.116	5.193	1102.0
400.0	0.2886	8.32	0.00600	1246.0	2078.0	31.22	3.116	5.193	1178.0
450.0	0.2566	9.36	0.00533	1402.0	2338.0	31.84	3.116	5.193	1249.0
500.0	0.2309	10.4	0.00480	1558.0	2597.0	32.38	3.116	5.193	1316.0
600.0	0.1925	12.5	0.00400	1870.0	3117.0	33.33	3.116	5.193	1442.0
700.0	0.1650	14.6	0.00343	2181.0	3636.0	34.13	3.116	5.193	1557.0
800.0	0.1444	16.6	0.00300	2493.0	4155.0	34.82	3.116	5.193	1665.0

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
900.0	0.1283	18.7	0.00267	2804.0	4674.0	35.44	3.116	5.193	1766.0
1000.0	0.1155	20.8	0.00240	3116.0	5194.0	35.98	3.116	5.193	1861.0
1100.0	0.1050	22.9	0.00218	3428.0	5713.0	36.48	3.116	5.193	1952.0
1200.0	0.09626	24.9	0.00200	3739.0	6232.0	36.93	3.116	5.193	2038.0
1300.0	0.08886	27.0	0.00185	4051.0	6752.0	37.35	3.116	5.193	2122.0
1400.0	0.08251	29.1	0.00171	4362.0	7271.0	37.73	3.116	5.193	2202.0
1500.0	0.07701	31.2	0.00160	4674.0	7790.0	38.09	3.116	5.193	2279.0
				$2.5 \times 10^{+5}$ pascal Isobar					
2.154	151.1								
2.5	149.8	0.561	2.64	−10.95	−9.287	2.007	1.798	1.936	245.7
3.0	146.8	0.482	3.55	−9.98	−8.288	2.375	1.888	2.253	239.7
3.5	142.5	0.386	4.01	−8.811	−7.056	2.758	2.073	2.790	228.0
4.0	136.3	0.285	4.15	−7.338	−5.504	3.173	2.230	3.534	212.5
4.5	127.4	0.180	3.95	−5.415	−3.452	3.654	2.419	4.833	189.5
5.0	111.6	0.0701	3.29	−2.501	−0.2628	4.321	2.693	8.883	152.0
5.1	106.1	0.0482	3.05	−1.591	0.7641	4.523	2.775	11.50	141.4
5.2	97.72	0.0282	2.71	−0.3106	2.248	4.810	2.872	17.08	129.4
5.3	81.86	0.00701	2.15	1.994	5.048	5.342	3.038	54.98	112.6
5.4	51.05	0.00971	1.26	6.875	11.77	6.600	3.299	37.30	104.8
5.5	42.77	0.0187	1.04	8.618	14.46	7.095	3.288	20.65	108.4
5.6	38.40	0.0263	0.922	9.726	16.24	7.414	3.267	15.55	111.9
5.7	35.41	0.0330	0.843	10.60	17.65	7.665	3.247	13.04	115.1
5.8	33.15	0.0390	0.784	11.34	18.88	7.878	3.229	11.53	118.0
5.9	31.34	0.0446	0.736	12.00	19.98	8.066	3.214	10.51	120.8
6.0	29.82	0.0498	0.696	12.61	20.99	8.236	3.200	9.775	123.3
6.5	24.65	0.0722	0.564	15.18	25.32	8.931	3.154	7.877	134.2
7.0	21.43	0.0910	0.485	17.37	29.03	9.481	3.130	7.062	143.3
7.5	19.14	0.108	0.429	19.38	32.44	9.95	3.118	6.609	151.2
8.0	17.38	0.124	0.387	21.28	35.67	10.37	3.112	6.321	158.4
8.5	15.96	0.138	0.354	23.12	38.78	10.75	3.109	6.124	165.0
9.0	14.79	0.152	0.326	24.90	41.80	11.09	3.108	5.981	171.2
9.5	13.80	0.166	0.303	26.65	44.76	11.41	3.108	5.873	177.1
10.0	12.95	0.179	0.284	28.38	47.68	11.71	3.109	5.788	182.6
11.0	11.56	0.205	0.252	31.75	53.37	12.25	3.111	5.671	193.1
12.0	10.46	0.229	0.227	35.08	58.98	12.74	3.113	5.590	202.8
13.0	9.562	0.253	0.207	38.37	64.52	13.19	3.115	5.529	212.0
14.0	8.812	0.277	0.191	41.64	70.01	13.59	3.117	5.483	220.6
15.0	8.176	0.300	0.176	44.88	75.46	13.97	3.119	5.446	228.9
16.0	7.630	0.323	0.164	48.12	80.89	14.32	3.120	5.414	236.7
17.0	7.155	0.346	0.154	51.34	86.29	14.65	3.121	5.387	244.3
18.0	6.738	0.368	0.144	54.56	91.66	14.95	3.121	5.366	251.6
19.0	6.368	0.391	0.136	57.76	97.02	15.24	3.122	5.347	258.6
20.0	6.038	0.413	0.129	60.95	102.4	15.52	3.122	5.332	265.5
21.0	5.741	0.435	0.122	64.14	107.7	15.78	3.122	5.319	272.1
22.0	5.473	0.457	0.117	67.32	113.0	16.02	3.122	5.307	278.6
23.0	5.230	0.478	0.111	70.49	118.3	16.26	3.122	5.297	284.9
24.0	5.007	0.500	0.106	73.66	123.6	16.49	3.122	5.288	291.0
25.0	4.803	0.522	0.102	76.83	128.9	16.70	3.122	5.281	297.0
26.0	4.616	0.543	0.0979	79.99	134.2	16.91	3.122	5.274	302.9
28.0	4.282	0.586	0.0906	86.30	144.7	17.30	3.122	5.262	314.3
30.0	3.994	0.629	0.0844	92.60	155.2	17.66	3.122	5.253	325.3
32.0	3.742	0.671	0.0790	98.90	165.7	18.00	3.122	5.246	335.9
34.0	3.521	0.714	0.0742	105.2	176.2	18.32	3.121	5.239	346.1
36.0	3.325	0.756	0.0700	111.5	186.7	18.62	3.121	5.234	356.1
38.0	3.149	0.798	0.0663	117.7	197.1	18.90	3.121	5.230	365.7
40.0	2.992	0.840	0.0629	124.0	207.6	19.17	3.121	5.226	375.1
45.0	2.659	0.945	0.0558	139.7	233.7	19.78	3.120	5.219	397.6

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
50.0	2.394	1.05	0.0502	155.3	259.8	20.33	3.120	5.213	418.9
55.0	2.176	1.15	0.0456	171.0	285.8	20.83	3.119	5.209	439.1
60.0	1.996	1.26	0.0418	186.6	311.9	21.28	3.119	5.207	458.5
65.0	1.842	1.36	0.0385	202.2	337.9	21.70	3.119	5.204	477.0
70.0	1.711	1.47	0.0358	217.8	363.9	22.08	3.119	5.203	494.8
75.0	1.597	1.57	0.0334	233.4	389.9	22.44	3.118	5.201	512.0
80.0	1.498	1.68	0.0313	249.0	415.9	22.78	3.118	5.200	528.7
90.0	1.332	1.88	0.0278	280.2	467.9	23.39	3.118	5.198	560.5
100.0	1.199	2.09	0.0250	311.4	519.9	23.94	3.118	5.197	590.5
125.0	0.9600	2.61	0.0200	389.4	649.8	25.10	3.117	5.195	659.7
150.0	0.8004	3.13	0.0167	467.3	779.7	26.05	3.117	5.194	722.3
175.0	0.6863	3.65	0.0143	545.2	909.5	26.85	3.117	5.194	779.9
200.0	0.6007	4.17	0.0125	623.1	1039.0	27.54	3.117	5.194	833.5
225.0	0.5340	4.69	0.0111	701.0	1169.0	28.15	3.117	5.193	883.9
250.0	0.4807	5.21	0.0100	779.0	1299.0	28.70	3.117	5.193	931.5
275.0	0.4371	5.73	0.00909	856.9	1429.0	29.19	3.116	5.193	976.9
300.0	0.4007	6.25	0.00833	934.8	1559.0	29.65	3.116	5.193	1020.0
350.0	0.3435	7.28	0.00714	1091.0	1818.0	30.45	3.116	5.193	1102.0
400.0	0.3006	8.32	0.00625	1246.0	2078.0	31.14	3.116	5.193	1178.0
450.0	0.2672	9.36	0.00555	1402.0	2338.0	31.75	3.116	5.193	1249.0
500.0	0.2405	10.4	0.00500	1558.0	2597.0	32.30	3.116	5.193	1316.0
600.0	0.2005	12.5	0.00417	1870.0	3117.0	33.25	3.116	5.193	1442.0
700.0	0.1719	14.6	0.00357	2181.0	3636.0	34.05	3.116	5.193	1557.0
800.0	0.1504	16.6	0.00312	2493.0	4155.0	34.74	3.116	5.193	1665.0
900.0	0.1337	18.7	0.00278	2804.0	4674.0	35.35	3.116	5.193	1766.0
1000.0	0.1203	20.8	0.00250	3116.0	5194.0	35.90	3.116	5.193	1861.0
1100.0	0.1094	22.9	0.00227	3428.0	5713.0	36.39	3.116	5.193	1952.0
1200.0	0.1003	24.9	0.00208	3739.0	6232.0	36.84	3.116	5.193	2038.0
1300.0	0.09256	27.0	0.00192	4051.0	6752.0	37.26	3.116	5.193	2122.0
1400.0	0.08595	29.1	0.00179	4362.0	7271.0	37.65	3.116	5.193	2202.0
1500.0	0.08022	31.2	0.00167	4674.0	7790.0	38.00	3.116	5.193	2279.0
				$2.6 \times 10^{+5}$ pascal Isobar					
* 2.153	151.2								
2.5	150.0	0.566	2.64	−10.95	−9.228	2.004	1.793	1.930	246.7
3.0	147.1	0.487	3.56	−9.99	−8.233	2.371	1.887	2.247	240.8
3.5	142.7	0.392	4.02	−8.828	−7.006	2.752	2.071	2.779	229.3
4.0	136.6	0.291	4.17	−7.365	−5.463	3.165	2.228	3.510	214.0
4.5	127.9	0.186	3.98	−5.465	−3.432	3.641	2.414	4.763	191.5
5.0	112.9	0.0776	3.35	−2.638	−0.3356	4.289	2.681	8.356	155.5
5.1	107.8	0.0563	3.13	−1.791	0.6191	4.476	2.757	10.38	145.7
5.2	100.7	0.0373	2.84	−0.6756	1.905	4.724	2.837	13.92	135.2
5.3	90.61	0.0172	2.45	0.0603	3.730	5.072	2.923	25.39	122.4
5.4	64.91	0.00580	1.65	4.695	8.701	5.999	3.229	63.10	106.5
5.5	49.03	0.0136	1.21	7.541	12.84	6.760	3.284	27.80	107.4
5.6	42.59	0.0216	1.03	8.978	15.08	7.164	3.272	18.58	110.7
5.7	38.67	0.0286	0.929	10.00	16.73	7.455	3.253	14.75	113.9
5.8	35.86	0.0350	0.854	10.84	18.09	7.692	3.235	12.65	116.9
5.9	33.68	0.0408	0.797	11.56	19.28	7.896	3.220	11.31	119.7
6.0	31.90	0.0462	0.750	12.21	20.36	8.078	3.205	10.38	122.4
6.5	26.06	0.0694	0.600	14.91	24.88	8.803	3.157	8.116	133.6
7.0	22.55	0.0887	0.512	17.15	28.69	9.367	3.132	7.196	142.8
7.5	20.07	0.106	0.451	19.20	32.15	9.845	3.118	6.698	150.8
8.0	18.19	0.122	0.406	21.12	35.41	10.27	3.112	6.386	158.1
8.5	16.69	0.137	0.371	22.97	38.55	10.65	3.109	6.174	164.8
9.0	15.45	0.151	0.342	24.77	41.60	10.99	3.108	6.021	171.0
9.5	14.41	0.165	0.317	26.53	44.58	11.32	3.108	5.905	176.9
10.0	13.51	0.178	0.297	28.27	47.51	11.62	3.109	5.816	182.5

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
11.0	12.05	0.204	0.264	31.65	53.22	12.16	3.110	5.692	193.0
12.0	10.90	0.228	0.237	34.99	58.84	12.65	3.113	5.607	202.8
13.0	9.96	0.253	0.216	38.29	64.40	13.10	3.115	5.544	212.0
14.0	9.174	0.276	0.199	41.56	69.90	13.51	3.117	5.495	220.7
15.0	8.510	0.300	0.184	44.81	75.36	13.88	3.119	5.456	228.9
16.0	7.940	0.323	0.171	48.05	80.80	14.23	3.120	5.423	236.8
17.0	7.444	0.346	0.160	51.28	86.21	14.56	3.121	5.395	244.4
18.0	7.009	0.368	0.150	54.50	91.59	14.87	3.122	5.373	251.7
19.0	6.624	0.390	0.142	57.70	96.95	15.16	3.122	5.354	258.7
20.0	6.280	0.413	0.134	60.90	102.3	15.43	3.122	5.337	265.6
21.0	5.971	0.435	0.127	64.09	107.6	15.69	3.122	5.324	272.2
22.0	5.692	0.457	0.121	67.27	112.9	15.94	3.123	5.312	278.7
23.0	5.439	0.478	0.116	70.45	118.3	16.18	3.123	5.301	285.0
24.0	5.207	0.500	0.111	73.62	123.5	16.40	3.123	5.292	291.1
25.0	4.995	0.522	0.106	76.79	128.8	16.62	3.123	5.284	297.1
26.0	4.800	0.543	0.102	79.95	134.1	16.82	3.122	5.277	303.0
28.0	4.452	0.586	0.0943	86.27	144.7	17.22	3.122	5.265	314.4
30.0	4.153	0.629	0.0878	92.57	155.2	17.58	3.122	5.256	325.4
32.0	3.891	0.672	0.0822	98.87	165.7	17.92	3.122	5.248	336.0
34.0	3.661	0.714	0.0772	105.2	176.2	18.24	3.122	5.241	346.2
36.0	3.457	0.756	0.0729	111.4	186.6	18.53	3.121	5.236	356.2
38.0	3.275	0.799	0.0690	117.7	197.1	18.82	3.121	5.231	365.8
40.0	3.111	0.841	0.0655	124.0	207.6	19.09	3.121	5.227	375.2
45.0	2.765	0.946	0.0581	139.7	233.7	19.70	3.120	5.220	397.8
50.0	2.489	1.05	0.0522	155.3	259.8	20.25	3.120	5.214	419.0
55.0	2.263	1.16	0.0474	170.9	285.8	20.75	3.119	5.210	439.2
60.0	2.075	1.26	0.0434	186.6	311.9	21.20	3.119	5.207	458.6
65.0	1.916	1.36	0.0401	202.2	337.9	21.62	3.119	5.205	477.1
70.0	1.779	1.47	0.0372	217.8	363.9	22.00	3.119	5.203	494.9
75.0	1.661	1.57	0.0347	233.4	389.9	22.36	3.118	5.201	512.1
80.0	1.558	1.68	0.0325	249.0	415.9	22.70	3.118	5.200	528.8
90.0	1.385	1.88	0.0289	280.2	467.9	23.31	3.118	5.199	560.5
100.0	1.247	2.09	0.0260	311.4	519.9	23.86	3.118	5.197	590.6
125.0	0.998	2.61	0.0208	389.4	649.8	25.02	3.117	5.195	659.8
150.0	0.8323	3.13	0.0173	467.3	779.7	25.96	3.117	5.195	722.4
175.0	0.7137	3.65	0.0149	545.2	909.5	26.76	3.117	5.194	780.0
200.0	0.6246	4.17	0.0130	623.1	1039.0	27.46	3.117	5.194	833.6
225.0	0.5554	4.69	0.0116	701.0	1169.0	28.07	3.117	5.193	883.9
250.0	0.4999	5.21	0.0104	779.0	1299.0	28.62	3.117	5.193	931.6
275.0	0.4545	5.73	0.00945	856.9	1429.0	29.11	3.117	5.193	976.9
300.0	0.4167	6.25	0.00867	934.8	1559.0	29.56	3.116	5.193	1020.0
350.0	0.3572	7.29	0.00743	1091.0	1818.0	30.36	3.116	5.193	1102.0
400.0	0.3126	8.32	0.00650	1246.0	2078.0	31.06	3.116	5.193	1178.0
450.0	0.2779	9.36	0.00578	1402.0	2338.0	31.67	3.116	5.193	1249.0
500.0	0.2502	10.4	0.00520	1558.0	2597.0	32.22	3.116	5.193	1316.0
600.0	0.2085	12.5	0.00433	1870.0	3117.0	33.16	3.116	5.193	1442.0
700.0	0.1787	14.6	0.00371	2181.0	3636.0	33.96	3.116	5.193	1557.0
800.0	0.1564	16.6	0.00325	2493.0	4155.0	34.66	3.116	5.193	1665.0
900.0	0.1390	18.7	0.00289	2804.0	4674.0	35.27	3.116	5.193	1766.0
1000.0	0.1251	20.8	0.00260	3116.0	5194.0	35.82	3.116	5.193	1861.0
1100.0	0.1138	22.9	0.00236	3428.0	5713.0	36.31	3.116	5.193	1952.0
1200.0	0.1043	24.9	0.00217	3739.0	6232.0	36.76	3.116	5.193	2038.0
1300.0	0.09626	27.0	0.00200	4051.0	6752.0	37.18	3.116	5.193	2122.0
1400.0	0.08939	29.1	0.00186	4362.0	7271.0	37.56	3.116	5.193	2202.0
1500.0	0.08343	31.2	0.00173	4674.0	7790.0	37.92	3.116	5.193	2279.0

$2.8 \times 10^{+5}$ pascal Isobar

* 2.151 151.6

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
2.5	150.4	0.576	2.63	−10.96	−9.110	1.998	1.784	1.917	248.7
3.0	147.5	0.497	3.56	−10.01	−8.123	2.363	1.884	2.235	242.9
3.5	143.2	0.403	4.04	−8.860	−6.905	2.741	2.068	2.759	231.7
4.0	137.3	0.302	4.21	−7.418	−5.379	3.149	2.223	3.465	217.0
4.5	128.9	0.198	4.04	−5.560	−3.388	3.617	2.406	4.635	195.4
5.0	115.0	0.0921	3.46	−2.878	−0.4445	4.232	2.660	7.575	161.9
5.1	110.7	0.0716	3.27	−2.121	0.4076	4.399	2.727	8.936	153.2
5.2	105.1	0.0538	3.03	−1.194	1.468	4.603	2.788	10.84	144.6
5.3	98.51	0.0351	2.76	−0.1230	2.719	4.841	2.827	14.70	135.1
5.4	88.20	0.0172	2.38	1.462	4.637	5.199	2.941	25.70	122.7
5.5	68.98	0.00865	1.77	4.415	8.475	5.903	3.178	45.12	110.8
5.6	54.34	0.0137	1.36	6.991	12.14	6.565	3.252	28.73	109.9
5.7	46.92	0.0205	1.15	8.553	14.52	6.985	3.254	19.98	112.3
5.8	42.34	0.0272	1.03	9.674	16.29	7.293	3.242	15.79	115.1
5.9	39.09	0.0334	0.940	10.58	17.74	7.541	3.228	13.43	117.9
6.0	36.59	0.0393	0.873	11.35	19.00	7.753	3.214	11.91	120.6
6.5	29.06	0.0639	0.676	14.34	23.97	8.551	3.162	8.659	132.3
7.0	24.86	0.0842	0.569	16.71	27.97	9.144	3.134	7.489	141.8
7.5	22.00	0.102	0.498	18.82	31.55	9.638	3.120	6.887	150.1
8.0	19.86	0.118	0.446	20.80	34.90	10.07	3.112	6.521	157.5
8.5	18.17	0.134	0.406	22.68	38.09	10.46	3.109	6.276	164.3
9.0	16.79	0.148	0.373	24.51	41.18	10.81	3.107	6.102	170.7
9.5	15.63	0.162	0.346	26.29	44.20	11.14	3.107	5.972	176.6
10.0	14.64	0.176	0.323	28.04	47.16	11.44	3.108	5.872	182.3
11.0	13.04	0.202	0.286	31.45	52.92	11.99	3.110	5.735	192.9
12.0	11.78	0.227	0.257	34.80	58.58	12.48	3.113	5.641	202.7
13.0	10.75	0.251	0.234	38.12	64.16	12.93	3.115	5.572	212.0
14.0	9.899	0.275	0.215	41.40	69.69	13.34	3.117	5.519	220.7
15.0	9.178	0.299	0.199	44.66	75.17	13.72	3.119	5.477	229.0
16.0	8.560	0.322	0.185	47.92	80.63	14.07	3.120	5.441	236.9
17.0	8.023	0.345	0.173	51.15	86.05	14.40	3.121	5.411	244.5
18.0	7.553	0.368	0.162	54.38	91.45	14.71	3.122	5.387	251.8
19.0	7.136	0.390	0.153	57.59	96.83	15.00	3.122	5.366	258.9
20.0	6.765	0.412	0.145	60.79	102.2	15.27	3.123	5.349	265.8
21.0	6.431	0.435	0.138	63.99	107.5	15.53	3.123	5.334	272.4
22.0	6.130	0.457	0.131	67.18	112.9	15.78	3.123	5.321	278.9
23.0	5.857	0.478	0.125	70.36	118.2	16.02	3.123	5.310	285.2
24.0	5.607	0.500	0.119	73.53	123.5	16.24	3.123	5.300	291.3
25.0	5.378	0.522	0.114	76.71	128.8	16.46	3.123	5.291	297.4
26.0	5.168	0.544	0.110	79.87	134.1	16.67	3.123	5.284	303.2
28.0	4.793	0.587	0.102	86.20	144.6	17.06	3.123	5.271	314.6
30.0	4.471	0.630	0.0947	92.51	155.1	17.42	3.123	5.260	325.6
32.0	4.189	0.672	0.0886	98.81	165.7	17.76	3.122	5.252	336.2
34.0	3.941	0.715	0.0833	105.1	176.1	18.08	3.122	5.245	346.5
36.0	3.721	0.757	0.0785	111.4	186.6	18.38	3.122	5.239	356.4
38.0	3.525	0.799	0.0743	117.7	197.1	18.66	3.121	5.234	366.1
40.0	3.348	0.842	0.0705	123.9	207.6	18.93	3.121	5.230	375.5
45.0	2.976	0.947	0.0626	139.6	233.7	19.55	3.121	5.222	398.0
50.0	2.679	1.05	0.0562	155.3	259.8	20.10	3.120	5.216	419.3
55.0	2.436	1.16	0.0511	170.9	285.9	20.59	3.120	5.211	439.5
60.0	2.234	1.26	0.0468	186.5	311.9	21.05	3.119	5.208	458.8
65.0	2.062	1.37	0.0432	202.2	337.9	21.46	3.119	5.206	477.3
70.0	1.915	1.47	0.0401	217.8	364.0	21.85	3.119	5.204	495.1
75.0	1.788	1.57	0.0374	233.4	390.0	22.21	3.119	5.202	512.3
80.0	1.677	1.68	0.0350	249.0	416.0	22.54	3.118	5.201	528.9
90.0	1.491	1.89	0.0311	280.2	468.0	23.16	3.118	5.199	560.7
100.0	1.343	2.09	0.0280	311.4	520.0	23.70	3.118	5.198	590.8
125.0	1.075	2.61	0.0224	389.4	649.9	24.86	3.117	5.196	660.0
150.0	0.8961	3.13	0.0187	467.3	779.7	25.81	3.117	5.195	722.5
175.0	0.7684	3.65	0.0160	545.2	909.6	26.61	3.117	5.194	780.1

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v	C_p	Velocity of sound m/s
							kJ/kg·K		
200.0	0.6726	4.17	0.0140	623.1	1039.0	27.30	3.117	5.194	833.7
225.0	0.5980	4.69	0.0124	701.1	1169.0	27.92	3.117	5.193	884.1
250.0	0.5383	5.21	0.0112	779.0	1299.0	28.46	3.117	5.193	931.7
275.0	0.4894	5.73	0.0102	856.9	1429.0	28.96	3.117	5.193	977.0
300.0	0.4487	6.25	0.00933	934.8	1559.0	29.41	3.117	5.193	1020.0
350.0	0.3847	7.29	0.00800	1091.0	1818.0	30.21	3.116	5.193	1102.0
400.0	0.3367	8.33	0.00700	1246.0	2078.0	30.90	3.116	5.193	1178.0
450.0	0.2993	9.36	0.00622	1402.0	2338.0	31.52	3.116	5.193	1249.0
500.0	0.2694	10.4	0.00560	1558.0	2597.0	32.06	3.116	5.193	1316.0
600.0	0.2245	12.5	0.00467	1870.0	3117.0	33.01	3.116	5.193	1442.0
700.0	0.1925	14.6	0.00400	2181.0	3636.0	33.81	3.116	5.193	1557.0
800.0	0.1684	16.6	0.00350	2493.0	4155.0	34.50	3.116	5.193	1665.0
900.0	0.1497	18.7	0.00311	2804.0	4675.0	35.12	3.116	5.193	1766.0
1000.0	0.1348	20.8	0.00280	3116.0	5194.0	35.66	3.116	5.193	1861.0
1100.0	0.1225	22.9	0.00255	3428.0	5713.0	36.16	3.116	5.193	1952.0
1200.0	0.1123	24.9	0.00233	3739.0	6232.0	36.61	3.116	5.193	2039.0
1300.0	0.1037	27.0	0.00215	4051.0	6752.0	37.02	3.116	5.193	2122.0
1400.0	0.09626	29.1	0.00200	4362.0	7271.0	37.41	3.116	5.193	2202.0
1500.0	0.08985	31.2	0.00187	4674.0	7790.0	37.77	3.116	5.193	2279.0
				$3.0 \times 10^{+5}$ pascal Isobar					
* 2.149	151.9								
2.5	150.8	0.585	2.63	−10.97	−8.992	1.992	1.775	1.905	250.6
3.0	147.9	0.508	3.56	−10.03	−8.012	2.354	1.881	2.224	245.0
3.5	143.7	0.413	4.06	−8.891	−6.804	2.730	2.064	2.739	234.1
4.0	138.0	0.313	4.24	−7.468	−5.294	3.134	2.218	3.423	219.9
4.5	129.8	0.210	4.09	−5.648	−3.337	3.594	2.398	4.524	199.2
5.0	116.9	0.106	3.56	−3.083	−0.5175	4.183	2.643	7.018	167.7
5.1	113.1	0.0861	3.39	−2.388	0.2642	4.336	2.703	8.023	159.8
5.2	108.4	0.0690	3.19	−1.572	1.195	4.515	2.754	9.265	152.4
5.3	103.2	0.0510	2.97	−0.6902	2.217	4.709	2.773	11.35	144.5
5.4	96.39	0.0334	2.69	0.4224	3.535	4.955	2.841	15.45	134.7
5.5	86.22	0.0182	2.32	2.015	5.495	5.315	2.955	24.82	123.7
5.6	70.92	0.0119	1.84	4.447	8.677	5.888	3.141	34.83	114.6
5.7	58.40	0.0153	1.47	6.664	11.80	6.441	3.219	26.93	113.1
5.8	50.77	0.0209	1.26	8.227	14.14	6.847	3.232	20.31	114.6
5.9	45.77	0.0269	1.12	9.399	15.95	7.158	3.227	16.39	116.9
6.0	42.17	0.0328	1.02	10.35	17.46	7.412	3.217	13.98	119.4
6.5	32.33	0.0585	0.760	13.73	23.01	8.301	3.167	9.301	131.1
7.0	27.30	0.0797	0.630	16.24	27.23	8.929	3.137	7.816	140.9
7.5	23.99	0.0982	0.547	18.44	30.94	9.441	3.121	7.091	149.4
8.0	21.57	0.115	0.497	20.46	34.37	9.884	3.112	6.663	157.0
8.5	19.68	0.131	0.442	22.39	37.63	10.28	3.108	6.383	163.9
9.0	18.15	0.146	0.405	24.24	40.77	10.64	3.107	6.186	170.3
9.5	16.87	0.160	0.375	26.04	43.82	10.97	3.107	6.041	176.3
10.0	15.79	0.174	0.350	27.81	46.81	11.27	3.108	5.929	182.1
11.0	14.04	0.200	0.309	31.25	52.62	11.83	3.109	5.779	192.8
12.0	12.66	0.225	0.278	34.62	58.31	12.33	3.112	5.676	202.7
13.0	11.55	0.250	0.253	37.95	63.92	12.77	3.115	5.601	212.0
14.0	10.63	0.274	0.232	41.24	69.47	13.19	3.117	5.544	220.8
15.0	9.849	0.298	0.214	44.52	74.98	13.57	3.119	5.499	229.1
16.0	9.182	0.321	0.199	47.78	80.46	13.92	3.121	5.459	237.1
17.0	8.604	0.344	0.186	51.03	85.90	14.25	3.122	5.427	244.7
18.0	8.097	0.367	0.175	54.26	91.31	14.56	3.122	5.401	252.0
19.0	7.649	0.390	0.165	57.48	96.70	14.85	3.123	5.379	259.1
20.0	7.250	0.412	0.156	60.69	102.1	15.13	3.123	5.360	266.0
21.0	6.892	0.434	0.148	63.89	107.4	15.39	3.123	5.344	272.6
22.0	6.568	0.457	0.141	67.08	112.8	15.63	3.124	5.330	279.1

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
23.0	6.275	0.479	0.134	70.27	118.1	15.87	3.124	5.318	285.4
24.0	6.007	0.500	0.128	73.45	123.4	16.10	3.124	5.307	291.6
25.0	5.761	0.522	0.123	76.62	128.7	16.31	3.124	5.298	297.6
26.0	5.536	0.544	0.118	79.80	134.0	16.52	3.123	5.290	303.5
28.0	5.134	0.587	0.109	86.13	144.6	16.91	3.123	5.276	314.9
30.0	4.788	0.630	0.102	92.44	155.1	17.28	3.123	5.265	325.9
32.0	4.486	0.673	0.0950	98.75	165.6	17.62	3.123	5.256	336.5
34.0	4.221	0.715	0.0893	105.0	176.1	17.93	3.122	5.249	346.7
36.0	3.985	0.758	0.0842	111.3	186.6	18.23	3.122	5.242	356.7
38.0	3.775	0.800	0.0797	117.6	197.1	18.52	3.122	5.237	366.3
40.0	3.586	0.842	0.0756	123.9	207.6	18.79	3.122	5.232	375.7
45.0	3.187	0.948	0.0671	139.6	233.7	19.40	3.121	5.224	398.2
50.0	2.869	1.05	0.0603	155.2	259.8	19.95	3.120	5.217	419.5
55.0	2.609	1.16	0.0547	170.9	285.9	20.45	3.120	5.213	439.7
60.0	2.392	1.26	0.0501	186.5	311.9	20.90	3.120	5.209	459.0
65.0	2.209	1.37	0.0463	202.1	338.0	21.32	3.119	5.207	477.5
70.0	2.052	1.47	0.0429	217.8	364.0	21.71	3.119	5.204	495.3
75.0	1.915	1.57	0.0401	233.4	390.0	22.06	3.119	5.203	512.5
80.0	1.796	1.68	0.0375	249.0	416.0	22.40	3.119	5.201	529.1
90.0	1.597	1.89	0.0334	280.2	468.0	23.01	3.118	5.199	560.9
100.0	1.438	2.10	0.0300	311.4	520.0	23.56	3.118	5.198	591.0
125.0	1.151	2.61	0.0240	389.4	649.9	24.72	3.118	5.196	660.1
150.0	0.9600	3.13	0.0200	467.3	779.8	25.67	3.117	5.195	722.7
175.0	0.8232	3.65	0.0171	545.2	909.7	26.47	3.117	5.194	780.2
200.0	0.7205	4.17	0.0150	623.1	1040.0	27.16	3.117	5.194	833.8
225.0	0.6406	4.69	0.0133	701.1	1169.0	27.77	3.117	5.194	884.2
250.0	0.5767	5.21	0.0120	779.0	1299.0	28.32	3.117	5.193	931.8
275.0	0.5243	5.73	0.0109	856.9	1429.0	28.82	3.117	5.193	977.1
300.0	0.4807	6.25	0.0100	934.8	1559.0	29.27	3.117	5.193	1020.0
350.0	0.4121	7.29	0.00857	1091.0	1818.0	30.07	3.116	5.193	1102.0
400.0	0.3607	8.33	0.00750	1246.0	2078.0	30.76	3.116	5.193	1178.0
450.0	0.3207	9.36	0.00667	1402.0	2338.0	31.37	3.116	5.193	1249.0
500.0	0.2886	10.4	0.00600	1558.0	2597.0	31.92	3.116	5.193	1317.0
600.0	0.2406	12.5	0.00500	1870.0	3117.0	32.87	3.116	5.193	1442.0
700.0	0.2062	14.6	0.00429	2181.0	3636.0	33.67	3.116	5.193	1557.0
800.0	0.1804	16.6	0.00375	2493.0	4155.0	34.36	3.116	5.193	1665.0
900.0	0.1604	18.7	0.00333	2804.0	4675.0	34.97	3.116	5.193	1766.0
1000.0	0.1444	20.8	0.00300	3116.0	5194.0	35.52	3.116	5.193	1861.0
1100.0	0.1313	22.9	0.00273	3428.0	5713.0	36.01	3.116	5.193	1952.0
1200.0	0.1203	24.9	0.00250	3739.0	6232.0	36.47	3.116	5.193	2039.0
1300.0	0.1111	27.0	0.00231	4051.0	6752.0	36.88	3.116	5.193	2122.0
1400.0	0.1031	29.1	0.00214	4362.0	7271.0	37.27	3.116	5.193	2202.0
1500.0	0.09626	31.2	0.00200	4674.0	7790.0	37.62	3.116	5.193	2279.0
				$3.5 \times 10^{+5}$ pascal Isobar					
* 2.143	152.7								
2.5	151.6	0.610	2.61	−11.00	−8.698	1.977	1.753	1.874	255.3
3.0	148.9	0.532	3.57	−10.08	−7.735	2.334	1.873	2.198	249.9
3.5	144.9	0.439	4.10	−8.963	−6.548	2.704	2.055	2.692	239.8
4.0	139.5	0.341	4.31	−7.584	−5.075	3.099	2.206	3.330	226.7
4.5	132.0	0.240	4.21	−5.845	−3.193	3.541	2.381	4.295	207.9
5.0	120.8	0.138	3.77	−3.496	−0.5991	4.082	2.608	6.121	180.2
5.1	117.7	0.120	3.63	−2.899	0.07317	4.214	2.660	6.714	173.8
5.2	114.2	0.104	3.48	−2.233	0.8314	4.358	2.696	7.340	168.1
5.3	110.6	0.0866	3.31	−1.558	1.606	4.506	2.696	8.190	162.2
5.4	106.5	0.0697	3.13	−0.8029	2.485	4.670	2.729	9.441	155.2
5.5	101.5	0.0536	2.92	0.07009	3.518	4.860	2.774	11.29	147.7
5.6	95.36	0.0390	2.68	1.119	4.789	5.089	2.835	14.18	139.6

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
5.7	87.50	0.0273	2.39	2.432	6.431	5.379	2.920	18.52	131.6
5.8	77.87	0.0209	2.07	4.059	8.554	5.748	3.029	22.64	125.0
5.9	68.30	0.0208	1.78	5.776	10.90	6.150	3.129	22.34	121.9
6.0	60.78	0.0237	1.55	7.245	13.00	6.503	3.166	19.67	121.4
6.5	41.92	0.0467	1.02	11.99	20.34	7.682	3.170	11.35	129.3
7.0	34.04	0.0692	0.804	14.99	25.27	8.414	3.141	8.789	139.1
7.5	29.34	0.0890	0.682	17.42	29.35	8.978	3.123	7.671	147.9
8.0	26.08	0.107	0.599	19.60	33.02	9.451	3.113	7.057	155.7
8.5	23.61	0.124	0.538	21.62	36.45	9.867	3.108	6.672	162.9
9.0	21.66	0.139	0.490	23.55	39.71	10.24	3.106	6.410	169.5
9.5	20.06	0.154	0.451	25.42	42.87	10.58	3.106	6.221	175.7
10.0	18.71	0.169	0.419	27.24	45.94	10.90	3.106	6.078	181.6
11.0	16.56	0.196	0.368	30.74	51.87	11.46	3.108	5.890	192.5
12.0	14.90	0.222	0.330	34.16	57.65	11.97	3.111	5.764	202.6
13.0	13.56	0.247	0.299	37.52	63.33	12.42	3.114	5.674	212.1
14.0	12.46	0.272	0.274	40.85	68.94	12.84	3.117	5.605	221.0
15.0	11.53	0.296	0.253	44.15	74.50	13.22	3.120	5.552	229.4
16.0	10.74	0.320	0.234	47.44	80.03	13.58	3.121	5.505	237.4
17.0	10.06	0.343	0.219	50.71	85.51	13.91	3.123	5.467	245.1
18.0	9.460	0.366	0.205	53.97	90.96	14.22	3.123	5.436	252.5
19.0	8.933	0.389	0.193	57.20	96.38	14.52	3.124	5.410	259.6
20.0	8.464	0.412	0.183	60.43	101.8	14.79	3.124	5.388	266.5
21.0	8.043	0.434	0.173	63.64	107.2	15.05	3.125	5.369	273.1
22.0	7.663	0.457	0.165	66.85	112.5	15.30	3.125	5.353	279.6
23.0	7.319	0.479	0.157	70.05	117.9	15.54	3.125	5.339	286.0
24.0	7.006	0.501	0.150	73.24	123.2	15.77	3.125	5.326	292.1
25.0	6.718	0.523	0.144	76.42	128.5	15.99	3.125	5.316	298.2
26.0	6.454	0.545	0.138	79.60	133.8	16.19	3.125	5.306	304.1
28.0	5.985	0.588	0.128	85.95	144.4	16.59	3.124	5.290	315.5
30.0	5.581	0.631	0.119	92.28	155.0	16.95	3.124	5.277	326.5
32.0	5.229	0.674	0.111	98.60	165.5	17.29	3.124	5.266	337.1
34.0	4.919	0.717	0.104	104.9	176.1	17.61	3.123	5.258	347.3
36.0	4.645	0.759	0.0984	111.2	186.6	17.91	3.123	5.250	357.3
38.0	4.399	0.802	0.0931	117.5	197.1	18.19	3.123	5.244	366.9
40.0	4.179	0.844	0.0883	123.8	207.5	18.46	3.123	5.239	376.3
45.0	3.715	0.950	0.0783	139.5	233.7	19.08	3.122	5.229	398.8
50.0	3.344	1.05	0.0704	155.2	259.8	19.63	3.121	5.221	420.1
55.0	3.041	1.16	0.0639	170.8	285.9	20.13	3.121	5.216	440.3
60.0	2.788	1.26	0.0585	186.5	312.0	20.58	3.120	5.212	459.5
65.0	2.574	1.37	0.0540	202.1	338.0	21.00	3.120	5.209	478.0
70.0	2.391	1.47	0.0501	217.7	364.1	21.38	3.120	5.206	495.8
75.0	2.232	1.58	0.0468	233.3	390.1	21.74	3.119	5.204	513.0
80.0	2.094	1.68	0.0438	248.9	416.1	22.08	3.119	5.203	529.6
90.0	1.862	1.89	0.0389	280.2	468.1	22.69	3.119	5.200	561.4
100.0	1.676	2.10	0.0350	311.4	520.1	23.24	3.118	5.199	591.4
125.0	1.342	2.62	0.0280	389.3	650.1	24.40	3.118	5.196	660.5
150.0	1.119	3.14	0.0233	467.3	780.0	25.35	3.117	5.195	723.0
175.0	0.9600	3.66	0.0200	545.2	909.8	26.15	3.117	5.194	780.5
200.0	0.8403	4.18	0.0175	623.1	1040.0	26.84	3.117	5.194	834.1
225.0	0.7472	4.70	0.0156	701.1	1170.0	27.45	3.117	5.194	884.4
250.0	0.6726	5.21	0.0140	779.0	1299.0	28.00	3.117	5.193	932.0
275.0	0.6116	5.73	0.0127	856.9	1429.0	28.49	3.117	5.193	977.3
300.0	0.5607	6.25	0.0117	934.8	1559.0	28.95	3.117	5.193	1021.0
350.0	0.4807	7.29	0.0100	1091.0	1819.0	29.75	3.117	5.193	1102.0
400.0	0.4207	8.33	0.00875	1246.0	2078.0	30.44	3.116	5.193	1178.0
450.0	0.3740	9.37	0.00778	1402.0	2338.0	31.05	3.116	5.193	1249.0
500.0	0.3367	10.4	0.00700	1558.0	2598.0	31.60	3.116	5.193	1317.0
600.0	0.2806	12.5	0.00583	1870.0	3117.0	32.55	3.116	5.193	1442.0
700.0	0.2406	14.6	0.00500	2181.0	3636.0	33.35	3.116	5.193	1557.0
800.0	0.2105	16.6	0.00437	2493.0	4155.0	34.04	3.116	5.193	1665.0

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
900.0	0.1871	18.7	0.00389	2804.0	4675.0	34.65	3.116	5.193	1766.0
1000.0	0.1684	20.8	0.00350	3116.0	5194.0	35.20	3.116	5.193	1861.0
1100.0	0.1531	22.9	0.00318	3428.0	5713.0	35.69	3.116	5.193	1952.0
1200.0	0.1404	24.9	0.00292	3739.0	6233.0	36.15	3.116	5.193	2039.0
1300.0	0.1296	27.0	0.00269	4051.0	6752.0	36.56	3.116	5.193	2122.0
1400.0	0.1203	29.1	0.00250	4362.0	7271.0	36.95	3.116	5.193	2202.0
1500.0	0.1123	31.2	0.00233	4674.0	7791.0	37.30	3.116	5.193	2279.0
				$4.0 \times 10^{+5}$ pascal Isobar					
* 2.138	153.5								
2.5	152.5	0.633	2.59	−11.02	−8.403	1.964	1.732	1.846	259.7
3.0	149.8	0.557	3.58	−10.12	−7.456	2.316	1.865	2.173	254.7
3.5	146.1	0.464	4.14	−9.028	−6.289	2.680	2.047	2.651	245.2
4.0	140.9	0.367	4.38	−7.687	−4.848	3.066	2.194	3.250	233.1
4.5	133.9	0.268	4.32	−6.015	−3.027	3.494	2.365	4.116	215.8
5.0	123.9	0.169	3.94	−3.819	−0.5911	4.002	2.581	5.575	190.9
5.1	121.3	0.151	3.82	−3.281	0.01650	4.121	2.628	5.992	185.3
5.2	118.4	0.135	3.70	−2.694	0.6847	4.247	2.657	6.400	180.6
5.3	115.5	0.119	3.56	−2.114	1.349	4.374	2.650	6.895	175.9
5.4	112.3	0.102	3.42	−1.489	2.071	4.509	2.671	7.564	170.2
5.5	108.8	0.0863	3.26	−0.8071	2.870	4.656	2.699	8.426	164.1
5.6	104.7	0.0712	3.09	−0.04926	3.770	4.818	2.733	9.566	157.8
5.7	100.0	0.0572	2.89	0.8073	4.806	5.001	2.777	11.10	151.2
5.8	94.51	0.0451	2.67	1.793	6.026	5.214	2.832	13.13	144.6
5.9	88.05	0.0357	2.44	2.938	7.481	5.462	2.899	15.54	138.4
6.0	80.84	0.0302	2.19	4.235	9.183	5.749	2.977	17.57	133.4
6.5	53.65	0.0399	1.35	9.98	17.43	7.073	3.147	13.49	130.7
7.0	41.78	0.0607	1.01	13.59	23.16	7.923	3.138	9.931	138.6
7.5	35.24	0.0809	0.836	16.33	27.68	8.548	3.122	8.340	147.0
8.0	30.92	0.100	0.723	18.69	31.62	9.057	3.112	7.498	154.9
8.5	27.77	0.117	0.642	20.83	35.24	9.495	3.107	6.988	162.2
9.0	25.33	0.133	0.580	22.85	38.64	9.884	3.105	6.651	168.9
9.5	23.36	0.149	0.532	24.78	41.90	10.24	3.104	6.412	175.2
10.0	21.72	0.164	0.491	26.65	45.06	10.56	3.105	6.235	181.2
11.0	19.15	0.191	0.430	30.22	51.11	11.14	3.107	6.004	192.4
12.0	17.17	0.218	0.384	33.69	56.98	11.65	3.110	5.853	202.6
13.0	15.60	0.244	0.347	37.10	62.74	12.11	3.114	5.747	212.2
14.0	14.31	0.269	0.317	40.46	68.41	12.53	3.117	5.667	221.2
15.0	13.23	0.294	0.292	43.78	74.02	12.92	3.120	5.605	229.8
16.0	12.31	0.318	0.271	47.10	79.60	13.28	3.122	5.551	237.8
17.0	11.52	0.342	0.252	50.40	85.12	13.61	3.123	5.507	245.5
18.0	10.83	0.365	0.236	53.67	90.61	13.93	3.124	5.471	252.9
19.0	10.22	0.389	0.222	56.93	96.07	14.22	3.125	5.441	260.1
20.0	9.678	0.411	0.210	60.17	101.5	14.50	3.125	5.416	267.0
21.0	9.194	0.434	0.199	63.40	106.9	14.77	3.126	5.394	273.7
22.0	8.758	0.457	0.189	66.62	112.3	15.02	3.126	5.376	280.2
23.0	8.363	0.479	0.180	69.83	117.7	15.25	3.126	5.360	286.5
24.0	8.004	0.501	0.172	73.03	123.0	15.48	3.126	5.345	292.7
25.0	7.674	0.523	0.165	76.22	128.3	15.70	3.126	5.333	298.8
26.0	7.372	0.545	0.158	79.41	133.7	15.91	3.126	5.322	304.7
28.0	6.835	0.589	0.146	85.78	144.3	16.30	3.126	5.304	316.1
30.0	6.373	0.632	0.136	92.12	154.9	16.67	3.125	5.289	327.1
32.0	5.970	0.675	0.127	98.45	165.5	17.01	3.125	5.277	337.7
34.0	5.616	0.718	0.119	104.8	176.0	17.33	3.125	5.267	347.9
36.0	5.302	0.761	0.113	111.1	186.5	17.63	3.124	5.258	357.9
38.0	5.022	0.804	0.107	117.4	197.0	17.91	3.124	5.251	367.5
40.0	4.770	0.846	0.101	123.7	207.5	18.18	3.123	5.245	376.9
45.0	4.240	0.952	0.0896	139.4	233.7	18.80	3.123	5.234	399.4

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
50.0	3.817	1.06	0.0805	155.1	259.9	19.35	3.122	5.225	420.6
55.0	3.471	1.16	0.0731	170.7	286.0	19.85	3.121	5.219	440.8
60.0	3.183	1.27	0.0669	186.4	312.1	20.30	3.121	5.215	460.1
65.0	2.939	1.37	0.0617	202.0	338.1	20.72	3.121	5.211	478.6
70.0	2.730	1.48	0.0573	217.7	364.2	21.11	3.120	5.208	496.4
75.0	2.549	1.58	0.0534	233.3	390.2	21.47	3.120	5.206	513.5
80.0	2.391	1.68	0.0501	248.9	416.2	21.80	3.120	5.204	530.1
90.0	2.126	1.89	0.0445	280.1	468.3	22.41	3.119	5.201	561.8
100.0	1.915	2.10	0.0400	311.3	520.3	22.96	3.119	5.200	591.8
125.0	1.533	2.62	0.0320	389.3	650.2	24.12	3.118	5.197	660.9
150.0	1.279	3.14	0.0267	467.3	780.1	25.07	3.118	5.195	723.4
175.0	1.097	3.66	0.0229	545.2	910.0	25.87	3.117	5.194	780.9
200.0	0.9600	4.18	0.0200	623.2	1040.0	26.56	3.117	5.194	834.4
225.0	0.8536	4.70	0.0178	701.1	1170.0	27.18	3.117	5.194	884.7
250.0	0.7685	5.22	0.0160	779.0	1300.0	27.72	3.117	5.193	932.3
275.0	0.6988	5.74	0.0145	856.9	1429.0	28.22	3.117	5.193	977.6
300.0	0.6407	6.26	0.0133	934.8	1559.0	28.67	3.117	5.193	1021.0
350.0	0.5493	7.29	0.0114	1091.0	1819.0	29.47	3.117	5.193	1102.0
400.0	0.4807	8.33	0.0100	1246.0	2078.0	30.16	3.117	5.193	1178.0
450.0	0.4274	9.37	0.00889	1402.0	2338.0	30.78	3.117	5.193	1249.0
500.0	0.3847	10.4	0.00800	1558.0	2598.0	31.32	3.116	5.193	1317.0
600.0	0.3207	12.5	0.00667	1870.0	3117.0	32.27	3.116	5.193	1442.0
700.0	0.2749	14.6	0.00571	2181.0	3636.0	33.07	3.116	5.193	1558.0
800.0	0.2406	16.6	0.00500	2493.0	4156.0	33.76	3.116	5.193	1665.0
900.0	0.2138	18.7	0.00444	2804.0	4675.0	34.37	3.116	5.193	1766.0
1000.0	0.1925	20.8	0.00400	3116.0	5194.0	34.92	3.116	5.193	1861.0
1100.0	0.1750	22.9	0.00364	3428.0	5713.0	35.42	3.116	5.193	1952.0
1200.0	0.1604	24.9	0.00333	3739.0	6233.0	35.87	3.116	5.193	2039.0
1300.0	0.1481	27.0	0.00308	4051.0	6752.0	36.28	3.116	5.193	2122.0
1400.0	0.1375	29.1	0.00286	4362.0	7271.0	36.67	3.116	5.193	2202.0
1500.0	0.1283	31.2	0.00267	4674.0	7791.0	37.03	3.116	5.193	2279.0

$5.0 \times 10^{+5}$ pascal Isobar

* 2.127	155.0								
2.5	154.0	0.678	2.55	−11.05	−7.813	1.938	1.692	1.793	268.1
3.0	151.6	0.604	3.59	−10.18	−6.895	2.282	1.849	2.128	263.6
3.5	148.2	0.513	4.20	−9.139	−5.764	2.636	2.029	2.577	255.3
4.0	143.4	0.418	4.51	−7.863	−4.377	3.008	2.173	3.118	244.8
4.5	137.2	0.321	4.51	−6.297	−2.653	3.413	2.338	3.851	229.8
5.0	128.8	0.225	4.22	−4.310	−0.4282	3.876	2.539	4.920	208.9
5.1	126.7	0.208	4.13	−3.841	0.1039	3.980	2.582	5.186	204.3
5.2	124.5	0.194	4.03	−3.341	0.6754	4.087	2.605	5.425	200.8
5.3	122.3	0.177	3.93	−2.857	1.230	4.193	2.589	5.676	197.2
5.4	120.0	0.161	3.83	−2.351	1.814	4.302	2.601	6.001	192.9
5.5	117.6	0.146	3.71	−1.819	2.433	4.416	2.617	6.379	188.4
5.6	114.9	0.130	3.59	−1.257	3.093	4.535	2.636	6.822	183.7
5.7	112.0	0.116	3.46	−0.6594	3.803	4.661	2.658	7.344	178.9
5.8	108.9	0.102	3.32	−0.01961	4.571	4.795	2.684	7.962	173.9
5.9	105.5	0.0890	3.17	0.6690	5.408	4.938	2.714	8.695	168.8
6.0	101.7	0.0772	3.01	1.414	6.328	5.093	2.749	9.553	163.8
6.5	78.53	0.0459	2.15	6.057	12.42	6.067	2.975	13.59	144.9
7.0	59.56	0.0547	1.54	10.57	18.96	7.037	3.093	11.67	143.6
7.5	48.57	0.0710	1.21	13.96	24.26	7.769	3.106	9.665	148.6
8.0	41.61	0.0888	1.01	16.74	28.75	8.350	3.104	8.430	155.3
8.5	36.77	0.106	0.878	19.16	32.76	8.836	3.102	7.665	162.1
9.0	33.15	0.123	0.782	21.38	36.46	9.259	3.100	7.163	168.7
9.5	30.31	0.139	0.708	23.46	39.95	9.637	3.100	6.815	175.0
10.0	28.01	0.155	0.649	25.44	43.29	9.98	3.102	6.563	181.0

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
11.0	24.48	0.184	0.561	29.17	49.60	10.58	3.103	6.238	192.4
12.0	21.82	0.212	0.496	32.75	55.66	11.11	3.107	6.034	202.9
13.0	19.74	0.239	0.446	36.24	61.56	11.58	3.112	5.894	212.6
14.0	18.05	0.265	0.406	39.66	67.36	12.01	3.116	5.791	221.8
15.0	16.65	0.290	0.373	43.04	73.07	12.41	3.120	5.712	230.5
16.0	15.47	0.315	0.345	46.42	78.75	12.77	3.123	5.642	238.7
17.0	14.45	0.340	0.321	49.76	84.36	13.11	3.125	5.587	246.4
18.0	13.57	0.364	0.300	53.08	89.92	13.43	3.126	5.541	253.9
19.0	12.80	0.387	0.282	56.37	95.44	13.73	3.127	5.503	261.1
20.0	12.11	0.411	0.266	59.64	100.9	14.01	3.128	5.471	268.1
21.0	11.50	0.434	0.252	62.90	106.4	14.28	3.128	5.444	274.8
22.0	10.95	0.457	0.239	66.15	111.8	14.53	3.128	5.421	281.3
23.0	10.45	0.480	0.227	69.38	117.2	14.77	3.128	5.401	287.7
24.0	10.00	0.502	0.217	72.61	122.6	15.00	3.128	5.383	293.9
25.0	9.583	0.524	0.208	75.82	128.0	15.22	3.128	5.368	300.0
26.0	9.204	0.547	0.199	79.03	133.4	15.43	3.128	5.354	305.9
28.0	8.530	0.591	0.184	85.43	144.0	15.83	3.128	5.331	317.3
30.0	7.951	0.635	0.171	91.80	154.7	16.19	3.128	5.312	328.3
32.0	7.447	0.678	0.160	98.16	165.3	16.54	3.127	5.297	338.9
34.0	7.005	0.721	0.150	104.5	175.9	16.86	3.127	5.285	349.2
36.0	6.613	0.764	0.141	110.8	186.4	17.16	3.126	5.275	359.1
38.0	6.264	0.807	0.134	117.1	197.0	17.44	3.126	5.266	368.8
40.0	5.950	0.850	0.127	123.5	207.5	17.71	3.125	5.258	378.1
45.0	5.288	0.956	0.112	139.2	233.7	18.33	3.124	5.244	400.6
50.0	4.761	1.06	0.101	154.9	259.9	18.88	3.124	5.233	421.8
55.0	4.330	1.17	0.0915	170.6	286.1	19.38	3.123	5.226	441.9
60.0	3.971	1.27	0.0837	186.3	312.2	19.84	3.122	5.220	461.2
65.0	3.667	1.38	0.0772	201.9	338.3	20.26	3.122	5.215	479.6
70.0	3.406	1.48	0.0717	217.6	364.4	20.64	3.121	5.212	497.4
75.0	3.181	1.59	0.0668	233.2	390.4	21.00	3.121	5.209	514.5
80.0	2.983	1.69	0.0626	248.8	416.4	21.34	3.120	5.207	531.1
90.0	2.654	1.90	0.0556	280.1	468.5	21.95	3.120	5.204	562.7
100.0	2.390	2.11	0.0501	311.3	520.5	22.50	3.119	5.201	592.7
125.0	1.914	2.63	0.0400	389.3	650.5	23.66	3.119	5.198	661.7
150.0	1.597	3.15	0.0333	467.3	780.4	24.61	3.118	5.196	724.1
175.0	1.370	3.67	0.0286	545.2	910.3	25.41	3.118	5.195	781.5
200.0	1.199	4.19	0.0250	623.2	1040.0	26.10	3.118	5.194	835.0
225.0	1.066	4.70	0.0222	701.1	1170.0	26.71	3.117	5.194	885.2
250.0	0.9600	5.22	0.0200	779.0	1300.0	27.26	3.117	5.194	932.8
275.0	0.8730	5.74	0.0182	856.9	1430.0	27.75	3.117	5.193	978.1
300.0	0.8004	6.26	0.0167	934.8	1560.0	28.21	3.117	5.193	1021.0
350.0	0.6863	7.30	0.0143	1091.0	1819.0	29.01	3.117	5.193	1103.0
400.0	0.6007	8.34	0.0125	1246.0	2079.0	29.70	3.117	5.193	1179.0
450.0	0.5341	9.38	0.0111	1402.0	2338.0	30.31	3.117	5.193	1250.0
500.0	0.4808	10.4	0.0100	1558.0	2598.0	30.86	3.117	5.193	1317.0
600.0	0.4007	12.5	0.00833	1870.0	3117.0	31.81	3.117	5.193	1443.0
700.0	0.3436	14.6	0.00714	2181.0	3637.0	32.61	3.116	5.193	1558.0
800.0	0.3007	16.6	0.00625	2493.0	4156.0	33.30	3.116	5.193	1665.0
900.0	0.2673	18.7	0.00555	2805.0	4675.0	33.91	3.116	5.193	1766.0
1000.0	0.2406	20.8	0.00500	3116.0	5195.0	34.46	3.116	5.193	1861.0
1100.0	0.2187	22.9	0.00454	3428.0	5714.0	34.95	3.116	5.193	1952.0
1200.0	0.2005	24.9	0.00417	3739.0	6233.0	35.40	3.116	5.193	2039.0
1300.0	0.1851	27.0	0.00385	4051.0	6752.0	35.82	3.116	5.193	2122.0
1400.0	0.1719	29.1	0.00357	4363.0	7272.0	36.21	3.116	5.193	2202.0
1500.0	0.1604	31.2	0.00333	4674.0	7791.0	36.56	3.116	5.193	2279.0

$6.0 \times 10^{+5}$ pascal Isobar

* 2.116 156.4

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
2.5	155.5	0.722	2.51	−11.07	−7.224	1.916	1.655	1.745	275.9
3.0	153.3	0.649	3.59	−10.24	−6.333	2.250	1.833	2.087	271.8
3.5	150.0	0.560	4.26	−9.231	−5.232	2.596	2.011	2.515	264.5
4.0	145.7	0.466	4.61	−8.008	−3.890	2.957	2.153	3.013	255.4
4.5	140.0	0.371	4.66	−6.523	−2.239	3.345	2.314	3.660	242.2
5.0	132.6	0.278	4.44	−4.677	−0.1544	3.778	2.508	4.527	223.8
5.1	130.9	0.261	4.37	−4.250	0.3333	3.872	2.548	4.727	220.0
5.2	129.0	0.247	4.29	−3.798	0.8515	3.970	2.567	4.899	217.1
5.3	127.2	0.231	4.21	−3.366	1.349	4.064	2.549	5.060	214.2
5.4	125.4	0.215	4.12	−2.920	1.866	4.161	2.557	5.271	210.7
5.5	123.4	0.200	4.03	−2.457	2.404	4.260	2.568	5.506	207.0
5.6	121.3	0.185	3.93	−1.976	2.968	4.362	2.581	5.769	203.1
5.7	119.1	0.170	3.83	−1.475	3.561	4.467	2.597	6.064	199.2
5.8	116.8	0.156	3.72	−0.9521	4.185	4.576	2.614	6.395	195.1
5.9	114.3	0.142	3.61	−0.4029	4.845	4.689	2.634	6.767	191.0
6.0	111.7	0.129	3.49	0.1743	5.546	4.807	2.657	7.185	186.8
6.5	95.80	0.0786	2.81	3.582	9.845	5.495	2.804	9.931	166.9
7.0	77.17	0.0630	2.14	7.750	15.53	6.337	2.975	11.49	155.9
7.5	62.75	0.0717	1.66	11.58	21.15	7.113	3.062	10.34	155.6
8.0	53.17	0.0856	1.35	14.72	26.00	7.741	3.082	9.142	159.3
8.5	46.46	0.101	1.15	17.43	30.34	8.267	3.089	8.268	164.5
9.0	41.50	0.117	1.01	19.86	34.31	8.721	3.092	7.652	170.3
9.5	37.67	0.133	0.905	22.10	38.02	9.122	3.094	7.211	176.1
10.0	34.61	0.149	0.822	24.21	41.54	9.484	3.097	6.889	181.9
11.0	29.99	0.179	0.702	28.10	48.11	10.11	3.099	6.470	193.1
12.0	26.60	0.207	0.616	31.80	54.36	10.66	3.104	6.212	203.5
13.0	23.97	0.235	0.551	35.37	60.41	11.14	3.110	6.038	213.4
14.0	21.86	0.261	0.499	38.87	66.32	11.58	3.115	5.912	222.7
15.0	20.12	0.287	0.457	42.31	72.13	11.98	3.120	5.816	231.5
16.0	18.65	0.313	0.421	45.74	77.91	12.35	3.123	5.732	239.6
17.0	17.40	0.338	0.391	49.13	83.60	12.70	3.126	5.665	247.5
18.0	16.32	0.362	0.365	52.49	89.24	13.02	3.127	5.610	255.0
19.0	15.38	0.387	0.342	55.82	94.83	13.32	3.129	5.564	262.2
20.0	14.55	0.410	0.323	59.12	100.4	13.61	3.129	5.526	269.2
21.0	13.80	0.434	0.305	62.41	105.9	13.88	3.130	5.493	275.9
22.0	13.14	0.457	0.289	65.68	111.4	14.13	3.130	5.465	282.5
23.0	12.53	0.480	0.275	68.94	116.8	14.37	3.131	5.441	288.9
24.0	11.99	0.503	0.263	72.19	122.2	14.61	3.131	5.420	295.1
25.0	11.49	0.526	0.251	75.42	127.7	14.83	3.131	5.402	301.2
26.0	11.03	0.548	0.241	78.65	133.0	15.04	3.130	5.385	307.1
28.0	10.22	0.593	0.222	85.08	143.8	15.44	3.130	5.358	318.6
30.0	9.524	0.637	0.206	91.48	154.5	15.81	3.130	5.336	329.6
32.0	8.919	0.681	0.192	97.86	165.1	16.15	3.129	5.318	340.2
34.0	8.388	0.725	0.181	104.2	175.8	16.47	3.129	5.303	350.4
36.0	7.918	0.768	0.170	110.6	186.3	16.77	3.128	5.290	360.3
38.0	7.499	0.811	0.161	116.9	196.9	17.06	3.128	5.280	370.0
40.0	7.123	0.854	0.152	123.2	207.5	17.33	3.127	5.271	379.4
45.0	6.332	0.961	0.135	139.0	233.8	17.95	3.126	5.254	401.8
50.0	5.700	1.07	0.121	154.8	260.0	18.50	3.125	5.241	422.9
55.0	5.185	1.17	0.110	170.5	286.2	19.00	3.124	5.232	443.1
60.0	4.755	1.28	0.101	186.2	312.3	19.46	3.123	5.225	462.3
65.0	4.392	1.38	0.0927	201.8	338.4	19.87	3.123	5.220	480.7
70.0	4.080	1.49	0.0860	217.5	364.5	20.26	3.122	5.216	498.4
75.0	3.810	1.59	0.0803	233.1	390.6	20.62	3.122	5.212	515.5
80.0	3.574	1.70	0.0752	248.8	416.7	20.96	3.121	5.210	532.0
90.0	3.179	1.90	0.0668	280.0	468.7	21.57	3.121	5.206	563.7
100.0	2.864	2.11	0.0601	311.3	520.8	22.12	3.120	5.203	593.6
125.0	2.295	2.63	0.0480	389.3	650.8	23.28	3.119	5.199	662.4
150.0	1.914	3.15	0.0400	467.3	780.7	24.23	3.119	5.196	724.8
175.0	1.642	3.67	0.0343	545.2	910.6	25.03	3.118	5.195	782.1

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
200.0	1.438	4.19	0.0300	623.2	1040.0	25.72	3.118	5.194	835.6
225.0	1.279	4.71	0.0267	701.1	1170.0	26.33	3.118	5.194	885.8
250.0	1.151	5.23	0.0240	779.0	1300.0	26.88	3.118	5.194	933.3
275.0	1.047	5.75	0.0218	857.0	1430.0	27.38	3.117	5.193	978.5
300.0	0.9601	6.27	0.0200	934.9	1560.0	27.83	3.117	5.193	1022.0
350.0	0.8233	7.31	0.0171	1091.0	1819.0	28.63	3.117	5.193	1103.0
400.0	0.7206	8.34	0.0150	1247.0	2079.0	29.32	3.117	5.193	1179.0
450.0	0.6407	9.38	0.0133	1402.0	2339.0	29.93	3.117	5.193	1250.0
500.0	0.5768	10.4	0.0120	1558.0	2598.0	30.48	3.117	5.193	1317.0
600.0	0.4808	12.5	0.0100	1870.0	3118.0	31.43	3.117	5.193	1443.0
700.0	0.4122	14.6	0.00857	2181.0	3637.0	32.23	3.117	5.193	1558.0
800.0	0.3607	16.6	0.00750	2493.0	4156.0	32.92	3.117	5.193	1665.0
900.0	0.3207	18.7	0.00667	2805.0	4676.0	33.53	3.117	5.193	1766.0
1000.0	0.2887	20.8	0.00600	3116.0	5195.0	34.08	3.116	5.193	1862.0
1100.0	0.2624	22.9	0.00545	3428.0	5714.0	34.57	3.116	5.193	1952.0
1200.0	0.2406	25.0	0.00500	3739.0	6233.0	35.03	3.116	5.193	2039.0
1300.0	0.2221	27.0	0.00461	4051.0	6753.0	35.44	3.116	5.193	2122.0
1400.0	0.2062	29.1	0.00428	4363.0	7272.0	35.83	3.116	5.193	2202.0
1500.0	0.1925	31.2	0.00400	4674.0	7791.0	36.19	3.116	5.193	2279.0

$7.0 \times 10^{+5}$ pascal Isobar

* 2.104	157.8								
2.5	156.9	0.763	2.47	−11.09	−6.636	1.895	1.620	1.701	283.1
3.0	154.8	0.692	3.59	−10.28	−5.769	2.222	1.816	2.049	279.4
3.5	151.8	0.605	4.30	−9.307	−4.696	2.560	1.994	2.459	273.1
4.0	147.7	0.512	4.70	−8.130	−3.392	2.911	2.133	2.925	265.0
4.5	142.5	0.419	4.80	−6.710	−1.799	3.286	2.293	3.512	253.2
5.0	135.9	0.327	4.63	−4.968	0.1830	3.697	2.482	4.257	236.8
5.1	134.3	0.311	4.57	−4.569	0.6409	3.785	2.521	4.421	233.4
5.2	132.7	0.297	4.51	−4.150	1.124	3.875	2.538	4.558	231.0
5.3	131.1	0.282	4.44	−3.751	1.586	3.963	2.518	4.674	228.6
5.4	129.5	0.266	4.36	−3.343	2.061	4.052	2.524	4.830	225.6
5.5	127.9	0.250	4.29	−2.922	2.552	4.142	2.533	5.001	222.4
5.6	126.1	0.235	4.20	−2.489	3.061	4.234	2.543	5.187	219.1
5.7	124.3	0.221	4.12	−2.041	3.590	4.328	2.556	5.390	215.7
5.8	122.4	0.206	4.03	−1.578	4.141	4.424	2.570	5.613	212.3
5.9	120.4	0.192	3.93	−1.099	4.715	4.522	2.585	5.855	208.7
6.0	118.3	0.179	3.83	−0.6029	5.316	4.624	2.603	6.121	205.2
6.5	106.1	0.121	3.28	2.206	8.802	5.182	2.712	7.821	187.1
7.0	91.23	0.0871	2.67	5.631	13.30	5.850	2.850	9.731	172.4
7.5	76.22	0.0807	2.13	9.385	18.57	6.577	2.979	10.21	166.3
8.0	64.65	0.0898	1.73	12.80	23.63	7.231	3.046	9.433	166.7
8.5	56.34	0.102	1.46	15.72	28.14	7.778	3.068	8.647	169.7
9.0	50.10	0.116	1.27	18.33	32.30	8.254	3.079	8.022	174.0
9.5	45.27	0.131	1.12	20.72	36.19	8.674	3.086	7.544	178.8
10.0	41.42	0.146	1.01	22.96	39.86	9.052	3.090	7.170	184.0
11.0	35.66	0.175	0.852	27.03	46.67	9.703	3.094	6.684	194.5
12.0	31.47	0.204	0.743	30.85	53.09	10.26	3.100	6.379	204.7
13.0	28.26	0.231	0.661	34.51	59.28	10.76	3.107	6.174	214.5
14.0	25.71	0.259	0.596	38.08	65.31	11.21	3.114	6.027	223.7
15.0	23.61	0.285	0.544	41.57	71.22	11.62	3.119	5.916	232.6
16.0	21.86	0.311	0.500	45.06	77.09	11.99	3.123	5.819	240.8
17.0	20.37	0.337	0.463	48.50	82.86	12.34	3.126	5.740	248.6
18.0	19.09	0.362	0.432	51.90	88.57	12.67	3.129	5.677	256.1
19.0	17.97	0.386	0.405	55.27	94.22	12.98	3.130	5.624	263.4
20.0	16.98	0.410	0.381	58.61	99.8	13.26	3.131	5.579	270.4
21.0	16.11	0.434	0.360	61.92	105.4	13.53	3.132	5.542	277.2
22.0	15.32	0.458	0.341	65.22	110.9	13.79	3.132	5.509	283.7

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
23.0	14.61	0.481	0.324	68.50	116.4	14.04	3.133	5.481	290.1
24.0	13.97	0.504	0.309	71.77	121.9	14.27	3.133	5.457	296.3
25.0	13.39	0.527	0.295	75.03	127.3	14.49	3.133	5.435	302.4
26.0	12.85	0.550	0.282	78.27	132.7	14.70	3.133	5.416	308.3
28.0	11.90	0.595	0.260	84.73	143.5	15.10	3.132	5.384	319.8
30.0	11.09	0.640	0.242	91.16	154.3	15.47	3.132	5.359	330.8
32.0	10.38	0.684	0.226	97.57	165.0	15.82	3.131	5.338	341.4
34.0	9.765	0.728	0.211	104.0	175.6	16.14	3.131	5.321	351.7
36.0	9.218	0.771	0.199	110.3	186.3	16.45	3.130	5.306	361.6
38.0	8.730	0.815	0.188	116.7	196.9	16.73	3.129	5.294	371.2
40.0	8.292	0.858	0.178	123.0	207.4	17.00	3.129	5.284	380.6
45.0	7.370	0.965	0.158	138.8	233.8	17.63	3.128	5.263	403.0
50.0	6.636	1.07	0.142	154.6	260.1	18.18	3.126	5.249	424.1
55.0	6.036	1.18	0.128	170.3	286.3	18.68	3.126	5.239	444.2
60.0	5.536	1.28	0.117	186.0	312.5	19.13	3.125	5.231	463.3
65.0	5.114	1.39	0.108	201.7	338.6	19.55	3.124	5.224	481.7
70.0	4.751	1.49	0.100	217.4	364.7	19.94	3.123	5.219	499.4
75.0	4.437	1.60	0.0937	233.0	390.8	20.30	3.123	5.216	516.5
80.0	4.162	1.70	0.0878	248.7	416.9	20.64	3.122	5.212	533.0
90.0	3.704	1.91	0.0779	280.0	469.0	21.25	3.122	5.208	564.6
100.0	3.336	2.12	0.0701	311.2	521.0	21.80	3.121	5.204	594.4
125.0	2.674	2.64	0.0560	389.3	651.1	22.96	3.120	5.199	663.2
150.0	2.231	3.16	0.0467	467.3	781.0	23.91	3.119	5.197	725.5
175.0	1.914	3.68	0.0400	545.2	910.9	24.71	3.119	5.195	782.8
200.0	1.676	4.20	0.0350	623.2	1041.0	25.40	3.118	5.195	836.2
225.0	1.491	4.72	0.0311	701.1	1171.0	26.01	3.118	5.194	886.3
250.0	1.342	5.24	0.0280	779.1	1300.0	26.56	3.118	5.194	933.8
275.0	1.221	5.75	0.0254	857.0	1430.0	27.06	3.118	5.193	979.0
300.0	1.120	6.27	0.0233	934.9	1560.0	27.51	3.118	5.193	1022.0
350.0	0.9601	7.31	0.0200	1091.0	1820.0	28.31	3.117	5.193	1104.0
400.0	0.8404	8.35	0.0175	1247.0	2079.0	29.00	3.117	5.193	1179.0
450.0	0.7473	9.39	0.0156	1402.0	2339.0	29.61	3.117	5.193	1250.0
500.0	0.6727	10.4	0.0140	1558.0	2599.0	30.16	3.117	5.193	1318.0
600.0	0.5608	12.5	0.0117	1870.0	3118.0	31.11	3.117	5.193	1443.0
700.0	0.4808	14.6	0.0100	2181.0	3637.0	31.91	3.117	5.193	1558.0
800.0	0.4208	16.7	0.00875	2493.0	4157.0	32.60	3.117	5.193	1666.0
900.0	0.3741	18.7	0.00778	2805.0	4676.0	33.21	3.117	5.193	1766.0
1000.0	0.3367	20.8	0.00700	3116.0	5195.0	33.76	3.117	5.193	1862.0
1100.0	0.3061	22.9	0.00636	3428.0	5714.0	34.25	3.117	5.193	1952.0
1200.0	0.2806	25.0	0.00583	3739.0	6234.0	34.71	3.117	5.193	2039.0
1300.0	0.2591	27.0	0.00538	4051.0	6753.0	35.12	3.116	5.193	2122.0
1400.0	0.2406	29.1	0.00500	4363.0	7272.0	35.51	3.116	5.193	2202.0
1500.0	0.2246	31.2	0.00467	4674.0	7792.0	35.86	3.116	5.193	2279.0
				$8.0 \times 10^{+5}$ pascal Isobar					
* 2.093	159.0								
2.5	158.2	0.803	2.43	−11.10	−6.049	1.876	1.587	1.661	289.9
3.0	156.3	0.734	3.59	−10.31	−5.204	2.196	1.800	2.015	286.6
3.5	153.4	0.648	4.34	−9.371	−4.156	2.527	1.976	2.409	281.0
4.0	149.6	0.557	4.79	−8.233	−2.886	2.870	2.114	2.850	273.9
4.5	144.8	0.464	4.92	−6.868	−1.342	3.233	2.273	3.393	263.3
5.0	138.7	0.374	4.79	−5.207	0.5616	3.627	2.460	4.056	248.4
5.1	137.3	0.358	4.74	−4.830	0.997	3.711	2.497	4.198	245.4
5.2	135.8	0.345	4.69	−4.434	1.456	3.796	2.514	4.314	243.3
5.3	134.4	0.330	4.63	−4.059	1.891	3.879	2.493	4.403	241.2
5.4	133.0	0.314	4.57	−3.677	2.338	3.962	2.498	4.528	238.5
5.5	131.5	0.299	4.50	−3.286	2.797	4.047	2.505	4.662	235.7
5.6	130.0	0.284	4.43	−2.884	3.270	4.132	2.514	4.807	232.8

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
5.7	128.4	0.269	4.35	−2.472	3.759	4.219	2.525	4.963	229.9
5.8	126.7	0.254	4.27	−2.048	4.263	4.307	2.537	5.130	226.8
5.9	125.0	0.240	4.19	−1.613	4.786	4.396	2.550	5.310	223.7
6.0	123.2	0.227	4.11	−1.164	5.327	4.487	2.565	5.503	220.6
6.5	113.2	0.166	3.63	1.307	8.374	4.976	2.656	6.690	204.3
7.0	101.2	0.121	3.10	4.228	12.14	5.535	2.769	8.177	189.4
7.5	87.83	0.100	2.57	7.561	16.67	6.162	2.888	9.312	179.3
8.0	75.51	0.0989	2.12	10.99	21.58	6.797	2.986	9.360	176.0
8.5	65.88	0.108	1.78	14.12	26.26	7.365	3.040	8.789	177.0
9.0	58.60	0.120	1.54	16.86	30.51	7.851	3.061	8.235	179.5
9.5	52.88	0.133	1.35	19.38	34.51	8.283	3.074	7.773	183.2
10.0	48.28	0.146	1.21	21.73	38.30	8.672	3.082	7.400	187.4
11.0	41.39	0.174	1.01	25.97	45.30	9.343	3.088	6.865	196.9
12.0	36.40	0.202	0.876	29.91	51.89	9.917	3.096	6.527	206.5
13.0	32.60	0.230	0.775	33.66	58.20	10.42	3.104	6.299	216.0
14.0	29.59	0.257	0.697	37.29	64.33	10.88	3.111	6.134	225.1
15.0	27.12	0.284	0.635	40.84	70.33	11.29	3.118	6.010	233.9
16.0	25.08	0.310	0.582	44.39	76.29	11.68	3.123	5.901	242.1
17.0	23.34	0.336	0.538	47.87	82.14	12.03	3.127	5.813	249.9
18.0	21.85	0.361	0.500	51.31	87.92	12.36	3.130	5.741	257.4
19.0	20.56	0.386	0.468	54.72	93.63	12.67	3.132	5.681	264.6
20.0	19.42	0.411	0.440	58.09	99.28	12.96	3.133	5.631	271.6
21.0	18.41	0.435	0.415	61.44	104.9	13.24	3.134	5.588	278.4
22.0	17.50	0.459	0.393	64.76	110.5	13.49	3.134	5.552	285.0
23.0	16.69	0.482	0.373	68.07	116.0	13.74	3.135	5.520	291.4
24.0	15.95	0.506	0.356	71.36	121.5	13.97	3.135	5.492	297.6
25.0	15.28	0.529	0.339	74.63	127.0	14.20	3.135	5.468	303.7
26.0	14.67	0.552	0.325	77.89	132.4	14.41	3.135	5.446	309.6
28.0	13.58	0.597	0.299	84.39	143.3	14.81	3.134	5.410	321.1
30.0	12.65	0.642	0.277	90.85	154.1	15.19	3.134	5.381	332.1
32.0	11.84	0.687	0.259	97.28	164.8	15.53	3.133	5.358	342.7
34.0	11.14	0.731	0.243	103.7	175.5	15.86	3.133	5.338	352.9
36.0	10.51	0.775	0.228	110.1	186.2	16.16	3.132	5.322	362.8
38.0	9.95	0.818	0.216	116.4	196.8	16.45	3.131	5.308	372.4
40.0	9.455	0.862	0.204	122.8	207.4	16.72	3.131	5.296	381.8
45.0	8.404	0.969	0.181	138.6	233.8	17.34	3.129	5.273	404.1
50.0	7.567	1.08	0.162	154.4	260.2	17.90	3.128	5.257	425.2
55.0	6.883	1.18	0.147	170.2	286.4	18.40	3.127	5.245	445.3
60.0	6.314	1.29	0.134	185.9	312.6	18.86	3.126	5.236	464.4
65.0	5.833	1.39	0.124	201.6	338.8	19.27	3.125	5.229	482.8
70.0	5.420	1.50	0.115	217.3	364.9	19.66	3.124	5.223	500.4
75.0	5.062	1.60	0.107	233.0	391.0	20.02	3.124	5.219	517.5
80.0	4.749	1.71	0.100	248.6	417.1	20.36	3.123	5.215	534.0
90.0	4.226	1.92	0.0891	279.9	469.2	20.97	3.122	5.210	565.5
100.0	3.807	2.13	0.0801	311.2	521.3	21.52	3.122	5.206	595.3
125.0	3.052	2.65	0.0640	389.2	651.4	22.68	3.120	5.200	664.0
150.0	2.547	3.17	0.0533	467.3	781.3	23.63	3.120	5.197	726.2
175.0	2.186	3.68	0.0457	545.2	911.2	24.43	3.119	5.196	783.4
200.0	1.914	4.20	0.0400	623.2	1041.0	25.12	3.119	5.195	836.7
225.0	1.703	4.72	0.0355	701.2	1171.0	25.74	3.118	5.194	886.9
250.0	1.533	5.24	0.0320	779.1	1301.0	26.28	3.118	5.194	934.3
275.0	1.395	5.76	0.0291	857.0	1431.0	26.78	3.118	5.194	979.5
300.0	1.279	6.28	0.0267	934.9	1560.0	27.23	3.118	5.193	1023.0
350.0	1.097	7.32	0.0228	1091.0	1820.0	28.03	3.118	5.193	1104.0
400.0	0.9602	8.35	0.0200	1247.0	2080.0	28.72	3.117	5.193	1180.0
450.0	0.8538	9.39	0.0178	1402.0	2339.0	29.34	3.117	5.193	1251.0
500.0	0.7686	10.4	0.0160	1558.0	2599.0	29.88	3.117	5.193	1318.0
600.0	0.6408	12.5	0.0133	1870.0	3118.0	30.83	3.117	5.193	1443.0
700.0	0.5494	14.6	0.0114	2181.0	3638.0	31.63	3.117	5.193	1559.0
800.0	0.4808	16.7	0.0100	2493.0	4157.0	32.32	3.117	5.193	1666.0

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
900.0	0.4275	18.7	0.00889	2805.0	4676.0	32.93	3.117	5.193	1767.0
1000.0	0.3848	20.8	0.00800	3116.0	5195.0	33.48	3.117	5.193	1862.0
1100.0	0.3498	22.9	0.00727	3428.0	5715.0	33.98	3.117	5.193	1953.0
1200.0	0.3207	25.0	0.00666	3740.0	6234.0	34.43	3.117	5.193	2039.0
1300.0	0.2961	27.0	0.00615	4051.0	6753.0	34.84	3.117	5.193	2122.0
1400.0	0.2749	29.1	0.00571	4363.0	7273.0	35.23	3.117	5.193	2202.0
1500.0	0.2566	31.2	0.00533	4674.0	7792.0	35.59	3.117	5.193	2280.0
				$10.0 \times 10^{+5}$ pascal Isobar					
* 2.068	161.4								
2.5	160.6	0.879	2.36	−11.10	−4.881	1.841	1.526	1.588	302.3
3.0	158.9	0.814	3.57	−10.36	−4.075	2.149	1.766	1.952	299.9
3.5	156.4	0.730	4.41	−9.466	−3.071	2.468	1.941	2.322	295.6
4.0	152.9	0.642	4.93	−8.396	−1.857	2.796	2.079	2.726	290.0
4.5	148.6	0.552	5.13	−7.118	−0.3919	3.141	2.237	3.208	281.2
5.0	143.4	0.464	5.07	−5.579	1.395	3.510	2.423	3.771	268.6
5.1	142.2	0.448	5.03	−5.232	1.800	3.587	2.459	3.887	266.0
5.2	140.9	0.435	5.00	−4.870	2.224	3.666	2.475	3.978	264.4
5.3	139.8	0.420	4.95	−4.529	2.625	3.742	2.453	4.038	262.8
5.4	138.6	0.404	4.90	−4.182	3.033	3.818	2.457	4.129	260.6
5.5	137.3	0.389	4.85	−3.830	3.450	3.895	2.463	4.225	258.4
5.6	136.1	0.374	4.79	−3.470	3.877	3.972	2.471	4.327	256.0
5.7	134.8	0.359	4.73	−3.103	4.315	4.050	2.480	4.436	253.6
5.8	133.4	0.345	4.67	−2.729	4.764	4.128	2.490	4.550	251.1
5.9	132.1	0.331	4.61	−2.346	5.225	4.207	2.501	4.670	248.5
6.0	130.7	0.317	4.54	−1.955	5.698	4.287	2.514	4.797	245.9
6.5	122.9	0.253	4.16	0.1428	8.276	4.701	2.588	5.532	232.4
7.0	114.1	0.199	3.73	2.516	11.28	5.148	2.676	6.437	218.9
7.5	104.1	0.160	3.28	5.191	14.80	5.636	2.770	7.423	207.0
8.0	93.49	0.138	2.83	8.126	18.82	6.156	2.864	8.203	198.5
8.5	83.33	0.131	2.44	11.17	23.17	6.685	2.945	8.479	194.3
9.0	74.49	0.136	2.11	14.15	27.58	7.189	3.006	8.301	193.9
9.5	67.32	0.146	1.85	16.92	31.77	7.644	3.043	7.945	195.5
10.0	61.55	0.157	1.65	19.42	35.67	8.043	3.061	7.627	197.7
11.0	52.72	0.180	1.35	23.94	42.91	8.737	3.075	7.102	204.1
12.0	46.25	0.205	1.16	28.08	49.71	9.330	3.085	6.747	211.9
13.0	41.30	0.231	1.02	32.00	56.21	9.853	3.096	6.497	220.3
14.0	37.37	0.257	0.908	35.75	62.51	10.32	3.106	6.313	228.8
15.0	34.18	0.284	0.822	39.41	68.67	10.75	3.114	6.172	237.2
16.0	31.53	0.310	0.751	43.06	74.78	11.14	3.122	6.047	245.1
17.0	29.30	0.336	0.692	46.64	80.77	11.50	3.127	5.945	252.8
18.0	27.39	0.362	0.642	50.16	86.67	11.84	3.131	5.860	260.3
19.0	25.73	0.387	0.599	53.63	92.49	12.16	3.134	5.789	267.4
20.0	24.28	0.412	0.561	57.07	98.25	12.45	3.136	5.728	274.4
21.0	23.00	0.437	0.529	60.47	104.0	12.73	3.137	5.677	281.1
22.0	21.85	0.461	0.500	63.85	109.6	12.99	3.138	5.633	287.7
23.0	20.83	0.485	0.474	67.20	115.2	13.24	3.138	5.594	294.1
24.0	19.90	0.509	0.451	70.53	120.8	13.48	3.139	5.560	300.3
25.0	19.05	0.533	0.430	73.85	126.3	13.70	3.139	5.531	306.3
26.0	18.28	0.556	0.411	77.15	131.9	13.92	3.139	5.505	312.3
28.0	16.91	0.602	0.378	83.70	142.8	14.33	3.138	5.461	323.7
30.0	15.75	0.648	0.350	90.22	153.7	14.70	3.138	5.425	334.7
32.0	14.74	0.693	0.326	96.69	164.5	15.05	3.137	5.396	345.3
34.0	13.86	0.738	0.305	103.1	175.3	15.38	3.136	5.372	355.5
36.0	13.08	0.782	0.287	109.6	186.0	15.69	3.136	5.352	365.3
38.0	12.39	0.826	0.271	116.0	196.7	15.97	3.135	5.335	374.9
40.0	11.76	0.870	0.257	122.4	207.4	16.25	3.134	5.321	384.3
45.0	10.46	0.978	0.227	138.3	233.9	16.87	3.132	5.293	406.5

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
50.0	9.417	1.09	0.203	154.1	260.3	17.43	3.131	5.272	427.6
55.0	8.568	1.19	0.184	169.9	286.6	17.93	3.130	5.258	447.5
60.0	7.861	1.30	0.168	185.7	312.9	18.39	3.128	5.246	466.6
65.0	7.263	1.40	0.155	201.4	339.1	18.81	3.127	5.238	484.9
70.0	6.750	1.51	0.144	217.1	365.3	19.19	3.127	5.231	502.5
75.0	6.305	1.61	0.134	232.8	391.4	19.56	3.126	5.225	519.5
80.0	5.916	1.72	0.126	248.5	417.5	19.89	3.125	5.221	535.9
90.0	5.266	1.93	0.111	279.8	469.7	20.51	3.124	5.214	567.3
100.0	4.746	2.14	0.100	311.1	521.8	21.06	3.123	5.209	597.0
125.0	3.806	2.66	0.0801	389.2	651.9	22.22	3.122	5.202	665.5
150.0	3.178	3.18	0.0667	467.3	781.9	23.17	3.121	5.199	727.5
175.0	2.728	3.70	0.0571	545.3	911.9	23.97	3.120	5.197	784.7
200.0	2.389	4.22	0.0500	623.2	1042.0	24.66	3.119	5.195	837.9
225.0	2.126	4.73	0.0444	701.2	1172.0	25.27	3.119	5.195	888.0
250.0	1.914	5.25	0.0400	779.1	1301.0	25.82	3.119	5.194	935.3
275.0	1.741	5.77	0.0363	857.1	1431.0	26.31	3.118	5.194	980.4
300.0	1.597	6.29	0.0333	935.0	1561.0	26.77	3.118	5.193	1024.0
350.0	1.370	7.33	0.0286	1091.0	1821.0	27.57	3.118	5.193	1105.0
400.0	1.199	8.37	0.0250	1247.0	2080.0	28.26	3.118	5.193	1180.0
450.0	1.067	9.40	0.0222	1403.0	2340.0	28.87	3.118	5.193	1251.0
500.0	0.9603	10.4	0.0200	1558.0	2600.0	29.42	3.117	5.193	1319.0
600.0	0.8006	12.5	0.0167	1870.0	3119.0	30.37	3.117	5.193	1444.0
700.0	0.6865	14.6	0.0143	2182.0	3638.0	31.17	3.117	5.193	1559.0
800.0	0.6009	16.7	0.0125	2493.0	4158.0	31.86	3.117	5.193	1666.0
900.0	0.5342	18.7	0.0111	2805.0	4677.0	32.47	3.117	5.193	1767.0
1000.0	0.4809	20.8	0.0100	3116.0	5196.0	33.02	3.117	5.193	1862.0
1100.0	0.4372	22.9	0.00909	3428.0	5715.0	33.51	3.117	5.193	1953.0
1200.0	0.4008	25.0	0.00833	3740.0	6235.0	33.97	3.117	5.193	2040.0
1300.0	0.3700	27.0	0.00769	4051.0	6754.0	34.38	3.117	5.193	2123.0
1400.0	0.3436	29.1	0.00714	4363.0	7273.0	34.77	3.117	5.193	2203.0
1500.0	0.3207	31.2	0.00666	4675.0	7792.0	35.12	3.117	5.193	2280.0
				12.0 × 10^{+5} pascal Isobar					
* 2.043	163.6								
2.5	162.9	0.950	2.29	−11.08	−3.719	1.811	1.472	1.524	313.6
3.0	161.3	0.889	3.55	−10.38	−2.948	2.109	1.732	1.895	311.8
3.5	159.0	0.808	4.47	−9.530	−1.982	2.417	1.906	2.248	308.7
4.0	155.9	0.722	5.04	−8.515	−0.8168	2.733	2.044	2.625	304.4
4.5	152.0	0.634	5.30	−7.306	0.5885	3.063	2.205	3.069	297.0
5.0	147.3	0.547	5.29	−5.856	2.292	3.414	2.391	3.572	285.9
5.1	146.2	0.532	5.27	−5.531	2.675	3.487	2.428	3.674	283.7
5.2	145.1	0.519	5.25	−5.191	3.076	3.561	2.443	3.752	282.4
5.3	144.1	0.504	5.21	−4.873	3.453	3.632	2.421	3.795	281.1
5.4	143.1	0.489	5.17	−4.551	3.836	3.704	2.425	3.868	279.3
5.5	142.0	0.474	5.13	−4.224	4.226	3.776	2.431	3.946	277.3
5.6	140.9	0.459	5.08	−3.892	4.624	3.848	2.438	4.027	275.3
5.7	139.8	0.444	5.04	−3.554	5.031	3.920	2.446	4.112	273.3
5.8	138.6	0.430	4.98	−3.210	5.445	3.992	2.456	4.200	271.1
5.9	137.5	0.416	4.93	−2.860	5.869	4.065	2.466	4.293	268.9
6.0	136.3	0.402	4.87	−2.503	6.303	4.138	2.478	4.390	266.7
6.5	129.8	0.336	4.56	−0.6162	8.628	4.512	2.546	4.932	255.0
7.0	122.6	0.278	4.20	1.469	11.26	4.904	2.624	5.573	243.0
7.5	114.6	0.231	3.81	3.774	14.24	5.318	2.706	6.292	231.6
8.0	106.0	0.195	3.40	6.300	17.62	5.756	2.788	7.012	221.7
8.5	97.05	0.174	3.02	9.004	21.37	6.213	2.865	7.583	214.5
9.0	88.41	0.165	2.66	11.80	25.37	6.672	2.933	7.867	210.5
9.5	80.57	0.166	2.35	14.58	29.48	7.117	2.988	7.861	209.3
10.0	73.79	0.174	2.10	17.29	33.55	7.535	3.029	7.671	210.1

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
11.0	63.43	0.194	1.71	22.08	41.00	8.250	3.060	7.191	213.7
12.0	55.78	0.216	1.45	26.38	47.90	8.852	3.074	6.860	219.3
13.0	49.83	0.239	1.27	30.42	54.50	9.383	3.087	6.620	226.2
14.0	45.07	0.263	1.13	34.29	60.91	9.859	3.099	6.438	233.6
15.0	41.18	0.288	1.02	38.03	67.17	10.29	3.109	6.296	241.4
16.0	37.95	0.314	0.927	41.78	73.40	10.69	3.119	6.165	248.9
17.0	35.22	0.339	0.852	45.44	79.51	11.06	3.126	6.055	256.3
18.0	32.89	0.365	0.788	49.04	85.52	11.41	3.131	5.962	263.6
19.0	30.88	0.390	0.734	52.58	91.44	11.73	3.135	5.883	270.6
20.0	29.12	0.415	0.687	56.07	97.28	12.03	3.137	5.815	277.5
21.0	27.56	0.440	0.646	59.53	103.1	12.31	3.139	5.757	284.1
22.0	26.17	0.465	0.609	62.96	108.8	12.58	3.141	5.707	290.6
23.0	24.93	0.489	0.577	66.35	114.5	12.83	3.141	5.663	296.9
24.0	23.81	0.513	0.549	69.73	120.1	13.07	3.142	5.624	303.1
25.0	22.79	0.537	0.523	73.08	125.7	13.30	3.142	5.590	309.1
26.0	21.86	0.561	0.499	76.41	131.3	13.52	3.142	5.560	315.0
28.0	20.22	0.608	0.458	83.03	142.4	13.93	3.142	5.508	326.4
30.0	18.82	0.654	0.424	89.60	153.3	14.30	3.142	5.467	337.3
32.0	17.61	0.700	0.394	96.12	164.2	14.66	3.141	5.433	347.9
34.0	16.56	0.745	0.369	102.6	175.1	14.98	3.140	5.405	358.0
36.0	15.63	0.790	0.347	109.1	185.9	15.29	3.139	5.382	367.9
38.0	14.80	0.834	0.327	115.5	196.6	15.58	3.138	5.362	377.4
40.0	14.05	0.878	0.309	121.9	207.3	15.86	3.138	5.345	386.7
45.0	12.49	0.987	0.273	137.9	234.0	16.49	3.135	5.311	408.9
50.0	11.25	1.10	0.244	153.8	260.4	17.04	3.134	5.288	429.9
55.0	10.24	1.20	0.221	169.6	286.8	17.55	3.132	5.270	449.8
60.0	9.395	1.31	0.202	185.4	313.2	18.00	3.131	5.257	468.8
65.0	8.682	1.41	0.186	201.2	339.4	18.42	3.130	5.246	487.0
70.0	8.070	1.52	0.173	216.9	365.6	18.81	3.129	5.238	504.5
75.0	7.540	1.63	0.161	232.6	391.8	19.17	3.128	5.231	521.4
80.0	7.075	1.73	0.151	248.3	417.9	19.51	3.127	5.226	537.8
90.0	6.300	1.94	0.134	279.7	470.2	20.13	3.126	5.218	569.1
100.0	5.679	2.15	0.120	311.0	522.3	20.68	3.125	5.212	598.8
125.0	4.557	2.67	0.0961	389.2	652.5	21.84	3.123	5.204	667.0
150.0	3.806	3.19	0.0800	467.2	782.5	22.79	3.121	5.200	728.9
175.0	3.268	3.71	0.0686	545.3	912.5	23.59	3.121	5.197	785.9
200.0	2.863	4.23	0.0600	623.3	1042.0	24.28	3.120	5.196	839.1
225.0	2.548	4.75	0.0533	701.2	1172.0	24.89	3.120	5.195	889.0
250.0	2.295	5.27	0.0480	779.2	1302.0	25.44	3.119	5.194	936.4
275.0	2.088	5.78	0.0436	857.1	1432.0	25.94	3.119	5.194	981.4
300.0	1.915	6.30	0.0400	935.1	1562.0	26.39	3.119	5.193	1024.0
350.0	1.643	7.34	0.0343	1091.0	1821.0	27.19	3.118	5.193	1106.0
400.0	1.438	8.38	0.0300	1247.0	2081.0	27.88	3.118	5.193	1181.0
450.0	1.279	9.42	0.0267	1403.0	2341.0	28.49	3.118	5.193	1252.0
500.0	1.152	10.5	0.0240	1558.0	2600.0	29.04	3.118	5.193	1319.0
600.0	0.9604	12.5	0.0200	1870.0	3120.0	29.99	3.118	5.193	1444.0
700.0	0.8235	14.6	0.0171	2182.0	3639.0	30.79	3.117	5.193	1559.0
800.0	0.7208	16.7	0.0150	2493.0	4158.0	31.48	3.117	5.193	1667.0
900.0	0.6409	18.8	0.0133	2805.0	4677.0	32.09	3.117	5.193	1767.0
1000.0	0.5769	20.8	0.0120	3117.0	5197.0	32.64	3.117	5.193	1863.0
1100.0	0.5245	22.9	0.0109	3428.0	5716.0	33.14	3.117	5.193	1953.0
1200.0	0.4809	25.0	0.0100	3740.0	6235.0	33.59	3.117	5.193	2040.0
1300.0	0.4440	27.1	0.00923	4051.0	6754.0	34.00	3.117	5.193	2123.0
1400.0	0.4123	29.1	0.00857	4363.0	7274.0	34.39	3.117	5.193	2203.0
1500.0	0.3848	31.2	0.00800	4675.0	7793.0	34.75	3.117	5.193	2280.0

$14.0 \times 10^{+5}$ pascal Isobar

* 2.017 165.6

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
2.5	165.0	1.02	2.24	−11.04	−2.566	1.785	1.422	1.467	323.8
3.0	163.5	0.960	3.54	−10.38	−1.826	2.072	1.698	1.844	322.8
3.5	161.4	0.882	4.51	−9.569	−0.8950	2.371	1.872	2.182	320.7
4.0	158.5	0.798	5.15	−8.601	0.2310	2.677	2.012	2.540	317.4
4.5	154.9	0.712	5.45	−7.449	1.587	2.995	2.175	2.957	311.1
5.0	150.6	0.627	5.49	−6.069	3.224	3.332	2.363	3.422	301.2
5.1	149.7	0.612	5.47	−5.760	3.592	3.402	2.400	3.515	299.3
5.2	148.7	0.599	5.46	−5.437	3.976	3.472	2.416	3.584	298.2
5.3	147.8	0.584	5.43	−5.136	4.336	3.541	2.394	3.618	297.2
5.4	146.8	0.569	5.40	−4.832	4.700	3.609	2.398	3.681	295.6
5.5	145.9	0.554	5.37	−4.524	5.071	3.677	2.404	3.746	293.9
5.6	144.9	0.539	5.33	−4.212	5.449	3.745	2.411	3.815	292.1
5.7	143.9	0.525	5.29	−3.894	5.833	3.813	2.419	3.886	290.3
5.8	142.9	0.510	5.25	−3.572	6.224	3.882	2.429	3.960	288.4
5.9	141.9	0.496	5.20	−3.245	6.623	3.950	2.439	4.037	286.5
6.0	140.8	0.482	5.15	−2.913	7.030	4.019	2.451	4.117	284.5
6.5	135.2	0.415	4.88	−1.165	9.191	4.367	2.516	4.556	274.1
7.0	129.0	0.355	4.56	0.7393	11.59	4.725	2.590	5.059	263.3
7.5	122.2	0.303	4.22	2.816	14.27	5.097	2.665	5.617	252.7
8.0	115.0	0.261	3.86	5.072	17.25	5.484	2.740	6.203	242.9
8.5	107.3	0.229	3.50	7.494	20.54	5.885	2.812	6.758	234.6
9.0	99.5	0.209	3.15	10.05	24.12	6.296	2.878	7.196	228.5
9.5	91.96	0.199	2.83	12.67	27.90	6.707	2.936	7.448	224.8
10.0	84.98	0.198	2.54	15.30	31.78	7.106	2.984	7.507	223.2
11.0	73.36	0.212	2.08	20.35	39.43	7.841	3.040	7.208	224.4
12.0	64.75	0.231	1.76	24.83	46.46	8.455	3.063	6.893	228.2
13.0	58.01	0.251	1.53	28.97	53.10	8.989	3.078	6.676	233.3
14.0	52.56	0.272	1.36	32.91	59.55	9.468	3.091	6.510	239.5
15.0	48.05	0.295	1.22	36.73	65.87	9.904	3.103	6.377	246.3
16.0	44.26	0.320	1.11	40.55	72.18	10.31	3.115	6.251	253.4
17.0	41.07	0.345	1.02	44.29	78.38	10.69	3.124	6.140	260.4
18.0	38.34	0.370	0.939	47.95	84.47	11.04	3.131	6.045	267.4
19.0	35.97	0.395	0.872	51.55	90.47	11.36	3.135	5.962	274.2
20.0	33.91	0.420	0.815	55.10	96.39	11.66	3.139	5.890	280.9
21.0	32.08	0.445	0.766	58.61	102.3	11.95	3.141	5.828	287.4
22.0	30.45	0.470	0.722	62.08	108.1	12.22	3.143	5.773	293.8
23.0	29.00	0.494	0.683	65.52	113.8	12.48	3.144	5.724	300.0
24.0	27.68	0.519	0.648	68.93	119.5	12.72	3.145	5.682	306.1
25.0	26.49	0.543	0.617	72.32	125.2	12.95	3.145	5.644	312.1
26.0	25.41	0.567	0.589	75.69	130.8	13.17	3.146	5.610	317.9
28.0	23.49	0.614	0.540	82.37	142.0	13.58	3.146	5.553	329.2
30.0	21.87	0.661	0.499	88.98	153.0	13.96	3.145	5.507	340.1
32.0	20.46	0.707	0.463	95.55	164.0	14.32	3.144	5.469	350.6
34.0	19.23	0.752	0.433	102.1	174.9	14.65	3.144	5.437	360.7
36.0	18.15	0.797	0.407	108.6	185.7	14.96	3.143	5.410	370.5
38.0	17.18	0.842	0.383	115.1	196.5	15.25	3.142	5.387	380.0
40.0	16.32	0.887	0.363	121.5	207.3	15.53	3.141	5.368	389.2
45.0	14.51	1.00	0.320	137.5	234.0	16.16	3.139	5.330	411.3
50.0	13.07	1.11	0.286	153.5	260.6	16.72	3.136	5.302	432.2
55.0	11.89	1.21	0.259	169.4	287.1	17.22	3.135	5.282	452.0
60.0	10.92	1.32	0.236	185.2	313.4	17.68	3.133	5.267	470.9
65.0	10.09	1.43	0.218	201.0	339.7	18.10	3.132	5.255	489.1
70.0	9.380	1.53	0.202	216.7	366.0	18.49	3.131	5.245	506.6
75.0	8.765	1.64	0.188	232.5	392.2	18.85	3.130	5.238	523.4
80.0	8.227	1.74	0.176	248.2	418.4	19.19	3.129	5.231	539.7
90.0	7.328	1.95	0.156	279.6	470.6	19.81	3.127	5.222	570.9
100.0	6.607	2.16	0.140	310.9	522.8	20.36	3.126	5.216	600.5
125.0	5.304	2.68	0.112	389.1	653.1	21.52	3.124	5.206	668.6
150.0	4.432	3.20	0.0934	467.2	783.1	22.47	3.122	5.201	730.3
175.0	3.806	3.72	0.0800	545.3	913.1	23.27	3.121	5.198	787.2

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
200.0	3.335	4.24	0.0700	623.3	1043.0	23.96	3.121	5.196	840.2
225.0	2.968	4.76	0.0622	701.3	1173.0	24.57	3.120	5.195	890.1
250.0	2.674	5.28	0.0560	779.2	1303.0	25.12	3.120	5.194	937.4
275.0	2.433	5.80	0.0509	857.2	1433.0	25.62	3.119	5.194	982.3
300.0	2.232	6.32	0.0466	935.1	1562.0	26.07	3.119	5.193	1025.0
350.0	1.915	7.35	0.0400	1091.0	1822.0	26.87	3.119	5.193	1106.0
400.0	1.677	8.39	0.0350	1247.0	2082.0	27.56	3.119	5.193	1182.0
450.0	1.491	9.43	0.0311	1403.0	2341.0	28.17	3.118	5.193	1253.0
500.0	1.343	10.5	0.0280	1559.0	2601.0	28.72	3.118	5.193	1320.0
600.0	1.120	12.5	0.0233	1870.0	3120.0	29.67	3.118	5.193	1445.0
700.0	0.9604	14.6	0.0200	2182.0	3640.0	30.47	3.118	5.193	1560.0
800.0	0.8407	16.7	0.0175	2493.0	4159.0	31.16	3.118	5.193	1667.0
900.0	0.7475	18.8	0.0155	2805.0	4678.0	31.77	3.117	5.193	1768.0
1000.0	0.6729	20.8	0.0140	3117.0	5197.0	32.32	3.117	5.193	1863.0
1100.0	0.6119	22.9	0.0127	3428.0	5717.0	32.81	3.117	5.193	1954.0
1200.0	0.5610	25.0	0.0117	3740.0	6236.0	33.27	3.117	5.193	2040.0
1300.0	0.5179	27.1	0.0108	4052.0	6755.0	33.68	3.117	5.193	2123.0
1400.0	0.4809	29.1	0.0100	4363.0	7274.0	34.07	3.117	5.193	2203.0
1500.0	0.4489	31.2	0.00933	4675.0	7794.0	34.43	3.117	5.193	2280.0

$16.0 \times 10^{+5}$ pascal Isobar

2.0	167.6	1.08	0.885	−11.69	−2.156	1.414	2.397	2.402	328.5
2.5	166.9	1.08	2.20	−11.00	−1.420	1.761	1.377	1.418	333.3
3.0	165.6	1.03	3.52	−10.36	−0.7096	2.040	1.665	1.797	333.0
3.5	163.6	0.953	4.55	−9.589	0.1912	2.330	1.838	2.122	331.7
4.0	160.9	0.871	5.24	−8.662	1.282	2.626	1.980	2.467	329.4
4.5	157.6	0.786	5.58	−7.558	2.595	2.935	2.147	2.865	323.9
5.0	153.6	0.703	5.66	−6.235	4.180	3.260	2.338	3.303	315.1
5.1	152.7	0.688	5.65	−5.939	4.535	3.328	2.376	3.390	313.3
5.2	151.8	0.676	5.64	−5.630	4.906	3.395	2.392	3.453	312.4
5.3	151.0	0.661	5.62	−5.343	5.252	3.461	2.370	3.481	311.5
5.4	150.1	0.646	5.60	−5.053	5.603	3.526	2.375	3.536	310.1
5.5	149.3	0.631	5.57	−4.759	5.959	3.592	2.381	3.594	308.6
5.6	148.4	0.616	5.54	−4.462	6.320	3.657	2.388	3.654	307.0
5.7	147.5	0.602	5.50	−4.161	6.688	3.723	2.396	3.717	305.4
5.8	146.5	0.587	5.47	−3.855	7.062	3.788	2.406	3.782	303.7
5.9	145.6	0.573	5.43	−3.545	7.442	3.853	2.417	3.849	302.0
6.0	144.7	0.559	5.39	−3.231	7.829	3.919	2.428	3.918	300.2
6.5	139.6	0.491	5.15	−1.585	9.874	4.248	2.493	4.294	290.8
7.0	134.1	0.430	4.87	0.1917	12.12	4.583	2.565	4.714	281.0
7.5	128.2	0.375	4.56	2.113	14.59	4.927	2.638	5.173	271.1
8.0	121.9	0.328	4.24	4.184	17.31	5.281	2.709	5.658	261.7
8.5	115.2	0.290	3.90	6.400	20.29	5.645	2.776	6.144	253.2
9.0	108.3	0.261	3.57	8.747	23.53	6.017	2.839	6.587	246.1
9.5	101.3	0.242	3.25	11.19	26.98	6.393	2.896	6.936	240.9
10.0	94.60	0.232	2.96	13.70	30.61	6.767	2.946	7.153	237.6
11.0	82.59	0.234	2.45	18.71	38.08	7.485	3.014	7.138	235.4
12.0	73.13	0.250	2.07	23.38	45.26	8.114	3.050	6.894	237.5
13.0	65.74	0.267	1.79	27.64	51.98	8.654	3.069	6.684	241.3
14.0	59.73	0.286	1.59	31.64	58.43	9.134	3.083	6.537	246.2
15.0	54.70	0.306	1.43	35.51	64.76	9.571	3.097	6.421	252.0
16.0	50.43	0.329	1.29	39.40	71.12	9.98	3.111	6.306	258.4
17.0	46.80	0.353	1.18	43.19	77.38	10.36	3.122	6.202	265.0
18.0	43.69	0.378	1.09	46.91	83.53	10.71	3.130	6.109	271.6
19.0	40.99	0.402	1.01	50.56	89.60	11.04	3.135	6.026	278.1
20.0	38.63	0.427	0.947	54.16	95.59	11.35	3.140	5.953	284.6
21.0	36.54	0.452	0.888	57.72	101.5	11.64	3.143	5.888	290.9
22.0	34.68	0.476	0.836	61.23	107.4	11.91	3.145	5.830	297.2

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v	C_p	Velocity of sound m/s
							kJ/kg·K		
23.0	33.02	0.501	0.791	64.71	113.2	12.17	3.147	5.779	303.3
24.0	31.52	0.525	0.750	68.16	118.9	12.41	3.148	5.734	309.3
25.0	30.16	0.549	0.713	71.58	124.6	12.65	3.148	5.693	315.2
26.0	28.91	0.573	0.680	74.98	130.3	12.87	3.149	5.657	320.9
28.0	26.73	0.621	0.623	81.71	141.6	13.28	3.149	5.595	332.1
30.0	24.88	0.668	0.574	88.38	152.7	13.67	3.148	5.544	342.9
32.0	23.27	0.714	0.533	95.00	163.7	14.03	3.148	5.502	353.3
34.0	21.87	0.760	0.498	101.6	174.7	14.36	3.147	5.467	363.4
36.0	20.64	0.806	0.467	108.1	185.6	14.67	3.146	5.437	373.1
38.0	19.55	0.851	0.440	114.6	196.5	14.96	3.145	5.412	382.6
40.0	18.56	0.895	0.416	121.1	207.3	15.24	3.144	5.390	391.8
45.0	16.51	1.01	0.367	137.2	234.1	15.87	3.141	5.348	413.8
50.0	14.87	1.12	0.328	153.2	260.8	16.43	3.139	5.317	434.5
55.0	13.54	1.22	0.296	169.1	287.3	16.94	3.137	5.294	454.3
60.0	12.43	1.33	0.271	184.9	313.7	17.40	3.136	5.277	473.1
65.0	11.49	1.44	0.249	200.8	340.1	17.82	3.134	5.263	491.2
70.0	10.68	1.54	0.231	216.5	366.3	18.21	3.133	5.252	508.6
75.0	9.98	1.65	0.215	232.3	392.6	18.57	3.132	5.244	525.4
80.0	9.371	1.75	0.201	248.0	418.8	18.91	3.131	5.237	541.7
90.0	8.349	1.96	0.179	279.5	471.1	19.53	3.129	5.226	572.8
100.0	7.530	2.17	0.161	310.8	523.3	20.08	3.127	5.219	602.2
125.0	6.048	2.70	0.128	389.1	653.6	21.24	3.125	5.208	670.1
150.0	5.055	3.22	0.107	467.2	783.7	22.19	3.123	5.202	731.7
175.0	4.343	3.73	0.0914	545.3	913.7	22.99	3.122	5.199	788.5
200.0	3.806	4.25	0.0800	623.3	1044.0	23.68	3.121	5.197	841.4
225.0	3.388	4.77	0.0711	701.3	1174.0	24.30	3.121	5.195	891.2
250.0	3.053	5.29	0.0640	779.3	1303.0	24.84	3.120	5.195	938.4
275.0	2.778	5.81	0.0581	857.3	1433.0	25.34	3.120	5.194	983.3
300.0	2.548	6.33	0.0533	935.2	1563.0	25.79	3.120	5.194	1026.0
350.0	2.187	7.36	0.0457	1091.0	1823.0	26.59	3.119	5.193	1107.0
400.0	1.915	8.40	0.0400	1247.0	2082.0	27.29	3.119	5.193	1183.0
450.0	1.703	9.44	0.0355	1403.0	2342.0	27.90	3.119	5.193	1253.0
500.0	1.534	10.5	0.0320	1559.0	2602.0	28.44	3.118	5.193	1321.0
600.0	1.279	12.5	0.0266	1870.0	3121.0	29.39	3.118	5.192	1445.0
700.0	1.097	14.6	0.0228	2182.0	3640.0	30.19	3.118	5.192	1560.0
800.0	0.9605	16.7	0.0200	2494.0	4159.0	30.88	3.118	5.192	1667.0
900.0	0.8541	18.8	0.0178	2805.0	4679.0	31.50	3.118	5.192	1768.0
1000.0	0.7689	20.8	0.0160	3117.0	5198.0	32.04	3.118	5.193	1863.0
1100.0	0.6991	22.9	0.0145	3429.0	5717.0	32.54	3.117	5.193	1954.0
1200.0	0.6410	25.0	0.0133	3740.0	6236.0	32.99	3.117	5.193	2040.0
1300.0	0.5918	27.1	0.0123	4052.0	6756.0	33.41	3.117	5.193	2123.0
1400.0	0.5496	29.1	0.0114	4363.0	7275.0	33.79	3.117	5.193	2203.0
1500.0	0.5130	31.2	0.0107	4675.0	7794.0	34.15	3.117	5.193	2280.0
				18.0 × 10^{+5} pascal Isobar					
2.0	169.4	1.13	1.13	−11.58	−0.9689	1.414	2.172	2.180	336.2
2.5	168.7	1.14	2.18	−10.94	−0.2846	1.739	1.337	1.374	342.0
3.0	167.5	1.09	3.51	−10.33	0.4016	2.010	1.632	1.753	342.5
3.5	165.6	1.02	4.59	−9.593	1.274	2.292	1.805	2.068	342.1
4.0	163.1	0.941	5.32	−8.702	2.333	2.581	1.950	2.402	340.5
4.5	160.0	0.858	5.70	−7.641	3.610	2.881	2.120	2.786	335.8
5.0	156.3	0.776	5.81	−6.366	5.150	3.196	2.315	3.204	327.7
5.1	155.5	0.761	5.80	−6.081	5.495	3.261	2.353	3.287	326.1
5.2	154.7	0.749	5.80	−5.783	5.855	3.327	2.370	3.347	325.3
5.3	153.9	0.735	5.79	−5.507	6.191	3.390	2.349	3.369	324.6
5.4	153.1	0.720	5.77	−5.228	6.530	3.454	2.354	3.419	323.3
5.5	152.3	0.705	5.75	−4.947	6.874	3.517	2.360	3.472	322.0
5.6	151.4	0.690	5.72	−4.662	7.223	3.580	2.368	3.526	320.6

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
5.7	150.6	0.675	5.69	−4.373	7.577	3.643	2.377	3.583	319.1
5.8	149.8	0.661	5.66	−4.081	7.937	3.706	2.387	3.642	317.6
5.9	148.9	0.647	5.63	−3.785	8.303	3.769	2.397	3.702	316.0
6.0	148.0	0.633	5.59	−3.485	8.675	3.832	2.409	3.764	314.4
6.5	143.4	0.565	5.38	−1.919	10.63	4.147	2.474	4.097	305.8
7.0	138.5	0.502	5.13	−0.2370	12.76	4.466	2.545	4.464	296.6
7.5	133.1	0.445	4.85	1.570	15.09	4.789	2.617	4.858	287.4
8.0	127.5	0.395	4.56	3.506	17.63	5.120	2.686	5.273	278.4
8.5	121.5	0.352	4.25	5.571	20.38	5.457	2.751	5.696	270.1
9.0	115.3	0.318	3.93	7.755	23.36	5.800	2.812	6.104	262.8
9.5	109.0	0.292	3.63	10.04	26.56	6.148	2.867	6.466	256.7
10.0	102.7	0.275	3.33	12.41	29.93	6.497	2.916	6.751	252.2
11.0	90.86	0.263	2.80	17.31	37.12	7.188	2.992	6.958	247.1
12.0	80.97	0.270	2.38	22.00	44.23	7.812	3.034	6.854	247.1
13.0	73.01	0.286	2.06	26.39	51.04	8.360	3.059	6.673	249.7
14.0	66.53	0.303	1.82	30.48	57.53	8.843	3.076	6.533	253.5
15.0	61.09	0.320	1.63	34.38	63.85	9.279	3.090	6.434	258.2
16.0	56.39	0.342	1.48	38.31	70.23	9.692	3.106	6.335	263.9
17.0	52.38	0.364	1.35	42.15	76.52	10.07	3.119	6.241	270.0
18.0	48.92	0.388	1.25	45.92	82.72	10.43	3.128	6.154	276.2
19.0	45.90	0.412	1.16	49.62	88.83	10.76	3.135	6.074	282.4
20.0	43.26	0.436	1.08	53.26	94.87	11.07	3.140	6.002	288.6
21.0	40.93	0.460	1.01	56.86	100.8	11.36	3.144	5.937	294.7
22.0	38.85	0.484	0.953	60.41	106.7	11.63	3.146	5.879	300.8
23.0	36.98	0.509	0.900	63.92	112.6	11.89	3.148	5.827	306.8
24.0	35.30	0.533	0.853	67.40	118.4	12.14	3.150	5.779	312.6
25.0	33.77	0.557	0.811	70.86	124.2	12.38	3.151	5.737	318.4
26.0	32.38	0.581	0.772	74.28	129.9	12.60	3.151	5.699	324.1
28.0	29.94	0.629	0.706	81.07	141.2	13.02	3.152	5.633	335.1
30.0	27.85	0.676	0.651	87.79	152.4	13.41	3.152	5.578	345.8
32.0	26.06	0.722	0.604	94.45	163.5	13.76	3.151	5.533	356.1
34.0	24.49	0.768	0.564	101.1	174.5	14.10	3.150	5.495	366.1
36.0	23.11	0.814	0.529	107.6	185.5	14.41	3.149	5.463	375.8
38.0	21.88	0.859	0.498	114.2	196.4	14.71	3.148	5.435	385.2
40.0	20.79	0.904	0.470	120.7	207.2	14.98	3.147	5.412	394.3
45.0	18.49	1.02	0.414	136.8	234.2	15.62	3.144	5.365	416.2
50.0	16.66	1.13	0.370	152.9	260.9	16.18	3.142	5.331	436.9
55.0	15.16	1.23	0.334	168.8	287.5	16.69	3.140	5.306	456.5
60.0	13.92	1.34	0.305	184.7	314.0	17.15	3.138	5.287	475.3
65.0	12.87	1.45	0.281	200.6	340.4	17.57	3.136	5.272	493.3
70.0	11.97	1.55	0.260	216.4	366.7	17.96	3.135	5.260	510.6
75.0	11.19	1.66	0.242	232.1	393.0	18.33	3.133	5.250	527.4
80.0	10.51	1.77	0.227	247.9	419.2	18.66	3.132	5.242	543.6
90.0	9.364	1.98	0.201	279.3	471.6	19.28	3.130	5.230	574.6
100.0	8.447	2.19	0.181	310.7	523.8	19.83	3.129	5.222	603.9
125.0	6.789	2.71	0.144	389.0	654.2	21.00	3.126	5.209	671.6
150.0	5.676	3.23	0.120	467.2	784.3	21.94	3.124	5.203	733.1
175.0	4.877	3.75	0.103	545.3	914.4	22.75	3.123	5.199	789.7
200.0	4.276	4.27	0.0899	623.3	1044.0	23.44	3.122	5.197	842.6
225.0	3.807	4.78	0.0799	701.4	1174.0	24.05	3.122	5.196	892.3
250.0	3.430	5.30	0.0719	779.3	1304.0	24.60	3.121	5.195	939.4
275.0	3.122	5.82	0.0654	857.3	1434.0	25.09	3.121	5.194	984.2
300.0	2.864	6.34	0.0599	935.3	1564.0	25.55	3.120	5.194	1027.0
350.0	2.458	7.38	0.0514	1091.0	1823.0	26.35	3.120	5.193	1108.0
400.0	2.153	8.41	0.0450	1247.0	2083.0	27.04	3.119	5.193	1183.0
450.0	1.915	9.45	0.0400	1403.0	2343.0	27.65	3.119	5.193	1254.0
500.0	1.725	10.5	0.0360	1559.0	2602.0	28.20	3.119	5.192	1321.0
600.0	1.439	12.6	0.0300	1870.0	3122.0	29.15	3.118	5.192	1446.0
700.0	1.234	14.6	0.0257	2182.0	3641.0	29.95	3.118	5.192	1561.0
800.0	1.080	16.7	0.0225	2494.0	4160.0	30.64	3.118	5.192	1668.0

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
900.0	0.9606	18.8	0.0200	2805.0	4679.0	31.25	3.118	5.192	1768.0
1000.0	0.8648	20.9	0.0180	3117.0	5198.0	31.80	3.118	5.192	1864.0
1100.0	0.7864	22.9	0.0164	3429.0	5718.0	32.29	3.118	5.192	1954.0
1200.0	0.7210	25.0	0.0150	3740.0	6237.0	32.75	3.118	5.193	2041.0
1300.0	0.6656	27.1	0.0138	4052.0	6756.0	33.16	3.118	5.193	2124.0
1400.0	0.6182	29.2	0.0129	4364.0	7275.0	33.55	3.117	5.193	2204.0
1500.0	0.5770	31.2	0.0120	4675.0	7795.0	33.90	3.117	5.193	2281.0
				$20.0 \times 10^{+5}$ pascal Isobar					
2.0	171.2	1.17	1.43	−11.47	0.2027	1.413	1.977	1.989	343.2
2.5	170.5	1.20	2.18	−10.88	0.8436	1.718	1.301	1.335	350.2
3.0	169.3	1.15	3.51	−10.29	1.507	1.982	1.600	1.712	351.4
3.5	167.5	1.09	4.63	−9.583	2.353	2.257	1.772	2.018	351.8
4.0	165.1	1.01	5.39	−8.726	3.383	2.538	1.921	2.343	350.9
4.5	162.2	0.928	5.81	−7.702	4.628	2.831	2.095	2.717	346.8
5.0	158.7	0.847	5.94	−6.469	6.130	3.138	2.294	3.121	339.4
5.1	158.0	0.832	5.94	−6.192	6.467	3.202	2.332	3.200	337.9
5.2	157.2	0.820	5.95	−5.904	6.818	3.265	2.350	3.257	337.2
5.3	156.5	0.806	5.94	−5.637	7.144	3.327	2.329	3.276	336.6
5.4	155.7	0.791	5.92	−5.369	7.474	3.389	2.335	3.323	335.5
5.5	155.0	0.776	5.91	−5.097	7.808	3.450	2.341	3.371	334.2
5.6	154.2	0.761	5.89	−4.823	8.146	3.512	2.350	3.422	333.0
5.7	153.4	0.747	5.86	−4.545	8.490	3.573	2.359	3.474	331.6
5.8	152.6	0.732	5.84	−4.264	8.839	3.634	2.369	3.528	330.2
5.9	151.8	0.718	5.81	−3.979	9.193	3.694	2.380	3.583	328.8
6.0	151.0	0.704	5.78	−3.690	9.553	3.755	2.392	3.640	327.3
6.5	146.8	0.636	5.59	−2.188	11.44	4.059	2.458	3.943	319.3
7.0	142.2	0.572	5.37	−0.5822	13.48	4.365	2.530	4.272	310.8
7.5	137.3	0.514	5.11	1.137	15.70	4.673	2.601	4.621	302.1
8.0	132.2	0.461	4.83	2.970	18.10	4.986	2.669	4.986	293.6
8.5	126.8	0.416	4.54	4.918	20.69	5.303	2.732	5.359	285.5
9.0	121.2	0.377	4.25	6.975	23.48	5.625	2.791	5.728	278.1
9.5	115.4	0.346	3.96	9.133	26.46	5.951	2.845	6.075	271.7
10.0	109.6	0.322	3.67	11.37	29.63	6.277	2.894	6.376	266.5
11.0	98.17	0.297	3.12	16.12	36.50	6.939	2.973	6.720	259.2
12.0	88.17	0.296	2.67	20.78	43.47	7.551	3.020	6.751	257.1
13.0	79.84	0.306	2.32	25.21	50.26	8.099	3.049	6.640	258.2
14.0	72.96	0.321	2.05	29.39	56.80	8.586	3.069	6.513	261.1
15.0	67.19	0.337	1.84	33.34	63.11	9.022	3.084	6.423	264.8
16.0	62.13	0.356	1.67	37.30	69.49	9.434	3.102	6.342	269.9
17.0	57.77	0.377	1.53	41.18	75.79	9.816	3.115	6.261	275.4
18.0	54.00	0.400	1.41	44.98	82.02	10.17	3.126	6.183	281.1
19.0	50.70	0.423	1.30	48.72	88.16	10.50	3.134	6.109	287.0
20.0	47.80	0.446	1.22	52.40	94.24	10.82	3.140	6.040	292.9
21.0	45.23	0.470	1.14	56.03	100.2	11.11	3.144	5.977	298.8
22.0	42.94	0.494	1.07	59.61	106.2	11.39	3.148	5.919	304.6
23.0	40.88	0.517	1.01	63.16	112.1	11.65	3.150	5.866	310.4
24.0	39.02	0.541	0.957	66.67	117.9	11.90	3.152	5.819	316.2
25.0	37.34	0.565	0.909	70.15	123.7	12.13	3.153	5.775	321.8
26.0	35.80	0.589	0.866	73.61	129.5	12.36	3.154	5.736	327.4
28.0	33.10	0.637	0.791	80.45	140.9	12.78	3.154	5.667	338.3
30.0	30.80	0.684	0.729	87.21	152.2	13.17	3.154	5.610	348.8
32.0	28.81	0.731	0.676	93.91	163.3	13.53	3.154	5.562	359.0
34.0	27.08	0.777	0.630	100.6	174.4	13.87	3.153	5.522	368.9
36.0	25.55	0.823	0.590	107.2	185.4	14.18	3.152	5.487	378.5
38.0	24.20	0.868	0.556	113.7	196.4	14.48	3.151	5.458	387.8
40.0	22.99	0.914	0.525	120.2	207.2	14.76	3.150	5.432	396.9
45.0	20.45	1.03	0.461	136.5	234.3	15.39	3.147	5.382	418.7

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
50.0	18.43	1.14	0.412	152.5	261.1	15.96	3.145	5.345	439.2
55.0	16.78	1.24	0.372	168.5	287.7	16.47	3.142	5.317	458.8
60.0	15.41	1.35	0.340	184.5	314.3	16.93	3.140	5.296	477.5
65.0	14.25	1.46	0.312	200.3	340.7	17.35	3.138	5.280	495.4
70.0	13.25	1.57	0.289	216.2	367.1	17.74	3.137	5.267	512.7
75.0	12.39	1.67	0.269	232.0	393.4	18.10	3.135	5.256	529.4
80.0	11.64	1.78	0.252	247.8	419.6	18.44	3.134	5.247	545.5
90.0	10.37	1.99	0.224	279.2	472.0	19.06	3.132	5.234	576.4
100.0	9.360	2.20	0.201	310.6	524.3	19.61	3.130	5.225	605.6
125.0	7.526	2.72	0.160	389.0	654.8	20.78	3.127	5.211	673.2
150.0	6.294	3.24	0.133	467.2	784.9	21.73	3.125	5.204	734.4
175.0	5.410	3.76	0.114	545.3	915.0	22.53	3.124	5.200	791.0
200.0	4.744	4.28	0.100	623.4	1045.0	23.22	3.123	5.198	843.7
225.0	4.224	4.80	0.0888	701.4	1175.0	23.83	3.122	5.196	893.4
250.0	3.807	5.31	0.0799	779.4	1305.0	24.38	3.122	5.195	940.4
275.0	3.465	5.83	0.0727	857.4	1435.0	24.88	3.121	5.194	985.2
300.0	3.179	6.35	0.0666	935.3	1564.0	25.33	3.121	5.194	1028.0
350.0	2.729	7.39	0.0571	1091.0	1824.0	26.13	3.120	5.193	1109.0
400.0	2.391	8.42	0.0499	1247.0	2084.0	26.82	3.120	5.193	1184.0
450.0	2.127	9.46	0.0444	1403.0	2343.0	27.43	3.119	5.192	1255.0
500.0	1.915	10.5	0.0400	1559.0	2603.0	27.98	3.119	5.192	1322.0
600.0	1.598	12.6	0.0333	1871.0	3122.0	28.93	3.119	5.192	1447.0
700.0	1.371	14.6	0.0285	2182.0	3641.0	29.73	3.118	5.192	1561.0
800.0	1.200	16.7	0.0250	2494.0	4161.0	30.42	3.118	5.192	1668.0
900.0	1.067	18.8	0.0222	2806.0	4680.0	31.03	3.118	5.192	1769.0
1000.0	0.9607	20.9	0.0200	3117.0	5199.0	31.58	3.118	5.192	1864.0
1100.0	0.8736	22.9	0.0182	3429.0	5718.0	32.07	3.118	5.192	1954.0
1200.0	0.8009	25.0	0.0167	3740.0	6238.0	32.53	3.118	5.192	2041.0
1300.0	0.7395	27.1	0.0154	4052.0	6757.0	32.94	3.118	5.192	2124.0
1400.0	0.6867	29.2	0.0143	4364.0	7276.0	33.33	3.118	5.192	2204.0
1500.0	0.6410	31.2	0.0133	4675.0	7795.0	33.68	3.118	5.193	2281.0
				25.0 × 10^{+5} pascal Isobar					
2.0	175.3	1.27	2.45	−11.19	3.065	1.401	1.606	1.637	359.2
2.5	174.5	1.32	2.97	−10.69	3.627	1.673	1.229	1.261	368.5
3.0	173.5	1.30	3.55	−10.16	4.241	1.922	1.526	1.622	371.6
3.5	171.9	1.24	4.73	−9.514	5.031	2.181	1.695	1.909	373.8
4.0	169.7	1.17	5.57	−8.730	5.998	2.446	1.852	2.220	374.4
4.5	167.1	1.09	6.04	−7.783	7.176	2.723	2.038	2.576	371.5
5.0	164.1	1.01	6.23	−6.634	8.602	3.014	2.246	2.957	365.3
5.1	163.4	1.00	6.24	−6.376	8.922	3.073	2.286	3.031	364.0
5.2	162.7	0.989	6.26	−6.106	9.255	3.133	2.305	3.083	363.6
5.3	162.1	0.974	6.26	−5.858	9.564	3.192	2.286	3.097	363.3
5.4	161.4	0.960	6.25	−5.608	9.875	3.250	2.293	3.137	362.3
5.5	160.8	0.945	6.25	−5.356	10.19	3.308	2.301	3.179	361.3
5.6	160.1	0.930	6.24	−5.102	10.51	3.366	2.310	3.223	360.3
5.7	159.5	0.916	6.22	−4.845	10.83	3.423	2.321	3.268	359.1
5.8	158.8	0.902	6.20	−4.584	11.16	3.481	2.332	3.315	358.0
5.9	158.1	0.887	6.19	−4.321	11.49	3.538	2.344	3.362	356.7
6.0	157.4	0.873	6.16	−4.055	11.83	3.595	2.357	3.411	355.5
6.5	153.7	0.805	6.02	−2.673	13.59	3.878	2.427	3.667	348.7
7.0	149.9	0.740	5.84	−1.202	15.48	4.161	2.500	3.938	341.3
7.5	145.8	0.679	5.63	0.3588	17.50	4.444	2.571	4.220	333.7
8.0	141.5	0.623	5.40	2.014	19.68	4.727	2.639	4.509	326.2
8.5	137.1	0.572	5.15	3.762	22.00	5.012	2.701	4.803	318.8
9.0	132.5	0.526	4.90	5.600	24.47	5.298	2.759	5.097	311.8
9.5	127.7	0.487	4.64	7.523	27.10	5.585	2.811	5.385	305.3
10.0	122.8	0.453	4.38	9.526	29.88	5.873	2.858	5.660	299.5

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
11.0	112.9	0.403	3.84	13.90	36.05	6.469	2.940	6.111	289.2
12.0	103.4	0.378	3.36	18.37	42.55	7.040	2.994	6.358	283.2
13.0	94.84	0.372	2.96	22.77	49.13	7.572	3.028	6.423	280.8
14.0	87.43	0.377	2.62	27.02	55.61	8.056	3.053	6.391	281.0
15.0	81.06	0.387	2.35	31.09	61.93	8.494	3.071	6.331	282.6
16.0	75.37	0.402	2.14	35.08	68.25	8.901	3.091	6.296	286.0
17.0	70.38	0.418	1.96	39.00	74.52	9.282	3.108	6.250	290.1
18.0	65.98	0.437	1.80	42.86	80.75	9.638	3.120	6.198	294.6
19.0	62.10	0.457	1.67	46.66	86.92	9.97	3.131	6.143	299.5
20.0	58.65	0.478	1.56	50.40	93.03	10.28	3.138	6.089	304.5
21.0	55.56	0.500	1.46	54.10	99.09	10.58	3.144	6.035	309.7
22.0	52.80	0.522	1.37	57.75	105.1	10.86	3.149	5.984	315.0
23.0	50.30	0.545	1.29	61.37	111.1	11.13	3.153	5.936	320.3
24.0	48.05	0.568	1.22	64.94	117.0	11.38	3.155	5.890	325.6
25.0	45.99	0.591	1.16	68.49	122.8	11.62	3.157	5.848	330.9
26.0	44.11	0.614	1.10	72.00	128.7	11.84	3.159	5.809	336.1
28.0	40.81	0.661	1.01	78.95	140.2	12.27	3.160	5.738	346.5
30.0	37.98	0.708	0.926	85.81	151.6	12.67	3.161	5.677	356.6
32.0	35.55	0.755	0.857	92.60	162.9	13.03	3.161	5.625	366.5
34.0	33.42	0.801	0.798	99.33	174.1	13.37	3.160	5.581	376.1
36.0	31.54	0.847	0.747	106.0	185.3	13.69	3.159	5.542	385.4
38.0	29.88	0.893	0.702	112.6	196.3	13.99	3.158	5.508	394.6
40.0	28.39	0.938	0.663	119.2	207.3	14.27	3.157	5.479	403.5
45.0	25.26	1.05	0.581	135.6	234.5	14.91	3.154	5.421	424.9
50.0	22.78	1.16	0.518	151.8	261.5	15.48	3.151	5.377	445.2
55.0	20.76	1.27	0.468	167.9	288.3	15.99	3.148	5.345	464.5
60.0	19.07	1.38	0.426	183.9	315.0	16.45	3.146	5.320	483.0
65.0	17.64	1.49	0.392	199.8	341.5	16.88	3.144	5.300	500.7
70.0	16.42	1.59	0.363	215.7	368.0	17.27	3.142	5.284	517.8
75.0	15.36	1.70	0.338	231.6	394.4	17.64	3.140	5.271	534.3
80.0	14.43	1.81	0.316	247.4	420.7	17.98	3.139	5.260	550.3
90.0	12.87	2.02	0.280	279.0	473.2	18.59	3.136	5.244	580.9
100.0	11.62	2.23	0.251	310.4	525.6	19.15	3.134	5.233	609.9
125.0	9.354	2.75	0.200	388.9	656.2	20.31	3.130	5.216	677.0
150.0	7.830	3.27	0.167	467.2	786.5	21.26	3.128	5.207	737.9
175.0	6.735	3.79	0.143	545.3	916.6	22.06	3.126	5.202	794.1
200.0	5.909	4.31	0.125	623.4	1047.0	22.76	3.125	5.199	846.6
225.0	5.263	4.83	0.111	701.5	1176.0	23.37	3.124	5.197	896.0
250.0	4.745	5.34	0.100	779.5	1306.0	23.92	3.123	5.195	942.9
275.0	4.320	5.86	0.0908	857.5	1436.0	24.41	3.122	5.194	987.5
300.0	3.964	6.38	0.0832	935.5	1566.0	24.87	3.122	5.194	1030.0
350.0	3.404	7.42	0.0713	1091.0	1826.0	25.67	3.121	5.193	1111.0
400.0	2.983	8.45	0.0624	1247.0	2085.0	26.36	3.121	5.193	1186.0
450.0	2.655	9.49	0.0555	1403.0	2345.0	26.97	3.120	5.192	1256.0
500.0	2.391	10.5	0.0499	1559.0	2605.0	27.52	3.120	5.192	1323.0
600.0	1.995	12.6	0.0416	1871.0	3124.0	28.46	3.119	5.192	1448.0
700.0	1.712	14.7	0.0357	2183.0	3643.0	29.26	3.119	5.192	1563.0
800.0	1.499	16.7	0.0312	2494.0	4162.0	29.96	3.119	5.192	1669.0
900.0	1.333	18.8	0.0278	2806.0	4681.0	30.57	3.119	5.192	1770.0
1000.0	1.200	20.9	0.0250	3118.0	5201.0	31.12	3.118	5.192	1865.0
1100.0	1.091	23.0	0.0227	3429.0	5720.0	31.61	3.118	5.192	1955.0
1200.0	1.001	25.0	0.0208	3741.0	6239.0	32.06	3.118	5.192	2042.0
1300.0	0.9240	27.1	0.0192	4053.0	6758.0	32.48	3.118	5.192	2125.0
1400.0	0.8581	29.2	0.0178	4364.0	7278.0	32.86	3.118	5.192	2204.0
1500.0	0.8011	31.3	0.0167	4676.0	7797.0	33.22	3.118	5.192	2281.0
				30.0 × 10^{+5} pascal Isobar					
2.0	179.2	1.34	3.92	−10.90	5.835	1.376	1.385	1.457	375.0

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
2.5	178.2	1.44	2.52	−10.47	6.356	1.630	1.183	1.218	384.6
3.0	177.2	1.43	3.65	−9.99	6.934	1.869	1.459	1.548	389.5
3.5	175.7	1.38	4.86	−9.397	7.675	2.114	1.624	1.817	393.4
4.0	173.7	1.32	5.73	−8.673	8.592	2.367	1.789	2.119	395.2
4.5	171.4	1.25	6.25	−7.789	9.716	2.631	1.986	2.466	393.3
5.0	168.6	1.17	6.47	−6.706	11.08	2.909	2.204	2.833	387.9
5.1	168.0	1.16	6.49	−6.462	11.39	2.966	2.246	2.904	386.8
5.2	167.4	1.15	6.51	−6.206	11.71	3.023	2.266	2.953	386.4
5.3	166.8	1.13	6.52	−5.972	12.01	3.079	2.249	2.964	386.3
5.4	166.3	1.12	6.53	−5.736	12.31	3.135	2.257	3.001	385.5
5.5	165.7	1.10	6.52	−5.499	12.61	3.191	2.267	3.040	384.6
5.6	165.1	1.09	6.52	−5.259	12.91	3.246	2.278	3.080	383.7
5.7	164.5	1.07	6.51	−5.017	13.22	3.301	2.289	3.121	382.7
5.8	163.9	1.06	6.50	−4.772	13.53	3.355	2.302	3.163	381.7
5.9	163.3	1.05	6.49	−4.525	13.85	3.410	2.315	3.206	380.7
6.0	162.6	1.03	6.48	−4.274	14.17	3.464	2.329	3.250	379.6
6.5	159.4	0.963	6.37	−2.977	15.84	3.734	2.402	3.479	373.5
7.0	156.0	0.898	6.22	−1.602	17.63	4.001	2.478	3.719	367.0
7.5	152.5	0.835	6.05	−0.1460	19.53	4.267	2.551	3.963	360.2
8.0	148.8	0.777	5.85	1.392	21.56	4.533	2.619	4.211	353.4
8.5	144.9	0.723	5.63	3.010	23.71	4.797	2.682	4.459	346.7
9.0	140.9	0.673	5.41	4.707	26.00	5.061	2.739	4.707	340.2
9.5	136.8	0.629	5.17	6.478	28.41	5.325	2.790	4.952	334.0
10.0	132.6	0.589	4.94	8.320	30.94	5.589	2.837	5.191	328.2
11.0	123.9	0.522	4.44	12.40	36.62	6.136	2.922	5.625	317.0
12.0	115.3	0.478	3.96	16.65	42.67	6.669	2.978	5.944	308.8
13.0	107.1	0.455	3.53	20.93	48.94	7.176	3.016	6.125	303.9
14.0	99.7	0.447	3.16	25.16	55.26	7.649	3.042	6.189	301.7
15.0	93.05	0.450	2.85	29.27	61.51	8.083	3.062	6.186	301.4
16.0	87.05	0.457	2.60	33.24	67.71	8.483	3.084	6.196	303.1
17.0	81.68	0.469	2.38	37.17	73.90	8.858	3.101	6.184	305.8
18.0	76.87	0.484	2.20	41.04	80.07	9.211	3.116	6.159	309.2
19.0	72.57	0.500	2.04	44.87	86.21	9.543	3.127	6.126	313.0
20.0	68.70	0.518	1.90	48.65	92.32	9.856	3.136	6.089	317.2
21.0	65.22	0.538	1.78	52.39	98.39	10.15	3.144	6.049	321.7
22.0	62.07	0.558	1.67	56.09	104.4	10.43	3.149	6.009	326.3
23.0	59.21	0.579	1.58	59.74	110.4	10.70	3.154	5.968	331.0
24.0	56.61	0.601	1.49	63.36	116.4	10.95	3.157	5.929	335.8
25.0	54.24	0.623	1.41	66.95	122.3	11.19	3.160	5.891	340.7
26.0	52.06	0.645	1.35	70.51	128.1	11.42	3.162	5.855	345.5
28.0	48.21	0.690	1.23	77.55	139.8	11.86	3.165	5.788	355.2
30.0	44.91	0.736	1.13	84.50	151.3	12.25	3.166	5.728	364.8
32.0	42.06	0.782	1.04	91.37	162.7	12.62	3.166	5.675	374.3
34.0	39.56	0.828	0.969	98.17	174.0	12.96	3.166	5.629	383.6
36.0	37.36	0.874	0.906	104.9	185.2	13.28	3.165	5.588	392.7
38.0	35.40	0.919	0.851	111.6	196.4	13.58	3.164	5.552	401.6
40.0	33.65	0.965	0.802	118.3	207.4	13.87	3.163	5.520	410.3
45.0	29.96	1.08	0.702	134.7	234.9	14.51	3.160	5.456	431.3
50.0	27.04	1.19	0.625	151.0	262.0	15.09	3.157	5.407	451.2
55.0	24.65	1.30	0.564	167.2	288.9	15.60	3.154	5.370	470.2
60.0	22.66	1.41	0.514	183.3	315.7	16.07	3.151	5.341	488.5
65.0	20.97	1.52	0.472	199.3	342.4	16.49	3.149	5.319	506.0
70.0	19.53	1.62	0.436	215.3	368.9	16.89	3.147	5.300	522.9
75.0	18.27	1.73	0.406	231.2	395.4	17.25	3.145	5.285	539.3
80.0	17.17	1.84	0.380	247.0	421.8	17.59	3.143	5.273	555.1
90.0	15.33	2.05	0.336	278.7	474.4	18.21	3.140	5.254	585.4
100.0	13.85	2.26	0.302	310.2	526.9	18.77	3.137	5.241	614.2
125.0	11.16	2.78	0.241	388.8	657.6	19.93	3.133	5.220	680.8
150.0	9.352	3.30	0.200	467.2	788.0	20.88	3.130	5.210	741.3
175.0	8.049	3.82	0.171	545.4	918.1	21.69	3.128	5.203	797.2

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
200.0	7.065	4.34	0.150	623.5	1048.0	22.38	3.126	5.200	849.5
225.0	6.296	4.86	0.133	701.6	1178.0	22.99	3.125	5.197	898.7
250.0	5.678	5.38	0.120	779.6	1308.0	23.54	3.124	5.196	945.4
275.0	5.170	5.89	0.109	857.7	1438.0	24.03	3.124	5.195	989.9
300.0	4.746	6.41	0.100	935.7	1568.0	24.49	3.123	5.194	1032.0
350.0	4.077	7.45	0.0856	1092.0	1827.0	25.29	3.122	5.193	1113.0
400.0	3.574	8.48	0.0749	1248.0	2087.0	25.98	3.122	5.192	1188.0
450.0	3.181	9.52	0.0666	1403.0	2347.0	26.59	3.121	5.192	1258.0
500.0	2.866	10.6	0.0599	1559.0	2606.0	27.14	3.121	5.192	1325.0
600.0	2.392	12.6	0.0499	1871.0	3125.0	28.09	3.120	5.192	1449.0
700.0	2.052	14.7	0.0428	2183.0	3645.0	28.89	3.120	5.192	1564.0
800.0	1.797	16.8	0.0375	2495.0	4164.0	29.58	3.119	5.192	1670.0
900.0	1.599	18.8	0.0333	2806.0	4683.0	30.19	3.119	5.192	1771.0
1000.0	1.439	20.9	0.0300	3118.0	5202.0	30.74	3.119	5.192	1866.0
1100.0	1.309	23.0	0.0272	3430.0	5721.0	31.23	3.119	5.192	1956.0
1200.0	1.200	25.1	0.0250	3741.0	6241.0	31.68	3.119	5.192	2042.0
1300.0	1.108	27.1	0.0231	4053.0	6760.0	32.10	3.119	5.192	2125.0
1400.0	1.029	29.2	0.0214	4365.0	7279.0	32.49	3.119	5.192	2205.0
1500.0	0.9610	31.3	0.0200	4676.0	7798.0	32.84	3.118	5.192	2282.0
				$35.0 \times 10^{+5}$ pascal Isobar					
2.5	181.6	1.54	2.94	−10.23	9.033	1.589	1.164	1.207	399.0
3.0	180.6	1.55	3.83	−9.795	9.585	1.821	1.401	1.488	405.8
3.5	179.2	1.52	5.01	−9.246	10.29	2.055	1.559	1.739	411.2
4.0	177.3	1.46	5.90	−8.575	11.16	2.297	1.731	2.035	414.0
4.5	175.1	1.39	6.44	−7.743	12.24	2.550	1.939	2.376	412.8
5.0	172.6	1.32	6.69	−6.713	13.56	2.819	2.167	2.736	408.0
5.1	172.1	1.31	6.71	−6.480	13.86	2.874	2.210	2.805	407.0
5.2	171.5	1.30	6.74	−6.234	14.17	2.929	2.233	2.852	406.7
5.3	171.0	1.28	6.75	−6.012	14.46	2.983	2.217	2.861	406.7
5.4	170.5	1.27	6.76	−5.788	14.74	3.037	2.226	2.896	406.0
5.5	169.9	1.25	6.76	−5.562	15.03	3.090	2.237	2.932	405.3
5.6	169.4	1.24	6.76	−5.334	15.33	3.143	2.249	2.970	404.5
5.7	168.8	1.22	6.76	−5.104	15.63	3.196	2.262	3.008	403.6
5.8	168.3	1.21	6.76	−4.871	15.93	3.249	2.275	3.048	402.7
5.9	167.7	1.20	6.75	−4.635	16.23	3.302	2.290	3.088	401.7
6.0	167.2	1.18	6.74	−4.397	16.54	3.354	2.304	3.129	400.7
6.5	164.2	1.11	6.66	−3.165	18.14	3.613	2.382	3.341	395.3
7.0	161.2	1.05	6.54	−1.861	19.85	3.869	2.460	3.559	389.4
7.5	158.0	0.985	6.39	−0.4831	21.67	4.123	2.535	3.780	383.2
8.0	154.7	0.925	6.22	0.9696	23.60	4.376	2.604	4.002	376.9
8.5	151.2	0.868	6.03	2.495	25.64	4.626	2.667	4.223	370.8
9.0	147.7	0.816	5.83	4.090	27.79	4.876	2.725	4.442	364.7
9.5	144.1	0.768	5.62	5.754	30.05	5.124	2.777	4.658	358.9
10.0	140.3	0.724	5.40	7.481	32.42	5.371	2.824	4.869	353.4
11.0	132.6	0.646	4.93	11.35	37.74	5.885	2.910	5.265	342.0
12.0	124.8	0.588	4.48	15.40	43.44	6.387	2.968	5.593	332.9
13.0	117.2	0.550	4.05	19.54	49.41	6.870	3.008	5.827	326.4
14.0	110.0	0.529	3.66	23.70	55.52	7.327	3.037	5.962	322.4
15.0	103.4	0.522	3.32	27.80	61.66	7.753	3.058	6.017	320.4
16.0	97.29	0.522	3.04	31.73	67.70	8.143	3.079	6.068	320.7
17.0	91.74	0.528	2.80	35.63	73.78	8.512	3.097	6.089	322.1
18.0	86.69	0.537	2.59	39.50	79.87	8.860	3.112	6.090	324.3
19.0	82.10	0.550	2.40	43.33	85.96	9.189	3.124	6.079	327.2
20.0	77.94	0.565	2.24	47.12	92.03	9.501	3.134	6.059	330.5
21.0	74.16	0.582	2.10	50.88	98.07	9.796	3.143	6.033	334.2
22.0	70.72	0.600	1.97	54.60	104.1	10.08	3.149	6.005	338.2
23.0	67.57	0.619	1.86	58.28	110.1	10.34	3.155	5.974	342.3

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
24.0	64.69	0.639	1.76	61.94	116.0	10.60	3.159	5.942	346.6
25.0	62.05	0.659	1.67	65.56	122.0	10.84	3.162	5.911	351.0
26.0	59.61	0.680	1.59	69.15	127.9	11.07	3.165	5.879	355.4
28.0	55.29	0.723	1.45	76.26	139.6	11.50	3.168	5.819	364.4
30.0	51.57	0.767	1.33	83.27	151.1	11.90	3.170	5.763	373.5
32.0	48.33	0.812	1.23	90.20	162.6	12.27	3.171	5.712	382.5
34.0	45.50	0.857	1.14	97.07	174.0	12.62	3.171	5.666	391.4
36.0	42.99	0.903	1.07	103.9	185.3	12.94	3.171	5.625	400.1
38.0	40.76	0.948	1.00	110.6	196.5	13.24	3.170	5.588	408.8
40.0	38.75	0.993	0.943	117.3	207.6	13.53	3.169	5.555	417.2
45.0	34.55	1.11	0.825	133.9	235.2	14.18	3.166	5.487	437.7
50.0	31.19	1.22	0.734	150.3	262.5	14.75	3.163	5.435	457.3
55.0	28.46	1.33	0.661	166.6	289.6	15.27	3.159	5.394	476.0
60.0	26.17	1.44	0.602	182.8	316.5	15.74	3.157	5.362	494.0
65.0	24.24	1.55	0.552	198.8	343.2	16.17	3.154	5.336	511.3
70.0	22.58	1.65	0.510	214.8	369.9	16.56	3.151	5.316	528.0
75.0	21.14	1.76	0.475	230.8	396.4	16.93	3.149	5.299	544.2
80.0	19.87	1.87	0.444	246.7	422.8	17.27	3.147	5.285	559.9
90.0	17.75	2.08	0.393	278.4	475.6	17.89	3.144	5.264	590.0
100.0	16.05	2.29	0.352	310.0	528.1	18.44	3.141	5.248	618.5
125.0	12.95	2.81	0.281	388.7	659.0	19.61	3.136	5.225	684.6
150.0	10.86	3.33	0.233	467.1	789.5	20.56	3.132	5.212	744.7
175.0	9.352	3.85	0.200	545.4	919.7	21.37	3.130	5.205	800.4
200.0	8.213	4.37	0.175	623.6	1050.0	22.06	3.128	5.201	852.4
225.0	7.322	4.89	0.155	701.7	1180.0	22.67	3.127	5.198	901.4
250.0	6.605	5.41	0.140	779.8	1310.0	23.22	3.126	5.196	947.9
275.0	6.017	5.92	0.127	857.8	1440.0	23.72	3.125	5.195	992.2
300.0	5.524	6.44	0.116	935.8	1569.0	24.17	3.124	5.194	1035.0
350.0	4.748	7.47	0.100	1092.0	1829.0	24.97	3.123	5.193	1115.0
400.0	4.162	8.51	0.0873	1248.0	2089.0	25.66	3.123	5.192	1189.0
450.0	3.705	9.54	0.0776	1404.0	2348.0	26.27	3.122	5.192	1260.0
500.0	3.339	10.6	0.0699	1560.0	2608.0	26.82	3.122	5.192	1326.0
600.0	2.787	12.6	0.0582	1871.0	3127.0	27.77	3.121	5.192	1451.0
700.0	2.392	14.7	0.0499	2183.0	3646.0	28.57	3.120	5.192	1565.0
800.0	2.095	16.8	0.0437	2495.0	4165.0	29.26	3.120	5.192	1671.0
900.0	1.864	18.9	0.0388	2807.0	4685.0	29.87	3.120	5.192	1772.0
1000.0	1.678	20.9	0.0350	3118.0	5204.0	30.42	3.120	5.192	1866.0
1100.0	1.526	23.0	0.0318	3430.0	5723.0	30.91	3.119	5.192	1957.0
1200.0	1.400	25.1	0.0291	3742.0	6242.0	31.36	3.119	5.192	2043.0
1300.0	1.293	27.2	0.0269	4053.0	6761.0	31.78	3.119	5.192	2126.0
1400.0	1.201	29.2	0.0250	4365.0	7280.0	32.17	3.119	5.192	2206.0
1500.0	1.121	31.3	0.0233	4677.0	7800.0	32.52	3.119	5.192	2282.0
				$40.0 \times 10^{+5}$ pascal Isobar					
2.5	184.8	1.62	3.56	−9.98	11.66	1.547	1.172	1.229	412.4
3.0	183.7	1.66	4.09	−9.574	12.19	1.776	1.354	1.443	420.9
3.5	182.4	1.64	5.20	−9.069	12.86	2.002	1.501	1.674	427.7
4.0	180.6	1.59	6.08	−8.444	13.70	2.234	1.679	1.964	431.4
4.5	178.6	1.53	6.62	−7.657	14.74	2.479	1.897	2.302	430.5
5.0	176.2	1.46	6.88	−6.672	16.03	2.739	2.134	2.656	426.2
5.1	175.7	1.45	6.91	−6.448	16.32	2.792	2.179	2.724	425.3
5.2	175.2	1.44	6.94	−6.212	16.62	2.845	2.202	2.770	425.1
5.3	174.7	1.42	6.95	−5.998	16.90	2.898	2.188	2.778	425.1
5.4	174.2	1.41	6.97	−5.784	17.18	2.950	2.199	2.811	424.5
5.5	173.7	1.40	6.97	−5.567	17.46	3.002	2.211	2.846	423.9
5.6	173.2	1.38	6.98	−5.349	17.74	3.054	2.224	2.882	423.1
5.7	172.7	1.37	6.98	−5.128	18.03	3.105	2.238	2.918	422.4
5.8	172.2	1.35	6.98	−4.905	18.33	3.156	2.252	2.956	421.5

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
5.9	171.7	1.34	6.97	−4.679	18.62	3.207	2.268	2.994	420.7
6.0	171.1	1.33	6.97	−4.451	18.92	3.258	2.283	3.033	419.8
6.5	168.5	1.26	6.91	−3.271	20.47	3.509	2.364	3.232	414.8
7.0	165.7	1.19	6.81	−2.023	22.12	3.756	2.445	3.437	409.3
7.5	162.7	1.13	6.68	−0.7062	23.87	4.001	2.521	3.642	403.6
8.0	159.7	1.07	6.53	0.6804	25.73	4.244	2.592	3.846	397.8
8.5	156.6	1.01	6.36	2.134	27.68	4.484	2.656	4.047	392.1
9.0	153.4	0.955	6.18	3.654	29.73	4.723	2.714	4.247	386.5
9.5	150.1	0.904	5.99	5.235	31.89	4.960	2.767	4.442	381.0
10.0	146.7	0.858	5.80	6.876	34.14	5.194	2.814	4.633	375.8
11.0	139.7	0.772	5.36	10.58	39.21	5.684	2.901	4.995	364.6
12.0	132.6	0.704	4.92	14.46	44.63	6.162	2.962	5.311	355.2
13.0	125.6	0.653	4.50	18.47	50.33	6.624	3.004	5.563	347.8
14.0	118.7	0.620	4.11	22.54	56.23	7.065	3.034	5.739	342.5
15.0	112.3	0.602	3.75	26.61	62.23	7.482	3.056	5.841	339.2
16.0	106.3	0.594	3.46	30.47	68.11	7.862	3.077	5.926	338.2
17.0	100.7	0.593	3.19	34.33	74.07	8.223	3.095	5.977	338.5
18.0	95.51	0.598	2.96	38.18	80.06	8.566	3.110	6.003	339.7
19.0	90.76	0.606	2.76	42.00	86.07	8.890	3.123	6.012	341.6
20.0	86.41	0.618	2.58	45.79	92.08	9.199	3.133	6.009	344.1
21.0	82.41	0.631	2.41	49.55	98.08	9.492	3.142	5.998	347.1
22.0	78.75	0.647	2.27	53.28	104.1	9.770	3.149	5.981	350.4
23.0	75.38	0.663	2.14	56.98	110.0	10.04	3.155	5.961	354.0
24.0	72.27	0.681	2.03	60.65	116.0	10.29	3.160	5.937	357.7
25.0	69.41	0.700	1.93	64.29	121.9	10.53	3.164	5.913	361.7
26.0	66.76	0.720	1.83	67.90	127.8	10.76	3.167	5.887	365.7
28.0	62.04	0.760	1.67	75.06	139.5	11.20	3.171	5.836	374.0
30.0	57.94	0.803	1.53	82.13	151.2	11.60	3.174	5.785	382.4
32.0	54.37	0.846	1.42	89.11	162.7	11.97	3.175	5.738	390.9
34.0	51.22	0.890	1.32	96.03	174.1	12.32	3.176	5.694	399.4
36.0	48.44	0.934	1.23	102.9	185.5	12.64	3.176	5.654	407.8
38.0	45.95	0.979	1.15	109.7	196.7	12.94	3.175	5.617	416.1
40.0	43.71	1.02	1.09	116.4	207.9	13.23	3.174	5.584	424.3
45.0	39.01	1.14	0.948	133.1	235.7	13.89	3.171	5.514	444.3
50.0	35.25	1.25	0.843	149.6	263.1	14.46	3.168	5.459	463.5
55.0	32.18	1.36	0.758	166.0	290.3	14.98	3.165	5.416	481.9
60.0	29.62	1.47	0.690	182.2	317.3	15.45	3.162	5.381	499.6
65.0	27.44	1.58	0.633	198.3	344.1	15.88	3.159	5.353	516.7
70.0	25.58	1.68	0.585	214.4	370.8	16.28	3.156	5.331	533.2
75.0	23.95	1.79	0.544	230.4	397.4	16.64	3.154	5.312	549.2
80.0	22.53	1.90	0.508	246.4	423.9	16.99	3.151	5.297	564.7
90.0	20.14	2.11	0.449	278.1	476.8	17.61	3.148	5.273	594.5
100.0	18.21	2.32	0.403	309.8	529.4	18.16	3.145	5.255	622.8
125.0	14.72	2.84	0.321	388.6	660.4	19.33	3.139	5.229	688.3
150.0	12.35	3.36	0.267	467.1	791.0	20.28	3.135	5.215	748.1
175.0	10.64	3.88	0.228	545.4	921.2	21.09	3.132	5.207	803.5
200.0	9.353	4.40	0.200	623.7	1051.0	21.78	3.130	5.202	855.2
225.0	8.342	4.92	0.177	701.8	1181.0	22.40	3.129	5.199	904.0
250.0	7.528	5.44	0.160	779.9	1311.0	22.94	3.127	5.197	950.4
275.0	6.859	5.95	0.145	858.0	1441.0	23.44	3.126	5.195	994.5
300.0	6.299	6.47	0.133	936.0	1571.0	23.89	3.126	5.194	1037.0
350.0	5.415	7.50	0.114	1092.0	1831.0	24.69	3.124	5.193	1117.0
400.0	4.749	8.54	0.100	1248.0	2090.0	25.38	3.124	5.192	1191.0
450.0	4.228	9.57	0.0887	1404.0	2350.0	26.00	3.123	5.192	1261.0
500.0	3.811	10.6	0.0798	1560.0	2610.0	26.54	3.122	5.192	1328.0
600.0	3.182	12.7	0.0665	1872.0	3129.0	27.49	3.122	5.191	1452.0
700.0	2.732	14.7	0.0570	2183.0	3648.0	28.29	3.121	5.191	1566.0
800.0	2.393	16.8	0.0499	2495.0	4167.0	28.98	3.121	5.191	1672.0
900.0	2.129	18.9	0.0444	2807.0	4686.0	29.59	3.120	5.192	1773.0
1000.0	1.917	21.0	0.0399	3119.0	5205.0	30.14	3.120	5.192	1867.0

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
1100.0	1.744	23.0	0.0363	3430.0	5724.0	30.64	3.120	5.192	1958.0
1200.0	1.599	25.1	0.0333	3742.0	6244.0	31.09	3.120	5.192	2044.0
1300.0	1.477	27.2	0.0307	4054.0	6763.0	31.50	3.120	5.192	2126.0
1400.0	1.372	29.2	0.0285	4365.0	7282.0	31.89	3.119	5.192	2206.0
1500.0	1.280	31.3	0.0266	4677.0	7801.0	32.25	3.119	5.192	2283.0
				45.0 × 10^{+5} pascal Isobar					
2.5	187.9	1.70	4.39	−9.724	14.23	1.502	1.210	1.290	425.2
3.0	186.7	1.76	4.44	−9.339	14.76	1.733	1.318	1.415	435.1
3.5	185.3	1.76	5.43	−8.873	15.41	1.951	1.450	1.621	443.2
4.0	183.6	1.72	6.27	−8.288	16.21	2.176	1.633	1.905	447.5
4.5	181.7	1.66	6.80	−7.541	17.23	2.414	1.860	2.240	447.0
5.0	179.5	1.59	7.06	−6.594	18.48	2.667	2.105	2.590	442.9
5.1	179.0	1.58	7.09	−6.377	18.76	2.719	2.151	2.657	442.0
5.2	178.5	1.57	7.12	−6.149	19.06	2.771	2.176	2.702	441.9
5.3	178.0	1.56	7.14	−5.943	19.33	2.822	2.162	2.709	442.0
5.4	177.6	1.55	7.15	−5.737	19.60	2.873	2.174	2.741	441.5
5.5	177.1	1.53	7.16	−5.528	19.88	2.924	2.188	2.775	440.9
5.6	176.7	1.52	7.17	−5.318	20.15	2.974	2.202	2.809	440.2
5.7	176.2	1.51	7.17	−5.105	20.44	3.024	2.217	2.844	439.5
5.8	175.7	1.49	7.18	−4.890	20.72	3.074	2.232	2.881	438.7
5.9	175.2	1.48	7.17	−4.673	21.01	3.123	2.248	2.917	437.9
6.0	174.7	1.46	7.17	−4.453	21.30	3.173	2.264	2.954	437.1
6.5	172.2	1.40	7.12	−3.316	22.81	3.417	2.348	3.145	432.4
7.0	169.6	1.33	7.04	−2.114	24.41	3.658	2.431	3.338	427.3
7.5	166.9	1.27	6.93	−0.8467	26.11	3.895	2.509	3.532	422.0
8.0	164.1	1.20	6.80	0.4867	27.90	4.130	2.581	3.723	416.6
8.5	161.3	1.14	6.65	1.884	29.79	4.363	2.646	3.911	411.3
9.0	158.3	1.09	6.49	3.342	31.77	4.593	2.705	4.095	406.0
9.5	155.3	1.04	6.32	4.858	33.84	4.821	2.758	4.276	400.9
10.0	152.2	0.988	6.14	6.431	36.00	5.046	2.806	4.453	395.9
11.0	145.8	0.897	5.72	10.00	40.87	5.517	2.895	4.786	385.1
12.0	139.2	0.821	5.31	13.75	46.08	5.977	2.957	5.086	375.7
13.0	132.7	0.761	4.91	17.65	51.57	6.421	3.001	5.339	367.9
14.0	126.2	0.717	4.52	21.63	57.27	6.848	3.032	5.535	361.8
15.0	120.1	0.689	4.16	25.64	63.12	7.255	3.056	5.669	357.5
16.0	114.2	0.673	3.85	29.43	68.84	7.624	3.077	5.781	355.6
17.0	108.6	0.665	3.57	33.24	74.67	7.977	3.095	5.858	354.8
18.0	103.4	0.664	3.32	37.05	80.55	8.314	3.110	5.906	355.1
19.0	98.63	0.668	3.10	40.84	86.47	8.634	3.122	5.935	356.2
20.0	94.16	0.675	2.90	44.62	92.41	8.939	3.133	5.948	357.9
21.0	90.02	0.685	2.72	48.37	98.36	9.229	3.142	5.950	360.2
22.0	86.19	0.698	2.57	52.10	104.3	9.506	3.149	5.945	362.9
23.0	82.65	0.712	2.42	55.81	110.3	9.770	3.156	5.934	365.9
24.0	79.38	0.728	2.30	59.49	116.2	10.02	3.161	5.919	369.1
25.0	76.34	0.745	2.18	63.14	122.1	10.26	3.165	5.902	372.6
26.0	73.52	0.763	2.07	66.77	128.0	10.49	3.169	5.882	376.2
28.0	68.45	0.800	1.89	73.96	139.7	10.93	3.174	5.841	383.8
30.0	64.03	0.841	1.73	81.06	151.3	11.33	3.177	5.797	391.6
32.0	60.16	0.882	1.60	88.09	162.9	11.70	3.179	5.755	399.6
34.0	56.74	0.925	1.49	95.05	174.4	12.05	3.180	5.714	407.6
36.0	53.69	0.968	1.39	101.9	185.8	12.38	3.180	5.676	415.7
38.0	50.97	1.01	1.30	108.8	197.1	12.68	3.180	5.640	423.7
40.0	48.52	1.06	1.23	115.6	208.3	12.97	3.179	5.608	431.6
45.0	43.35	1.17	1.07	132.4	236.2	13.63	3.176	5.537	451.0
50.0	39.21	1.28	0.952	149.0	263.7	14.21	3.173	5.481	469.7
55.0	35.82	1.39	0.857	165.4	291.0	14.73	3.170	5.435	487.8
60.0	32.99	1.50	0.779	181.7	318.1	15.20	3.167	5.399	505.2

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
65.0	30.59	1.61	0.714	197.9	345.0	15.63	3.163	5.369	522.1
70.0	28.52	1.71	0.660	214.0	371.8	16.03	3.161	5.345	538.4
75.0	26.72	1.82	0.613	230.0	398.4	16.39	3.158	5.325	554.2
80.0	25.14	1.93	0.573	246.0	425.0	16.74	3.156	5.308	569.5
90.0	22.49	2.14	0.506	277.9	478.0	17.36	3.151	5.282	599.0
100.0	20.35	2.35	0.454	309.6	530.7	17.92	3.148	5.263	627.0
125.0	16.46	2.88	0.361	388.5	661.8	19.09	3.142	5.233	692.1
150.0	13.83	3.40	0.300	467.1	792.5	20.04	3.137	5.218	751.5
175.0	11.93	3.91	0.257	545.5	922.8	20.84	3.134	5.209	806.6
200.0	10.48	4.43	0.225	623.7	1053.0	21.54	3.132	5.203	858.1
225.0	9.355	4.95	0.200	701.9	1183.0	22.15	3.130	5.200	906.7
250.0	8.445	5.47	0.180	780.0	1313.0	22.70	3.129	5.197	952.8
275.0	7.697	5.98	0.163	858.1	1443.0	23.19	3.128	5.195	997.0
300.0	7.070	6.50	0.150	936.2	1573.0	23.65	3.127	5.194	1039.0
350.0	6.080	7.53	0.128	1092.0	1832.0	24.45	3.126	5.193	1119.0
400.0	5.333	8.57	0.112	1248.0	2092.0	25.14	3.125	5.192	1193.0
450.0	4.750	9.60	0.100	1404.0	2352.0	25.75	3.124	5.192	1263.0
500.0	4.282	10.6	0.0898	1560.0	2611.0	26.30	3.123	5.191	1329.0
600.0	3.576	12.7	0.0748	1872.0	3130.0	27.25	3.122	5.191	1453.0
700.0	3.070	14.8	0.0642	2184.0	3649.0	28.05	3.122	5.191	1567.0
800.0	2.690	16.8	0.0561	2496.0	4168.0	28.74	3.121	5.191	1674.0
900.0	2.393	18.9	0.0499	2807.0	4688.0	29.35	3.121	5.191	1773.0
1000.0	2.155	21.0	0.0449	3119.0	5207.0	29.90	3.121	5.191	1868.0
1100.0	1.961	23.1	0.0408	3431.0	5726.0	30.39	3.120	5.192	1958.0
1200.0	1.798	25.1	0.0374	3742.0	6245.0	30.84	3.120	5.192	2044.0
1300.0	1.661	27.2	0.0346	4054.0	6764.0	31.26	3.120	5.192	2127.0
1400.0	1.542	29.3	0.0321	4366.0	7283.0	31.64	3.120	5.192	2207.0
1500.0	1.440	31.3	0.0300	4678.0	7803.0	32.00	3.120	5.192	2284.0
				$50.0 \times 10^{+5}$ pascal Isobar					
2.5	190.8	1.76	5.46	−9.460	16.74	1.453	1.280	1.396	437.8
3.0	189.5	1.86	4.90	−9.093	17.29	1.690	1.294	1.402	448.6
3.5	188.1	1.87	5.71	−8.662	17.92	1.904	1.406	1.579	457.9
4.0	186.5	1.84	6.49	−8.114	18.70	2.122	1.592	1.856	462.6
4.5	184.6	1.78	6.99	−7.401	19.69	2.354	1.827	2.188	462.3
5.0	182.5	1.72	7.24	−6.488	20.91	2.601	2.079	2.535	458.4
5.1	182.0	1.71	7.27	−6.277	21.19	2.652	2.126	2.601	457.6
5.2	181.6	1.70	7.30	−6.055	21.48	2.703	2.152	2.646	457.5
5.3	181.1	1.69	7.32	−5.856	21.75	2.753	2.140	2.651	457.6
5.4	180.7	1.68	7.33	−5.656	22.01	2.803	2.153	2.683	457.1
5.5	180.3	1.66	7.34	−5.455	22.28	2.852	2.167	2.715	456.6
5.6	179.8	1.65	7.35	−5.251	22.56	2.902	2.182	2.749	456.0
5.7	179.4	1.64	7.35	−5.045	22.83	2.951	2.198	2.783	455.3
5.8	178.9	1.62	7.36	−4.837	23.11	2.999	2.214	2.818	454.6
5.9	178.5	1.61	7.36	−4.627	23.39	3.048	2.231	2.853	453.9
6.0	178.0	1.60	7.35	−4.414	23.68	3.096	2.248	2.889	453.1
6.5	175.6	1.53	7.32	−3.314	25.15	3.335	2.335	3.072	448.7
7.0	173.2	1.46	7.25	−2.150	26.72	3.570	2.419	3.257	443.9
7.5	170.7	1.40	7.16	−0.9244	28.37	3.801	2.499	3.441	438.9
8.0	168.1	1.34	7.04	0.3646	30.11	4.030	2.571	3.622	433.9
8.5	165.4	1.28	6.91	1.714	31.94	4.256	2.637	3.800	428.8
9.0	162.7	1.22	6.77	3.122	33.86	4.479	2.697	3.974	423.9
9.5	159.8	1.17	6.61	4.585	35.87	4.700	2.751	4.143	419.1
10.0	157.0	1.12	6.44	6.102	37.96	4.918	2.799	4.309	414.4
11.0	151.0	1.02	6.05	9.564	42.68	5.375	2.889	4.620	404.0
12.0	144.9	0.939	5.66	13.21	47.71	5.819	2.953	4.902	394.7
13.0	138.8	0.871	5.27	17.00	53.02	6.250	2.999	5.150	386.8
14.0	132.8	0.819	4.89	20.89	58.55	6.664	3.032	5.355	380.2

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
15.0	126.9	0.781	4.53	24.84	64.25	7.061	3.056	5.508	375.2
16.0	121.2	0.757	4.22	28.57	69.83	7.420	3.078	5.639	372.5
17.0	115.8	0.742	3.93	32.32	75.52	7.765	3.095	5.736	370.9
18.0	110.6	0.735	3.67	36.08	81.29	8.095	3.110	5.804	370.3
19.0	105.8	0.734	3.43	39.85	87.12	8.410	3.123	5.850	370.7
20.0	101.2	0.737	3.22	43.60	92.98	8.711	3.134	5.879	371.7
21.0	97.03	0.743	3.03	47.34	98.87	8.999	3.143	5.894	373.3
22.0	93.09	0.753	2.86	51.06	104.8	9.273	3.150	5.900	375.4
23.0	89.43	0.764	2.70	54.76	110.7	9.535	3.157	5.899	377.9
24.0	86.02	0.778	2.56	58.44	116.6	9.786	3.162	5.892	380.7
25.0	82.85	0.793	2.43	62.10	122.5	10.03	3.166	5.882	383.7
26.0	79.88	0.809	2.31	65.74	128.3	10.26	3.170	5.869	386.9
28.0	74.53	0.844	2.11	72.95	140.0	10.69	3.176	5.837	393.7
30.0	69.84	0.881	1.94	80.08	151.7	11.09	3.180	5.801	401.0
32.0	65.70	0.921	1.79	87.14	163.2	11.47	3.182	5.764	408.4
34.0	62.04	0.962	1.66	94.13	174.7	11.81	3.184	5.727	416.0
36.0	58.76	1.00	1.55	101.1	186.1	12.14	3.184	5.692	423.7
38.0	55.83	1.05	1.46	107.9	197.5	12.45	3.184	5.658	431.3
40.0	53.18	1.09	1.37	114.8	208.8	12.74	3.184	5.626	439.0
45.0	47.58	1.20	1.20	131.6	236.7	13.39	3.181	5.557	457.8
50.0	43.08	1.31	1.06	148.3	264.4	13.98	3.178	5.500	476.0
55.0	39.39	1.42	0.955	164.8	291.7	14.50	3.175	5.453	493.7
60.0	36.30	1.53	0.868	181.2	318.9	14.97	3.171	5.415	510.9
65.0	33.67	1.64	0.795	197.4	345.9	15.40	3.168	5.384	527.5
70.0	31.41	1.75	0.734	213.6	372.8	15.80	3.165	5.358	543.5
75.0	29.44	1.85	0.682	229.7	399.5	16.17	3.162	5.337	559.1
80.0	27.71	1.96	0.637	245.7	426.1	16.51	3.160	5.318	574.3
90.0	24.81	2.17	0.563	277.6	479.2	17.14	3.155	5.290	603.5
100.0	22.47	2.38	0.505	309.4	532.0	17.70	3.152	5.270	631.3
125.0	18.19	2.91	0.401	388.4	663.3	18.87	3.144	5.238	695.9
150.0	15.30	3.43	0.334	467.1	794.0	19.82	3.140	5.220	754.9
175.0	13.20	3.95	0.285	545.5	924.3	20.62	3.136	5.210	809.6
200.0	11.61	4.46	0.250	623.8	1055.0	21.32	3.134	5.204	860.9
225.0	10.36	4.98	0.222	702.0	1185.0	21.93	3.132	5.200	909.3
250.0	9.357	5.50	0.199	780.2	1315.0	22.48	3.130	5.198	955.3
275.0	8.530	6.01	0.181	858.3	1444.0	22.98	3.129	5.196	999.0
300.0	7.837	6.53	0.166	936.4	1574.0	23.43	3.128	5.194	1041.0
350.0	6.743	7.56	0.142	1092.0	1834.0	24.23	3.127	5.193	1121.0
400.0	5.916	8.60	0.125	1248.0	2094.0	24.92	3.126	5.192	1195.0
450.0	5.270	9.63	0.111	1404.0	2353.0	25.53	3.125	5.191	1265.0
500.0	4.751	10.7	0.100	1560.0	2613.0	26.08	3.124	5.191	1331.0
600.0	3.969	12.7	0.0831	1872.0	3132.0	27.03	3.123	5.191	1454.0
700.0	3.409	14.8	0.0713	2184.0	3651.0	27.83	3.122	5.191	1568.0
800.0	2.987	16.9	0.0624	2496.0	4170.0	28.52	3.122	5.191	1675.0
900.0	2.657	18.9	0.0555	2808.0	4689.0	29.13	3.121	5.191	1774.0
1000.0	2.394	21.0	0.0499	3119.0	5208.0	29.68	3.121	5.191	1869.0
1100.0	2.177	23.1	0.0454	3431.0	5727.0	30.17	3.121	5.191	1959.0
1200.0	1.997	25.1	0.0416	3743.0	6247.0	30.62	3.121	5.191	2045.0
1300.0	1.844	27.2	0.0384	4055.0	6766.0	31.04	3.121	5.192	2128.0
1400.0	1.713	29.3	0.0357	4366.0	7285.0	31.43	3.120	5.192	2207.0
1500.0	1.600	31.4	0.0333	4678.0	7804.0	31.78	3.120	5.192	2284.0
				$60.0 \times 10^{+5}$ pascal Isobar					
3.0	194.7	2.02	6.13	−8.584	22.23	1.602	1.287	1.434	474.8
3.5	193.2	2.07	6.42	−8.209	22.85	1.813	1.343	1.529	485.5
4.0	191.6	2.06	6.98	−7.722	23.59	2.023	1.527	1.785	490.6
4.5	189.8	2.02	7.38	−7.067	24.54	2.246	1.773	2.109	490.3
5.0	187.9	1.97	7.58	−6.208	25.73	2.484	2.036	2.450	486.6

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
5.1	187.4	1.96	7.61	−6.008	26.00	2.533	2.085	2.515	485.8
5.2	187.0	1.95	7.63	−5.797	26.28	2.582	2.113	2.557	485.7
5.3	186.6	1.94	7.65	−5.609	26.54	2.631	2.103	2.562	485.9
5.4	186.2	1.93	7.66	−5.420	26.79	2.679	2.118	2.592	485.5
5.5	185.8	1.91	7.67	−5.229	27.05	2.727	2.133	2.622	485.0
5.6	185.4	1.90	7.67	−5.036	27.32	2.774	2.150	2.654	484.5
5.7	185.0	1.89	7.68	−4.842	27.58	2.822	2.167	2.686	483.9
5.8	184.6	1.88	7.68	−4.645	27.85	2.869	2.184	2.719	483.2
5.9	184.2	1.86	7.68	−4.446	28.12	2.916	2.202	2.753	482.5
6.0	183.8	1.85	7.68	−4.244	28.40	2.962	2.220	2.787	481.8
6.5	181.7	1.78	7.66	−3.203	29.82	3.192	2.311	2.958	477.8
7.0	179.5	1.72	7.61	−2.101	31.32	3.418	2.399	3.130	473.5
7.5	177.3	1.65	7.54	−0.9414	32.91	3.640	2.480	3.300	469.0
8.0	174.9	1.59	7.45	0.2770	34.57	3.859	2.554	3.466	464.6
8.5	172.6	1.53	7.35	1.551	36.32	4.075	2.621	3.629	460.1
9.0	170.1	1.47	7.23	2.880	38.15	4.288	2.682	3.787	455.7
9.5	167.6	1.42	7.10	4.260	40.05	4.498	2.737	3.941	451.4
10.0	165.1	1.36	6.96	5.689	42.03	4.705	2.787	4.091	447.1
11.0	159.8	1.26	6.61	8.988	46.53	5.141	2.879	4.369	437.6
12.0	154.5	1.17	6.25	12.47	51.30	5.563	2.945	4.624	428.8
13.0	149.1	1.09	5.90	16.09	56.34	5.971	2.995	4.855	421.0
14.0	143.7	1.03	5.54	19.83	61.59	6.365	3.031	5.058	414.1
15.0	138.3	0.975	5.20	23.66	67.04	6.744	3.057	5.228	408.3
16.0	133.1	0.937	4.88	27.25	72.34	7.087	3.080	5.380	404.6
17.0	127.9	0.909	4.59	30.88	77.79	7.417	3.099	5.504	401.8
18.0	123.0	0.890	4.31	34.55	83.34	7.734	3.114	5.600	400.0
19.0	118.2	0.878	4.06	38.24	88.98	8.039	3.126	5.674	399.1
20.0	113.7	0.872	3.82	41.93	94.68	8.331	3.136	5.728	398.9
21.0	109.5	0.870	3.61	45.62	100.4	8.612	3.145	5.767	399.4
22.0	105.4	0.873	3.41	49.31	106.2	8.881	3.153	5.794	400.4
23.0	101.6	0.878	3.23	52.99	112.0	9.139	3.159	5.811	401.9
24.0	98.07	0.887	3.07	56.65	117.8	9.386	3.165	5.820	403.8
25.0	94.71	0.897	2.92	60.30	123.7	9.624	3.169	5.823	406.0
26.0	91.55	0.909	2.79	63.94	129.5	9.852	3.174	5.822	408.4
28.0	85.78	0.938	2.55	71.16	141.1	10.28	3.180	5.810	413.9
30.0	80.66	0.970	2.34	78.32	152.7	10.68	3.185	5.790	419.9
32.0	76.10	1.01	2.17	85.42	164.3	11.06	3.188	5.764	426.4
34.0	72.02	1.04	2.01	92.46	175.8	11.41	3.190	5.737	433.1
36.0	68.36	1.08	1.88	99.44	187.2	11.73	3.191	5.708	440.0
38.0	65.05	1.12	1.76	106.4	198.6	12.04	3.192	5.679	446.9
40.0	62.06	1.16	1.66	113.3	209.9	12.33	3.192	5.652	454.0
45.0	55.68	1.27	1.45	130.3	238.0	12.99	3.190	5.587	471.5
50.0	50.53	1.38	1.28	147.1	265.8	13.58	3.187	5.531	488.8
55.0	46.27	1.49	1.15	163.7	293.3	14.10	3.184	5.483	505.8
60.0	42.70	1.59	1.05	180.2	320.7	14.58	3.181	5.444	522.3
65.0	39.66	1.70	0.959	196.5	347.8	15.01	3.177	5.410	538.3
70.0	37.04	1.81	0.885	212.8	374.8	15.41	3.174	5.382	553.9
75.0	34.75	1.92	0.822	228.9	401.6	15.78	3.171	5.358	569.1
80.0	32.73	2.02	0.767	245.1	428.4	16.13	3.168	5.338	584.0
90.0	29.35	2.24	0.677	277.1	481.6	16.76	3.163	5.307	612.5
100.0	26.61	2.45	0.607	309.0	534.5	17.31	3.158	5.283	639.8
125.0	21.60	2.97	0.482	388.2	666.1	18.49	3.150	5.246	703.4
150.0	18.19	3.49	0.400	467.0	796.9	19.44	3.145	5.226	761.7
175.0	15.71	4.01	0.342	545.6	927.4	20.25	3.141	5.214	815.8
200.0	13.83	4.53	0.299	624.0	1058.0	20.94	3.137	5.207	866.6
225.0	12.36	5.04	0.266	702.2	1188.0	21.55	3.135	5.202	914.6
250.0	11.17	5.56	0.239	780.4	1318.0	22.10	3.133	5.199	960.2
275.0	10.18	6.07	0.217	858.6	1448.0	22.60	3.132	5.196	1004.0
300.0	9.362	6.59	0.199	936.7	1578.0	23.05	3.131	5.195	1046.0
350.0	8.060	7.62	0.171	1093.0	1837.0	23.85	3.129	5.193	1125.0

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
400.0	7.076	8.65	0.150	1249.0	2097.0	24.54	3.128	5.192	1198.0
450.0	6.306	9.68	0.133	1405.0	2356.0	25.16	3.127	5.191	1268.0
500.0	5.687	10.7	0.120	1561.0	2616.0	25.70	3.126	5.191	1334.0
600.0	4.753	12.8	0.100	1873.0	3135.0	26.65	3.125	5.191	1457.0
700.0	4.083	14.8	0.0855	2185.0	3654.0	27.45	3.124	5.191	1571.0
800.0	3.579	16.9	0.0748	2497.0	4173.0	28.14	3.123	5.191	1677.0
900.0	3.185	19.0	0.0665	2808.0	4692.0	28.75	3.123	5.191	1776.0
1000.0	2.869	21.1	0.0599	3120.0	5211.0	29.30	3.122	5.191	1871.0
1100.0	2.610	23.1	0.0544	3432.0	5730.0	29.80	3.122	5.191	1961.0
1200.0	2.394	25.2	0.0499	3744.0	6249.0	30.25	3.122	5.191	2047.0
1300.0	2.211	27.3	0.0461	4055.0	6769.0	30.66	3.121	5.191	2129.0
1400.0	2.054	29.3	0.0428	4367.0	7288.0	31.05	3.121	5.191	2208.0
1500.0	1.918	31.4	0.0399	4679.0	7807.0	31.41	3.121	5.191	2285.0
				$70.0 \times 10^{+5}$ pascal Isobar					
3.0	199.5	2.16	7.83	−8.065	27.02	1.506	1.340	1.554	500.7
3.5	197.8	2.25	7.34	−7.729	27.65	1.725	1.312	1.526	511.8
4.0	196.2	2.27	7.58	−7.290	28.38	1.931	1.484	1.748	516.5
4.5	194.5	2.24	7.81	−6.681	29.31	2.149	1.734	2.059	515.7
5.0	192.6	2.20	7.93	−5.863	30.47	2.381	2.005	2.391	511.8
5.1	192.3	2.19	7.95	−5.672	30.74	2.429	2.056	2.454	511.0
5.2	191.9	2.18	7.96	−5.468	31.01	2.477	2.085	2.495	511.0
5.3	191.5	2.17	7.97	−5.289	31.26	2.525	2.075	2.498	511.2
5.4	191.1	2.16	7.97	−5.108	31.51	2.572	2.091	2.526	510.8
5.5	190.8	2.15	7.97	−4.926	31.77	2.618	2.108	2.556	510.3
5.6	190.4	2.14	7.98	−4.742	32.02	2.664	2.126	2.586	509.8
5.7	190.0	2.12	7.98	−4.556	32.28	2.711	2.144	2.616	509.2
5.8	189.6	2.11	7.98	−4.368	32.54	2.756	2.162	2.647	508.6
5.9	189.3	2.10	7.97	−4.177	32.81	2.802	2.181	2.679	508.0
6.0	188.9	2.09	7.97	−3.985	33.07	2.847	2.199	2.711	507.3
6.5	187.0	2.02	7.95	−2.988	34.45	3.071	2.293	2.873	503.6
7.0	185.0	1.96	7.91	−1.935	35.91	3.290	2.382	3.035	499.6
7.5	182.9	1.89	7.85	−0.8258	37.44	3.505	2.464	3.194	495.6
8.0	180.8	1.83	7.79	0.3382	39.05	3.717	2.539	3.349	491.5
8.5	178.7	1.77	7.71	1.555	40.74	3.925	2.607	3.501	487.5
9.0	176.4	1.71	7.61	2.822	42.49	4.130	2.669	3.648	483.5
9.5	174.2	1.65	7.51	4.138	44.32	4.332	2.725	3.792	479.7
10.0	171.9	1.60	7.39	5.500	46.22	4.531	2.775	3.932	475.8
11.0	167.1	1.49	7.07	8.678	50.56	4.951	2.868	4.186	467.0
12.0	162.3	1.40	6.75	12.03	55.16	5.358	2.938	4.421	458.9
13.0	157.4	1.31	6.42	15.53	59.99	5.750	2.990	4.636	451.4
14.0	152.5	1.24	6.09	19.15	65.04	6.129	3.030	4.831	444.5
15.0	147.7	1.18	5.76	22.87	70.28	6.494	3.058	5.002	438.6
16.0	142.8	1.13	5.46	26.33	75.36	6.822	3.083	5.161	434.3
17.0	138.0	1.09	5.17	29.86	80.59	7.139	3.102	5.297	430.9
18.0	133.3	1.06	4.89	33.43	85.95	7.445	3.118	5.409	428.2
19.0	128.7	1.03	4.63	37.03	91.40	7.740	3.130	5.502	426.4
20.0	124.3	1.02	4.38	40.65	96.94	8.025	3.140	5.575	425.3
21.0	120.1	1.01	4.15	44.28	102.5	8.298	3.149	5.633	424.9
22.0	116.1	1.00	3.94	47.92	108.2	8.561	3.156	5.677	425.0
23.0	112.3	1.00	3.74	51.56	113.9	8.814	3.163	5.710	425.6
24.0	108.7	1.01	3.56	55.20	119.6	9.058	3.168	5.733	426.7
25.0	105.2	1.01	3.40	58.83	125.4	9.292	3.173	5.750	428.1
26.0	101.9	1.02	3.24	62.45	131.1	9.518	3.177	5.760	429.8
28.0	95.91	1.04	2.97	69.66	142.6	9.945	3.184	5.767	434.0
30.0	90.49	1.07	2.74	76.82	154.2	10.34	3.189	5.762	439.0
32.0	85.62	1.10	2.53	83.94	165.7	10.71	3.193	5.749	444.5
34.0	81.23	1.13	2.36	91.00	177.2	11.06	3.195	5.731	450.3

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
36.0	77.26	1.17	2.20	98.01	188.6	11.39	3.197	5.710	456.4
38.0	73.66	1.20	2.07	105.0	200.0	11.70	3.198	5.687	462.7
40.0	70.37	1.24	1.95	111.9	211.4	11.99	3.199	5.664	469.2
45.0	63.34	1.34	1.70	129.0	239.5	12.65	3.198	5.606	485.4
50.0	57.61	1.45	1.51	145.9	267.4	13.24	3.196	5.554	501.8
55.0	52.85	1.56	1.35	162.6	295.1	13.77	3.193	5.507	517.9
60.0	48.85	1.66	1.23	179.2	322.5	14.24	3.189	5.467	533.7
65.0	45.42	1.77	1.12	195.7	349.8	14.68	3.186	5.433	549.2
70.0	42.46	1.88	1.04	212.0	376.8	15.08	3.182	5.403	564.4
75.0	39.88	1.98	0.962	228.3	403.8	15.45	3.179	5.378	579.2
80.0	37.60	2.09	0.897	244.4	430.6	15.80	3.176	5.356	593.6
90.0	33.75	2.30	0.792	276.6	484.0	16.43	3.170	5.322	621.5
100.0	30.64	2.51	0.709	308.6	537.1	16.99	3.165	5.296	648.3
125.0	24.92	3.04	0.563	388.1	668.9	18.17	3.156	5.254	710.8
150.0	21.02	3.56	0.467	467.0	799.9	19.12	3.149	5.231	768.4
175.0	18.19	4.07	0.399	545.6	930.5	19.93	3.145	5.217	821.9
200.0	16.03	4.59	0.349	624.1	1061.0	20.62	3.141	5.209	872.2
225.0	14.33	5.10	0.310	702.5	1191.0	21.24	3.139	5.203	919.8
250.0	12.96	5.62	0.279	780.7	1321.0	21.78	3.136	5.199	965.1
275.0	11.82	6.13	0.254	858.9	1451.0	22.28	3.135	5.197	1008.0
300.0	10.87	6.65	0.232	937.0	1581.0	22.73	3.133	5.195	1050.0
350.0	9.367	7.68	0.199	1093.0	1841.0	23.53	3.131	5.193	1128.0
400.0	8.228	8.71	0.174	1249.0	2100.0	24.23	3.130	5.192	1202.0
450.0	7.335	9.74	0.155	1405.0	2360.0	24.84	3.128	5.191	1271.0
500.0	6.618	10.8	0.140	1561.0	2619.0	25.38	3.127	5.190	1337.0
600.0	5.534	12.8	0.116	1873.0	3138.0	26.33	3.126	5.190	1460.0
700.0	4.756	14.9	0.100	2185.0	3657.0	27.13	3.125	5.190	1573.0
800.0	4.169	17.0	0.0873	2497.0	4176.0	27.82	3.124	5.190	1679.0
900.0	3.711	19.0	0.0776	2809.0	4695.0	28.43	3.124	5.190	1778.0
1000.0	3.344	21.1	0.0698	3121.0	5214.0	28.98	3.123	5.191	1872.0
1100.0	3.042	23.2	0.0635	3433.0	5733.0	29.48	3.123	5.191	1962.0
1200.0	2.791	25.2	0.0582	3744.0	6252.0	29.93	3.123	5.191	2048.0
1300.0	2.578	27.3	0.0537	4056.0	6772.0	30.34	3.122	5.191	2130.0
1400.0	2.395	29.4	0.0499	4368.0	7291.0	30.73	3.122	5.191	2210.0
1500.0	2.236	31.4	0.0466	4680.0	7810.0	31.09	3.122	5.191	2286.0
				80.0 × 10^{+5} pascal Isobar					
3.5	202.1	2.42	8.50	−7.237	32.34	1.636	1.317	1.573	537.2
4.0	200.4	2.46	8.29	−6.833	33.08	1.844	1.464	1.742	540.7
4.5	198.7	2.45	8.30	−6.258	34.00	2.060	1.712	2.033	539.1
5.0	197.0	2.41	8.30	−5.473	35.14	2.289	1.985	2.353	534.8
5.1	196.6	2.41	8.30	−5.287	35.40	2.336	2.036	2.414	534.0
5.2	196.2	2.40	8.30	−5.090	35.67	2.383	2.066	2.454	533.9
5.3	195.9	2.39	8.29	−4.917	35.92	2.430	2.057	2.455	534.1
5.4	195.5	2.38	8.29	−4.744	36.17	2.476	2.074	2.481	533.7
5.5	195.2	2.37	8.28	−4.568	36.41	2.521	2.091	2.508	533.2
5.6	194.9	2.36	8.27	−4.391	36.67	2.567	2.109	2.537	532.7
5.7	194.5	2.35	8.26	−4.211	36.92	2.612	2.127	2.566	532.2
5.8	194.1	2.34	8.26	−4.030	37.18	2.657	2.146	2.595	531.6
5.9	193.8	2.33	8.25	−3.846	37.43	2.702	2.165	2.625	531.0
6.0	193.4	2.31	8.24	−3.660	37.70	2.746	2.184	2.655	530.3
6.5	191.6	2.25	8.21	−2.699	39.05	2.965	2.278	2.808	526.8
7.0	189.8	2.19	8.17	−1.684	40.47	3.179	2.368	2.960	523.1
7.5	187.9	2.13	8.13	−0.6162	41.96	3.388	2.450	3.110	519.4
8.0	186.0	2.06	8.08	0.5040	43.52	3.594	2.525	3.256	515.7
8.5	184.0	2.00	8.01	1.674	45.16	3.796	2.593	3.399	512.0
9.0	181.9	1.94	7.94	2.892	46.86	3.995	2.655	3.539	508.4
9.5	179.9	1.88	7.86	4.156	48.63	4.191	2.712	3.675	504.9

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
10.0	177.8	1.83	7.76	5.465	50.47	4.384	2.763	3.807	501.5
11.0	173.4	1.72	7.47	8.547	54.69	4.793	2.857	4.045	493.4
12.0	169.0	1.62	7.18	11.80	59.15	5.187	2.929	4.265	485.9
13.0	164.5	1.53	6.88	15.20	63.83	5.568	2.985	4.468	478.7
14.0	160.0	1.45	6.57	18.72	68.72	5.935	3.027	4.653	472.1
15.0	155.5	1.38	6.26	22.35	73.80	6.289	3.057	4.819	466.2
16.0	151.0	1.32	5.97	25.70	78.70	6.605	3.084	4.979	461.7
17.0	146.5	1.27	5.69	29.13	83.75	6.912	3.105	5.119	457.9
18.0	142.0	1.23	5.41	32.60	88.93	7.208	3.121	5.240	454.8
19.0	137.7	1.20	5.14	36.12	94.22	7.494	3.134	5.343	452.4
20.0	133.5	1.18	4.89	39.67	99.6	7.770	3.145	5.429	450.6
21.0	129.4	1.16	4.65	43.24	105.1	8.037	3.154	5.500	449.4
22.0	125.4	1.15	4.43	46.83	110.6	8.294	3.161	5.558	448.8
23.0	121.7	1.14	4.22	50.42	116.2	8.542	3.167	5.604	448.8
24.0	118.0	1.13	4.03	54.02	121.8	8.781	3.172	5.640	449.1
25.0	114.5	1.13	3.85	57.62	127.5	9.012	3.177	5.668	449.9
26.0	111.2	1.14	3.68	61.22	133.1	9.235	3.181	5.689	451.0
28.0	105.1	1.15	3.38	68.39	144.5	9.658	3.188	5.715	454.0
30.0	99.44	1.17	3.12	75.54	156.0	10.05	3.193	5.724	458.0
32.0	94.35	1.20	2.90	82.65	167.4	10.42	3.197	5.723	462.5
34.0	89.73	1.22	2.70	89.72	178.9	10.77	3.201	5.714	467.6
36.0	85.52	1.26	2.53	96.74	190.3	11.09	3.203	5.701	473.0
38.0	81.68	1.29	2.37	103.7	201.7	11.40	3.204	5.685	478.6
40.0	78.16	1.33	2.23	110.7	213.0	11.69	3.205	5.667	484.4
45.0	70.57	1.42	1.95	127.9	241.2	12.36	3.205	5.618	499.5
50.0	64.34	1.52	1.73	144.9	269.2	12.95	3.203	5.570	514.8
55.0	59.14	1.63	1.55	161.7	296.9	13.48	3.201	5.526	530.1
60.0	54.74	1.73	1.41	178.3	324.5	13.96	3.197	5.486	545.3
65.0	50.97	1.84	1.29	194.9	351.8	14.39	3.194	5.452	560.2
70.0	47.70	1.94	1.19	211.3	379.0	14.80	3.190	5.421	574.8
75.0	44.84	2.05	1.10	227.6	406.0	15.17	3.187	5.395	589.2
80.0	42.31	2.16	1.03	243.9	433.0	15.52	3.184	5.372	603.3
90.0	38.04	2.37	0.906	276.2	486.5	16.15	3.178	5.336	630.6
100.0	34.57	2.58	0.811	308.3	539.7	16.71	3.172	5.307	656.8
125.0	28.18	3.10	0.643	387.9	671.7	17.89	3.162	5.262	718.3
150.0	23.81	3.62	0.534	467.0	802.9	18.84	3.154	5.236	775.0
175.0	20.62	4.14	0.456	545.7	933.6	19.65	3.149	5.221	828.0
200.0	18.19	4.65	0.399	624.3	1064.0	20.35	3.145	5.211	877.8
225.0	16.28	5.17	0.354	702.7	1194.0	20.96	3.142	5.205	925.0
250.0	14.73	5.68	0.319	781.0	1324.0	21.51	3.139	5.200	969.9
275.0	13.45	6.19	0.290	859.2	1454.0	22.00	3.137	5.197	1013.0
300.0	12.37	6.71	0.265	937.4	1584.0	22.45	3.136	5.195	1054.0
350.0	10.66	7.74	0.228	1094.0	1844.0	23.26	3.133	5.193	1132.0
400.0	9.372	8.77	0.199	1250.0	2103.0	23.95	3.132	5.191	1205.0
450.0	8.359	9.80	0.177	1406.0	2363.0	24.56	3.130	5.191	1274.0
500.0	7.544	10.8	0.159	1562.0	2622.0	25.11	3.129	5.190	1340.0
600.0	6.312	12.9	0.133	1874.0	3141.0	26.05	3.127	5.190	1462.0
700.0	5.426	14.9	0.114	2186.0	3660.0	26.85	3.126	5.190	1575.0
800.0	4.758	17.0	0.100	2498.0	4179.0	27.55	3.126	5.190	1681.0
900.0	4.236	19.1	0.0886	2810.0	4698.0	28.16	3.125	5.190	1780.0
1000.0	3.817	21.1	0.0798	3122.0	5217.0	28.70	3.124	5.190	1874.0
1100.0	3.474	23.2	0.0725	3433.0	5736.0	29.20	3.124	5.190	1964.0
1200.0	3.187	25.3	0.0665	3745.0	6255.0	29.65	3.124	5.190	2049.0
1300.0	2.944	27.3	0.0614	4057.0	6774.0	30.07	3.123	5.191	2132.0
1400.0	2.735	29.4	0.0570	4369.0	7294.0	30.45	3.123	5.191	2211.0
1500.0	2.554	31.5	0.0532	4681.0	7813.0	30.81	3.123	5.191	2287.0

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
				90.0 × 10^{+5} pascal Isobar					
3.5	206.2	2.56	9.92	−6.740	36.91	1.543	1.358	1.674	562.2
4.0	204.4	2.63	9.13	−6.359	37.68	1.759	1.466	1.769	563.8
4.5	202.7	2.64	8.86	−5.809	38.60	1.976	1.704	2.030	560.9
5.0	200.9	2.62	8.70	−5.048	39.74	2.204	1.976	2.334	556.0
5.1	200.6	2.61	8.67	−4.867	40.00	2.250	2.027	2.392	555.2
5.2	200.2	2.61	8.66	−4.675	40.27	2.297	2.057	2.429	555.0
5.3	199.9	2.60	8.63	−4.507	40.51	2.343	2.048	2.428	555.2
5.4	199.6	2.59	8.61	−4.339	40.76	2.389	2.064	2.452	554.8
5.5	199.2	2.58	8.59	−4.168	41.00	2.434	2.082	2.477	554.3
5.6	198.9	2.57	8.57	−3.996	41.25	2.479	2.100	2.503	553.8
5.7	198.6	2.56	8.55	−3.822	41.50	2.523	2.118	2.530	553.2
5.8	198.2	2.55	8.53	−3.646	41.75	2.567	2.137	2.558	552.7
5.9	197.9	2.54	8.52	−3.468	42.01	2.611	2.155	2.586	552.1
6.0	197.6	2.53	8.50	−3.288	42.27	2.655	2.174	2.614	551.4
6.5	195.9	2.47	8.45	−2.355	43.59	2.870	2.268	2.757	548.0
7.0	194.1	2.41	8.40	−1.371	44.99	3.080	2.356	2.901	544.5
7.5	192.4	2.35	8.37	−0.3367	46.45	3.285	2.437	3.042	541.1
8.0	190.6	2.28	8.33	0.7472	47.97	3.487	2.512	3.181	537.6
8.5	188.7	2.22	8.28	1.878	49.57	3.684	2.580	3.316	534.3
9.0	186.8	2.16	8.23	3.055	51.22	3.878	2.642	3.449	531.1
9.5	184.9	2.10	8.16	4.276	52.95	4.068	2.699	3.579	527.9
10.0	182.9	2.05	8.08	5.540	54.73	4.256	2.751	3.706	524.8
11.0	178.9	1.94	7.82	8.544	58.86	4.656	2.845	3.932	517.4
12.0	174.8	1.84	7.56	11.71	63.21	5.041	2.920	4.140	510.4
13.0	170.6	1.74	7.27	15.03	67.78	5.413	2.978	4.333	503.7
14.0	166.4	1.66	6.98	18.47	72.54	5.771	3.023	4.509	497.4
15.0	162.3	1.58	6.69	22.02	77.49	6.116	3.055	4.669	491.6
16.0	158.0	1.52	6.42	25.28	82.23	6.422	3.084	4.827	487.1
17.0	153.8	1.46	6.15	28.62	87.13	6.719	3.107	4.968	483.1
18.0	149.6	1.41	5.88	32.01	92.16	7.007	3.124	5.092	479.7
19.0	145.5	1.37	5.62	35.45	97.31	7.285	3.138	5.200	476.9
20.0	141.4	1.34	5.36	38.93	102.6	7.554	3.149	5.294	474.7
21.0	137.5	1.31	5.12	42.43	107.9	7.814	3.158	5.375	473.0
22.0	133.6	1.30	4.89	45.96	113.3	8.066	3.165	5.442	471.8
23.0	129.9	1.28	4.68	49.51	118.8	8.309	3.171	5.499	471.2
24.0	126.3	1.27	4.47	53.07	124.3	8.544	3.177	5.545	471.0
25.0	122.9	1.27	4.28	56.63	129.9	8.771	3.181	5.583	471.2
26.0	119.6	1.26	4.11	60.19	135.5	8.991	3.185	5.613	471.7
28.0	113.3	1.27	3.78	67.33	146.7	9.409	3.192	5.656	473.7
30.0	107.6	1.28	3.50	74.44	158.1	9.800	3.198	5.679	476.7
32.0	102.4	1.30	3.25	81.53	169.4	10.17	3.202	5.690	480.4
34.0	97.58	1.32	3.04	88.60	180.8	10.51	3.205	5.691	484.7
36.0	93.19	1.35	2.84	95.63	192.2	10.84	3.208	5.685	489.4
38.0	89.16	1.38	2.67	102.6	203.6	11.14	3.210	5.675	494.4
40.0	85.45	1.42	2.52	109.6	214.9	11.43	3.211	5.663	499.7
45.0	77.40	1.51	2.20	126.8	243.1	12.10	3.212	5.623	513.5
50.0	70.73	1.60	1.95	143.9	271.1	12.69	3.211	5.581	527.8
55.0	65.14	1.70	1.75	160.8	298.9	13.22	3.208	5.539	542.4
60.0	60.39	1.81	1.59	177.5	326.5	13.70	3.205	5.501	556.8
65.0	56.30	1.91	1.45	194.1	353.9	14.14	3.202	5.467	571.2
70.0	52.75	2.02	1.34	210.6	381.2	14.54	3.198	5.437	585.3
75.0	49.63	2.12	1.24	227.0	408.3	14.92	3.195	5.410	599.3
80.0	46.87	2.23	1.16	243.3	435.3	15.27	3.191	5.387	612.9
90.0	42.20	2.44	1.02	275.7	489.0	15.90	3.185	5.348	639.6
100.0	38.40	2.65	0.913	307.9	542.3	16.46	3.179	5.318	665.2

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5 m³·Pa/kg	Isochore derivative 10^5 Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
125.0	31.38	3.17	0.724	387.7	674.6	17.64	3.168	5.269	725.7
150.0	26.55	3.68	0.600	467.0	805.9	18.60	3.159	5.241	781.7
175.0	23.02	4.20	0.513	545.8	936.7	19.40	3.153	5.224	834.0
200.0	20.33	4.71	0.448	624.4	1067.0	20.10	3.149	5.213	883.4
225.0	18.20	5.23	0.398	702.9	1197.0	20.72	3.145	5.206	930.1
250.0	16.48	5.74	0.358	781.3	1327.0	21.26	3.143	5.201	974.7
275.0	15.05	6.25	0.326	859.5	1457.0	21.76	3.140	5.198	1017.0
300.0	13.85	6.77	0.298	937.8	1587.0	22.21	3.138	5.196	1058.0
350.0	11.95	7.80	0.256	1094.0	1847.0	23.01	3.136	5.193	1136.0
400.0	10.51	8.82	0.224	1250.0	2107.0	23.71	3.134	5.191	1209.0
450.0	9.377	9.85	0.199	1406.0	2366.0	24.32	3.132	5.190	1278.0
500.0	8.465	10.9	0.179	1562.0	2626.0	24.86	3.131	5.190	1343.0
600.0	7.086	12.9	0.149	1875.0	3145.0	25.81	3.129	5.189	1465.0
700.0	6.093	15.0	0.128	2187.0	3664.0	26.61	3.128	5.189	1577.0
800.0	5.344	17.1	0.112	2498.0	4182.0	27.30	3.127	5.189	1683.0
900.0	4.759	19.1	0.100	2810.0	4701.0	27.91	3.126	5.190	1782.0
1000.0	4.290	21.2	0.0897	3122.0	5220.0	28.46	3.125	5.190	1876.0
1100.0	3.904	23.3	0.0816	3434.0	5739.0	28.95	3.125	5.190	1965.0
1200.0	3.582	25.3	0.0748	3746.0	6258.0	29.41	3.125	5.190	2051.0
1300.0	3.309	27.4	0.0690	4058.0	6777.0	29.82	3.124	5.190	2133.0
1400.0	3.075	29.5	0.0641	4370.0	7296.0	30.21	3.124	5.190	2212.0
1500.0	2.872	31.5	0.0598	4682.0	7815.0	30.56	3.124	5.191	2288.0
				100.0 × 10^{+5} pascal Isobar					
3.5	210.0	2.70	11.6	−6.248	41.37	1.445	1.438	1.835	586.6
4.0	208.0	2.80	10.1	−5.876	42.19	1.675	1.491	1.827	585.8
4.5	206.3	2.83	9.47	−5.342	43.13	1.896	1.712	2.048	581.4
5.0	204.6	2.81	9.12	−4.599	44.27	2.124	1.977	2.330	575.8
5.1	204.3	2.81	9.07	−4.421	44.53	2.170	2.027	2.386	574.9
5.2	203.9	2.81	9.03	−4.233	44.80	2.217	2.056	2.420	574.7
5.3	203.6	2.80	8.99	−4.069	45.04	2.263	2.047	2.416	574.8
5.4	203.3	2.79	8.94	−3.904	45.29	2.308	2.063	2.437	574.4
5.5	203.0	2.78	8.91	−3.738	45.53	2.353	2.080	2.460	573.9
5.6	202.6	2.78	8.87	−3.569	45.78	2.398	2.097	2.484	573.3
5.7	202.3	2.77	8.84	−3.399	46.02	2.442	2.115	2.508	572.8
5.8	202.0	2.76	8.81	−3.227	46.27	2.486	2.133	2.533	572.2
5.9	201.7	2.75	8.79	−3.053	46.53	2.529	2.151	2.559	571.6
6.0	201.4	2.74	8.76	−2.878	46.78	2.572	2.170	2.585	570.9
6.5	199.8	2.68	8.68	−1.968	48.09	2.785	2.261	2.718	567.7
7.0	198.1	2.62	8.62	−1.009	49.46	2.991	2.347	2.853	564.3
7.5	196.5	2.56	8.58	−0.003391	50.90	3.193	2.427	2.986	561.0
8.0	194.8	2.50	8.55	1.050	52.39	3.390	2.500	3.118	557.9
8.5	193.0	2.43	8.52	2.148	53.95	3.584	2.567	3.247	554.9
9.0	191.3	2.37	8.48	3.290	55.57	3.773	2.628	3.374	551.9
9.5	189.5	2.31	8.43	4.473	57.26	3.960	2.686	3.498	549.1
10.0	187.6	2.26	8.37	5.698	59.00	4.143	2.738	3.620	546.2
11.0	183.8	2.15	8.14	8.636	63.05	4.536	2.833	3.837	539.4
12.0	179.9	2.05	7.89	11.74	67.31	4.913	2.909	4.037	532.9
13.0	176.0	1.95	7.63	14.98	71.78	5.277	2.971	4.222	526.6
14.0	172.1	1.86	7.36	18.35	76.45	5.628	3.018	4.391	520.7
15.0	168.2	1.78	7.08	21.83	81.28	5.966	3.052	4.545	515.1
16.0	164.2	1.71	6.83	25.02	85.91	6.264	3.084	4.700	510.7
17.0	160.2	1.65	6.57	28.27	90.68	6.553	3.108	4.839	506.7
18.0	156.3	1.59	6.30	31.59	95.58	6.833	3.127	4.964	503.1
19.0	152.3	1.55	6.05	34.96	100.6	7.105	3.141	5.075	500.1
20.0	148.5	1.51	5.80	38.37	105.7	7.367	3.153	5.173	497.5
21.0	144.7	1.48	5.55	41.82	110.9	7.622	3.162	5.259	495.5
22.0	140.9	1.45	5.32	45.29	116.2	7.868	3.169	5.333	493.9

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative $10^5 Pa/K$	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
23.0	137.3	1.43	5.10	48.78	121.6	8.107	3.176	5.397	492.8
24.0	133.8	1.41	4.89	52.30	127.0	8.338	3.181	5.452	492.1
25.0	130.4	1.40	4.70	55.82	132.5	8.561	3.186	5.498	491.8
26.0	127.1	1.39	4.51	59.35	138.0	8.778	3.190	5.536	491.9
28.0	120.9	1.39	4.17	66.43	149.2	9.190	3.196	5.593	493.0
30.0	115.1	1.39	3.87	73.50	160.4	9.577	3.202	5.630	495.1
32.0	109.8	1.41	3.60	80.57	171.7	9.942	3.206	5.651	498.0
34.0	104.9	1.43	3.36	87.62	183.0	10.28	3.210	5.662	501.6
36.0	100.3	1.45	3.15	94.64	194.3	10.61	3.213	5.664	505.7
38.0	96.16	1.48	2.97	101.6	205.6	10.91	3.215	5.661	510.1
40.0	92.30	1.51	2.80	108.6	216.9	11.20	3.217	5.653	514.8
45.0	83.85	1.59	2.45	125.9	245.1	11.87	3.218	5.624	527.5
50.0	76.82	1.69	2.17	143.0	273.2	12.46	3.218	5.587	540.9
55.0	70.88	1.78	1.95	159.9	301.0	12.99	3.216	5.550	554.6
60.0	65.81	1.88	1.77	176.7	328.7	13.47	3.213	5.514	568.4
65.0	61.44	1.99	1.62	193.4	356.2	13.91	3.209	5.480	582.2
70.0	57.62	2.09	1.49	209.9	383.5	14.32	3.206	5.450	595.8
75.0	54.27	2.19	1.38	226.4	410.7	14.69	3.202	5.424	609.3
80.0	51.29	2.30	1.29	242.8	437.7	15.04	3.199	5.400	622.6
90.0	46.25	2.51	1.14	275.3	491.5	15.67	3.192	5.360	648.5
100.0	42.13	2.71	1.02	307.6	544.9	16.24	3.186	5.328	673.7
125.0	34.50	3.23	0.805	387.6	677.4	17.42	3.173	5.276	733.1
150.0	29.24	3.75	0.667	466.9	808.9	18.38	3.164	5.246	788.3
175.0	25.39	4.26	0.570	545.9	939.8	19.19	3.158	5.227	840.0
200.0	22.44	4.78	0.498	624.6	1070.0	19.88	3.153	5.215	888.9
225.0	20.10	5.29	0.442	703.1	1201.0	20.50	3.149	5.207	935.3
250.0	18.21	5.80	0.398	781.5	1331.0	21.05	3.146	5.202	979.5
275.0	16.64	6.32	0.362	859.9	1461.0	21.54	3.143	5.198	1022.0
300.0	15.33	6.83	0.331	938.1	1591.0	21.99	3.141	5.196	1063.0
350.0	13.23	7.85	0.284	1094.0	1850.0	22.79	3.138	5.193	1140.0
400.0	11.64	8.88	0.249	1251.0	2110.0	23.49	3.136	5.191	1212.0
450.0	10.39	9.91	0.221	1407.0	2369.0	24.10	3.134	5.190	1281.0
500.0	9.382	10.9	0.199	1563.0	2629.0	24.65	3.132	5.189	1346.0
600.0	7.858	13.0	0.166	1875.0	3148.0	25.59	3.130	5.189	1467.0
700.0	6.759	15.1	0.142	2187.0	3667.0	26.39	3.129	5.189	1580.0
800.0	5.930	17.1	0.124	2499.0	4186.0	27.08	3.128	5.189	1685.0
900.0	5.282	19.2	0.111	2811.0	4704.0	27.70	3.127	5.189	1784.0
1000.0	4.761	21.2	0.100	3123.0	5223.0	28.24	3.127	5.189	1877.0
1100.0	4.334	23.3	0.0906	3435.0	5742.0	28.74	3.126	5.190	1967.0
1200.0	3.977	25.4	0.0831	3747.0	6261.0	29.19	3.126	5.190	2052.0
1300.0	3.674	27.4	0.0767	4059.0	6780.0	29.60	3.125	5.190	2134.0
1400.0	3.414	29.5	0.0712	4371.0	7299.0	29.99	3.125	5.190	2213.0
1500.0	3.189	31.6	0.0665	4682.0	7818.0	30.35	3.125	5.190	2289.0
				$150.0 \times 10^{+5}$ pascal Isobar					
4.5	221.8	3.63	13.7	−2.895	64.74	1.513	1.974	2.447	670.4
5.0	220.0	3.68	11.8	−2.147	66.03	1.771	2.133	2.527	660.2
5.1	219.7	3.68	11.6	−1.971	66.31	1.821	2.169	2.554	658.7
5.2	219.3	3.69	11.4	−1.785	66.60	1.871	2.184	2.561	658.0
5.3	219.0	3.69	11.1	−1.626	66.85	1.919	2.162	2.534	657.8
5.4	218.7	3.69	11.0	−1.467	67.11	1.966	2.167	2.533	657.0
5.5	218.4	3.69	10.8	−1.306	67.36	2.013	2.173	2.536	656.3
5.6	218.2	3.69	10.6	−1.145	67.61	2.059	2.181	2.541	655.5
5.7	217.9	3.69	10.5	−0.9837	67.86	2.104	2.190	2.548	654.8
5.8	217.6	3.68	10.4	−0.8200	68.12	2.148	2.199	2.556	654.1
5.9	217.3	3.68	10.2	−0.6551	68.37	2.192	2.209	2.566	653.3
6.0	217.0	3.67	10.1	−0.4888	68.63	2.235	2.220	2.577	652.6
6.5	215.7	3.63	9.78	0.3624	69.91	2.444	2.278	2.646	649.3

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative $10^5 Pa/K$	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
7.0	214.3	3.58	9.57	1.248	71.23	2.643	2.338	2.728	646.4
7.5	213.0	3.53	9.47	2.166	72.59	2.835	2.397	2.818	643.8
8.0	211.6	3.47	9.43	3.117	73.99	3.020	2.455	2.913	641.6
8.5	210.3	3.41	9.43	4.101	75.44	3.200	2.510	3.012	639.6
9.0	208.9	3.35	9.45	5.118	76.93	3.375	2.565	3.114	637.8
9.5	207.4	3.29	9.46	6.168	78.48	3.546	2.618	3.219	636.1
10.0	206.0	3.23	9.47	7.252	80.07	3.715	2.670	3.324	634.5
11.0	202.9	3.12	9.36	9.96	83.87	4.083	2.764	3.513	630.0
12.0	199.9	3.02	9.22	12.81	87.86	4.437	2.850	3.695	625.7
13.0	196.8	2.92	9.03	15.81	92.04	4.778	2.924	3.862	621.2
14.0	193.7	2.83	8.83	18.94	96.39	5.105	2.983	4.011	616.7
15.0	190.6	2.74	8.61	22.19	100.9	5.420	3.025	4.142	612.3
16.0	187.4	2.65	8.42	25.08	105.1	5.692	3.067	4.283	608.8
17.0	184.3	2.58	8.21	28.04	109.5	5.956	3.100	4.412	605.3
18.0	181.1	2.50	8.00	31.08	113.9	6.211	3.126	4.529	602.0
19.0	177.9	2.43	7.77	34.17	118.5	6.459	3.146	4.636	598.9
20.0	174.7	2.37	7.55	37.32	123.2	6.700	3.161	4.735	596.0
21.0	171.5	2.32	7.32	40.51	128.0	6.933	3.174	4.826	593.4
22.0	168.4	2.26	7.10	43.75	132.8	7.159	3.183	4.910	591.0
23.0	165.2	2.22	6.88	47.02	137.8	7.379	3.191	4.987	588.8
24.0	162.2	2.18	6.66	50.32	142.8	7.593	3.198	5.058	587.0
25.0	159.1	2.14	6.46	53.64	147.9	7.801	3.203	5.123	585.4
26.0	156.1	2.11	6.25	56.99	153.1	8.003	3.208	5.182	584.1
28.0	150.3	2.06	5.87	63.75	163.5	8.391	3.216	5.283	582.3
30.0	144.8	2.03	5.51	70.57	174.2	8.758	3.222	5.365	581.4
32.0	139.5	2.01	5.19	77.43	185.0	9.107	3.227	5.430	581.3
34.0	134.5	2.00	4.89	84.32	195.9	9.437	3.232	5.479	582.1
36.0	129.7	2.00	4.61	91.23	206.9	9.752	3.235	5.516	583.5
38.0	125.2	2.00	4.36	98.14	217.9	10.05	3.239	5.543	585.4
40.0	121.0	2.01	4.14	105.1	229.0	10.34	3.241	5.562	587.8
45.0	111.4	2.06	3.65	122.3	256.9	10.99	3.246	5.582	595.4
50.0	103.2	2.13	3.25	139.5	284.8	11.58	3.248	5.579	604.5
55.0	96.10	2.21	2.93	156.6	312.7	12.11	3.248	5.563	614.6
60.0	89.89	2.29	2.66	173.6	340.4	12.59	3.247	5.541	625.3
65.0	84.44	2.38	2.44	190.5	368.1	13.04	3.244	5.517	636.3
70.0	79.62	2.47	2.25	207.2	395.6	13.44	3.241	5.492	647.6
75.0	75.33	2.57	2.08	223.9	423.0	13.82	3.237	5.468	658.9
80.0	71.49	2.67	1.94	240.5	450.3	14.18	3.234	5.445	670.3
90.0	64.91	2.87	1.71	273.4	504.5	14.81	3.226	5.404	693.0
100.0	59.46	3.07	1.53	306.1	558.4	15.38	3.218	5.369	715.4
125.0	49.21	3.57	1.21	387.0	691.8	16.57	3.202	5.306	769.5
150.0	42.02	4.08	1.00	467.0	823.9	17.54	3.189	5.267	820.9
175.0	36.69	4.59	0.853	546.4	955.2	18.35	3.179	5.242	869.7
200.0	32.57	5.10	0.745	625.5	1086.0	19.04	3.172	5.225	916.1
225.0	29.29	5.60	0.661	704.3	1217.0	19.66	3.166	5.214	960.5
250.0	26.61	6.11	0.595	783.0	1347.0	20.21	3.161	5.206	1003.0
275.0	24.38	6.62	0.541	861.5	1477.0	20.70	3.158	5.201	1044.0
300.0	22.49	7.13	0.495	940.0	1607.0	21.16	3.154	5.197	1084.0
350.0	19.48	8.14	0.425	1097.0	1867.0	21.96	3.150	5.192	1159.0
400.0	17.18	9.16	0.372	1253.0	2126.0	22.65	3.146	5.190	1229.0
450.0	15.37	10.2	0.331	1409.0	2386.0	23.26	3.143	5.188	1296.0
500.0	13.90	11.2	0.298	1566.0	2645.0	23.81	3.141	5.187	1360.0
600.0	11.67	13.3	0.248	1878.0	3164.0	24.75	3.138	5.187	1480.0
700.0	10.05	15.3	0.213	2190.0	3682.0	25.55	3.136	5.187	1591.0
800.0	8.832	17.4	0.186	2503.0	4201.0	26.25	3.134	5.187	1694.0
900.0	7.874	19.4	0.166	2815.0	4720.0	26.86	3.133	5.187	1792.0
1000.0	7.103	21.5	0.149	3127.0	5238.0	27.40	3.132	5.188	1885.0
1100.0	6.470	23.5	0.136	3439.0	5757.0	27.90	3.131	5.188	1974.0
1200.0	5.940	25.6	0.124	3751.0	6276.0	28.35	3.130	5.188	2059.0
1300.0	5.491	27.6	0.115	4063.0	6795.0	28.76	3.130	5.188	2140.0

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative $10^5 Pa/K$	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
1400.0	5.104	29.7	0.107	4375.0	7314.0	29.15	3.129	5.189	2219.0
1500.0	4.769	31.8	0.100	4687.0	7833.0	29.51	3.129	5.189	2294.0
				$200.0 \times 10^{+5}$ pascal Isobar					
5.2	231.6	4.45	14.5	0.8074	87.15	1.561	2.516	2.975	725.7
5.3	231.3	4.46	14.1	0.9814	87.44	1.617	2.467	2.905	725.1
5.4	231.0	4.47	13.6	1.153	87.73	1.671	2.446	2.866	723.9
5.5	230.7	4.48	13.2	1.325	88.02	1.723	2.429	2.834	722.8
5.6	230.4	4.48	12.9	1.496	88.30	1.774	2.415	2.807	721.7
5.7	230.1	4.49	12.6	1.666	88.57	1.824	2.404	2.784	720.7
5.8	229.9	4.49	12.3	1.837	88.85	1.872	2.395	2.765	719.7
5.9	229.6	4.49	12.0	2.007	89.12	1.919	2.388	2.750	718.8
6.0	229.3	4.49	11.8	2.178	89.39	1.965	2.383	2.738	717.9
6.5	228.0	4.47	11.0	3.035	90.74	2.183	2.374	2.712	714.2
7.0	226.8	4.43	10.5	3.903	92.07	2.384	2.385	2.723	711.3
7.5	225.7	4.38	10.2	4.785	93.41	2.573	2.406	2.759	709.0
8.0	224.5	4.33	10.1	5.682	94.77	2.753	2.435	2.811	707.3
8.5	223.3	4.28	10.1	6.598	96.16	2.926	2.469	2.878	706.1
9.0	222.1	4.22	10.2	7.535	97.57	3.093	2.509	2.954	705.1
9.5	220.9	4.17	10.2	8.496	99.03	3.255	2.552	3.040	704.3
10.0	219.7	4.11	10.3	9.485	100.5	3.413	2.599	3.132	703.6
11.0	217.1	4.00	10.3	12.03	104.2	3.766	2.689	3.307	701.0
12.0	214.4	3.90	10.2	14.71	108.0	4.106	2.783	3.484	698.3
13.0	211.7	3.80	10.1	17.55	112.0	4.433	2.870	3.650	695.1
14.0	209.1	3.71	9.94	20.53	116.2	4.749	2.940	3.795	691.6
15.0	206.4	3.62	9.75	23.63	120.5	5.052	2.990	3.916	688.3
16.0	203.7	3.53	9.61	26.32	124.5	5.310	3.041	4.050	685.6
17.0	201.0	3.45	9.45	29.10	128.6	5.559	3.081	4.171	683.0
18.0	198.2	3.37	9.27	31.95	132.8	5.800	3.113	4.282	680.3
19.0	195.5	3.29	9.07	34.86	137.2	6.035	3.138	4.383	677.7
20.0	192.7	3.22	8.87	37.82	141.6	6.262	3.158	4.476	675.2
21.0	189.9	3.15	8.67	40.83	146.1	6.482	3.174	4.563	672.8
22.0	187.2	3.09	8.46	43.89	150.7	6.697	3.187	4.644	670.5
23.0	184.5	3.03	8.25	46.99	155.4	6.905	3.197	4.719	668.3
24.0	181.7	2.97	8.05	50.12	160.2	7.107	3.206	4.790	666.3
25.0	179.0	2.92	7.85	53.29	165.0	7.304	3.213	4.857	664.4
26.0	176.4	2.87	7.65	56.48	169.9	7.496	3.219	4.919	662.7
28.0	171.1	2.79	7.26	62.95	179.8	7.864	3.229	5.033	659.7
30.0	166.0	2.73	6.89	69.51	190.0	8.215	3.237	5.132	657.4
32.0	161.0	2.67	6.54	76.14	200.4	8.549	3.244	5.217	655.8
34.0	156.2	2.64	6.21	82.83	210.9	8.868	3.250	5.289	654.8
36.0	151.6	2.61	5.90	89.56	221.5	9.172	3.255	5.349	654.5
38.0	147.2	2.59	5.62	96.34	232.2	9.462	3.259	5.398	654.7
40.0	142.9	2.58	5.35	103.1	243.1	9.740	3.263	5.438	655.3
45.0	133.1	2.58	4.76	120.2	270.5	10.38	3.270	5.503	658.9
50.0	124.4	2.61	4.28	137.3	298.1	10.97	3.275	5.534	664.5
55.0	116.7	2.67	3.87	154.4	325.8	11.49	3.277	5.542	671.5
60.0	109.9	2.73	3.53	171.4	353.5	11.98	3.277	5.538	679.5
65.0	103.8	2.81	3.23	188.4	381.1	12.42	3.275	5.525	688.1
70.0	98.31	2.89	2.99	205.3	408.7	12.83	3.273	5.508	697.3
75.0	93.41	2.98	2.77	222.1	436.2	13.21	3.270	5.490	706.7
80.0	88.97	3.06	2.59	238.8	463.6	13.56	3.266	5.470	716.4
90.0	81.28	3.25	2.28	272.1	518.1	14.20	3.258	5.432	736.1
100.0	74.85	3.44	2.03	305.0	572.3	14.77	3.249	5.398	755.9
125.0	62.55	3.93	1.61	386.6	706.3	15.97	3.230	5.330	805.1
150.0	53.79	4.42	1.33	467.1	838.9	16.94	3.214	5.285	852.7
175.0	47.21	4.92	1.13	547.0	970.7	17.75	3.202	5.254	898.6
200.0	42.08	5.42	0.990	626.5	1102.0	18.45	3.192	5.234	942.7

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative $10^5 Pa/K$	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
225.0	37.97	5.92	0.879	705.6	1232.0	19.07	3.184	5.220	985.1
250.0	34.59	6.42	0.790	784.5	1363.0	19.62	3.178	5.210	1026.0
275.0	31.76	6.92	0.718	863.3	1493.0	20.11	3.172	5.203	1066.0
300.0	29.37	7.43	0.658	941.9	1623.0	20.56	3.168	5.198	1104.0
350.0	25.51	8.43	0.564	1099.0	1883.0	21.36	3.161	5.192	1177.0
400.0	22.56	9.44	0.494	1256.0	2142.0	22.06	3.157	5.188	1246.0
450.0	20.21	10.5	0.439	1412.0	2402.0	22.67	3.153	5.187	1312.0
500.0	18.31	11.5	0.396	1568.0	2661.0	23.22	3.150	5.186	1374.0
600.0	15.41	13.5	0.330	1881.0	3179.0	24.16	3.146	5.185	1492.0
700.0	13.30	15.5	0.283	2194.0	3698.0	24.96	3.143	5.185	1601.0
800.0	11.69	17.6	0.248	2506.0	4216.0	25.65	3.140	5.185	1704.0
900.0	10.44	19.6	0.221	2818.0	4735.0	26.26	3.139	5.185	1801.0
1000.0	9.421	21.7	0.199	3131.0	5253.0	26.81	3.137	5.186	1893.0
1100.0	8.587	23.7	0.181	3443.0	5772.0	27.30	3.136	5.186	1981.0
1200.0	7.887	25.8	0.166	3755.0	6291.0	27.75	3.135	5.187	2065.0
1300.0	7.294	27.8	0.153	4067.0	6809.0	28.17	3.135	5.187	2146.0
1400.0	6.783	29.9	0.142	4379.0	7328.0	28.55	3.134	5.187	2224.0
1500.0	6.339	31.9	0.133	4691.0	7847.0	28.91	3.133	5.187	2299.0
				$250.0 \times 10^{+5}$ pascal Isobar					
5.9	239.9	5.23	14.2	4.754	109.0	1.674	2.679	3.076	774.7
6.0	239.6	5.23	13.8	4.940	109.3	1.725	2.649	3.032	773.6
6.5	238.4	5.23	12.4	5.849	110.7	1.961	2.543	2.877	769.2
7.0	237.2	5.21	11.5	6.738	112.1	2.171	2.482	2.798	766.1
7.5	236.1	5.17	11.0	7.614	113.5	2.363	2.450	2.766	763.9
8.0	235.1	5.12	10.8	8.486	114.8	2.542	2.439	2.768	762.6
8.5	234.0	5.07	10.7	9.359	116.2	2.711	2.444	2.796	761.8
9.0	233.0	5.02	10.8	10.24	117.5	2.872	2.462	2.844	761.5
9.5	231.9	4.97	10.8	11.13	118.9	3.027	2.491	2.909	761.4
10.0	230.8	4.91	10.9	12.05	120.4	3.179	2.528	2.986	761.5
11.0	228.5	4.80	11.1	14.45	123.9	3.519	2.613	3.150	760.6
12.0	226.1	4.70	11.1	17.00	127.6	3.848	2.714	3.329	759.2
13.0	223.7	4.61	11.0	19.72	131.5	4.166	2.813	3.500	757.0
14.0	221.3	4.52	10.9	22.58	135.6	4.474	2.895	3.648	754.4
15.0	218.9	4.43	10.7	25.57	139.8	4.771	2.952	3.766	751.7
16.0	216.4	4.34	10.6	28.11	143.6	5.018	3.011	3.898	749.9
17.0	214.0	4.26	10.5	30.75	147.6	5.258	3.057	4.015	747.9
18.0	211.5	4.18	10.3	33.45	151.7	5.490	3.095	4.122	746.0
19.0	209.0	4.10	10.2	36.22	155.8	5.716	3.125	4.219	743.9
20.0	206.6	4.02	10.0	39.05	160.1	5.935	3.148	4.308	741.9
21.0	204.1	3.95	9.79	41.93	164.4	6.147	3.168	4.390	739.9
22.0	201.6	3.88	9.59	44.86	168.9	6.353	3.183	4.467	737.9
23.0	199.1	3.81	9.40	47.82	173.4	6.553	3.196	4.539	736.0
24.0	196.7	3.75	9.20	50.83	177.9	6.748	3.207	4.608	734.1
25.0	194.2	3.69	9.01	53.87	182.6	6.937	3.216	4.672	732.3
26.0	191.8	3.64	8.81	56.94	187.3	7.121	3.224	4.734	730.6
28.0	187.0	3.53	8.43	63.17	196.9	7.476	3.237	4.847	727.4
30.0	182.3	3.44	8.06	69.50	206.7	7.814	3.248	4.950	724.6
32.0	177.6	3.37	7.70	75.92	216.7	8.137	3.256	5.042	722.2
34.0	173.1	3.31	7.36	82.42	226.8	8.445	3.264	5.123	720.3
36.0	168.7	3.25	7.04	88.98	237.1	8.740	3.271	5.195	718.9
38.0	164.5	3.21	6.73	95.60	247.6	9.023	3.277	5.257	717.9
40.0	160.4	3.18	6.44	102.3	258.2	9.294	3.282	5.311	717.4
45.0	150.7	3.14	5.79	119.1	285.0	9.925	3.292	5.411	717.9
50.0	141.9	3.13	5.23	136.0	312.2	10.50	3.299	5.471	720.6
55.0	133.9	3.16	4.76	153.0	339.7	11.02	3.303	5.504	725.0
60.0	126.8	3.20	4.35	170.0	367.2	11.50	3.304	5.517	730.7
65.0	120.3	3.26	4.01	187.0	394.8	11.94	3.304	5.518	737.3

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative $10^5 Pa/K$	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
70.0	114.4	3.32	3.70	203.9	422.4	12.35	3.303	5.511	744.5
75.0	109.1	3.40	3.44	220.8	449.9	12.73	3.300	5.499	752.3
80.0	104.3	3.48	3.22	237.6	477.4	13.09	3.297	5.484	760.4
90.0	95.80	3.65	2.84	271.1	532.0	13.73	3.289	5.451	777.4
100.0	88.62	3.83	2.54	304.3	586.4	14.30	3.280	5.419	794.9
125.0	74.73	4.29	2.00	386.4	720.9	15.50	3.258	5.349	839.5
150.0	64.67	4.77	1.66	467.4	854.0	16.47	3.239	5.300	883.7
175.0	57.04	5.26	1.41	547.8	986.1	17.29	3.224	5.266	926.8
200.0	51.04	5.75	1.23	627.6	1117.0	17.99	3.212	5.242	968.6
225.0	46.19	6.24	1.09	707.0	1248.0	18.61	3.202	5.226	1009.0
250.0	42.19	6.73	0.984	786.1	1379.0	19.16	3.194	5.214	1048.0
275.0	38.83	7.23	0.894	865.1	1509.0	19.65	3.188	5.205	1087.0
300.0	35.97	7.73	0.820	943.9	1639.0	20.11	3.182	5.199	1124.0
350.0	31.34	8.72	0.703	1101.0	1899.0	20.91	3.174	5.191	1195.0
400.0	27.77	9.73	0.615	1258.0	2158.0	21.60	3.167	5.187	1262.0
450.0	24.93	10.7	0.548	1415.0	2417.0	22.21	3.163	5.185	1326.0
500.0	22.62	11.7	0.493	1571.0	2677.0	22.76	3.159	5.184	1388.0
600.0	19.07	13.8	0.411	1884.0	3195.0	23.70	3.153	5.183	1504.0
700.0	16.49	15.8	0.353	2197.0	3713.0	24.50	3.150	5.183	1612.0
800.0	14.52	17.8	0.309	2509.0	4231.0	25.19	3.147	5.183	1713.0
900.0	12.97	19.9	0.275	2822.0	4750.0	25.80	3.145	5.184	1809.0
1000.0	11.72	21.9	0.248	3134.0	5268.0	26.35	3.143	5.184	1900.0
1100.0	10.68	23.9	0.225	3447.0	5787.0	26.84	3.142	5.185	1988.0
1200.0	9.819	26.0	0.207	3759.0	6305.0	27.29	3.140	5.185	2071.0
1300.0	9.084	28.0	0.191	4071.0	6824.0	27.71	3.139	5.185	2152.0
1400.0	8.450	30.1	0.177	4384.0	7342.0	28.09	3.139	5.186	2229.0
1500.0	7.899	32.1	0.165	4696.0	7861.0	28.45	3.138	5.186	2304.0
				300.0 × 10^{+5} pascal Isobar					
7.0	246.2	5.93	12.6	9.656	131.5	1.986	2.627	2.934	814.2
7.5	245.2	5.90	11.8	10.55	132.9	2.184	2.528	2.823	812.0
8.0	244.2	5.86	11.4	11.42	134.3	2.364	2.467	2.766	810.8
8.5	243.2	5.82	11.3	12.27	135.6	2.532	2.435	2.749	810.4
9.0	242.3	5.77	11.3	13.11	136.9	2.689	2.426	2.765	810.5
9.5	241.3	5.71	11.4	13.95	138.3	2.840	2.436	2.805	811.1
10.0	240.3	5.66	11.5	14.80	139.7	2.985	2.461	2.866	811.9
11.0	238.1	5.55	11.8	17.08	143.1	3.315	2.537	3.020	812.6
12.0	235.9	5.45	11.9	19.51	146.7	3.634	2.645	3.204	812.4
13.0	233.7	5.36	11.9	22.11	150.5	3.945	2.757	3.384	811.1
14.0	231.5	5.27	11.8	24.87	154.5	4.247	2.851	3.539	809.1
15.0	229.3	5.19	11.6	27.77	158.6	4.539	2.916	3.658	806.9
16.0	227.0	5.11	11.5	30.20	162.4	4.779	2.981	3.788	805.8
17.0	224.8	5.03	11.4	32.72	166.2	5.013	3.033	3.905	804.5
18.0	222.5	4.95	11.3	35.31	170.2	5.239	3.075	4.009	803.0
19.0	220.2	4.87	11.1	37.97	174.2	5.458	3.109	4.103	801.6
20.0	217.9	4.79	10.9	40.69	178.4	5.671	3.136	4.189	800.0
21.0	215.6	4.72	10.8	43.46	182.6	5.877	3.159	4.269	798.4
22.0	213.4	4.65	10.6	46.28	186.9	6.077	3.177	4.343	796.8
23.0	211.1	4.58	10.4	49.14	191.3	6.272	3.192	4.412	795.2
24.0	208.8	4.51	10.2	52.05	195.7	6.461	3.205	4.478	793.6
25.0	206.5	4.44	10.0	54.98	200.2	6.645	3.216	4.540	792.0
26.0	204.3	4.38	9.83	57.95	204.8	6.824	3.226	4.599	790.4
28.0	199.8	4.27	9.45	63.99	214.1	7.169	3.242	4.710	787.3
30.0	195.4	4.16	9.08	70.13	223.6	7.498	3.255	4.811	784.4
32.0	191.1	4.07	8.73	76.37	233.3	7.811	3.266	4.904	781.8
34.0	186.9	3.99	8.38	82.70	243.2	8.111	3.275	4.989	779.5
36.0	182.7	3.92	8.05	89.11	253.3	8.399	3.284	5.066	777.5
38.0	178.7	3.86	7.73	95.58	263.5	8.674	3.291	5.134	775.8

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative $10^5 Pa/K$	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v	C_p	Velocity of sound m/s
							kJ/kg·K		
40.0	174.7	3.81	7.43	102.1	273.8	8.939	3.298	5.196	774.5
45.0	165.3	3.72	6.73	118.6	300.1	9.559	3.311	5.318	772.9
50.0	156.6	3.68	6.13	135.4	326.9	10.12	3.321	5.402	773.3
55.0	148.6	3.67	5.60	152.3	354.1	10.64	3.327	5.455	775.4
60.0	141.3	3.69	5.14	169.2	381.5	11.12	3.330	5.486	779.0
65.0	134.7	3.72	4.74	186.1	408.9	11.56	3.332	5.500	783.7
70.0	128.6	3.77	4.40	203.1	436.4	11.96	3.331	5.503	789.3
75.0	123.0	3.83	4.10	220.0	463.9	12.34	3.329	5.499	795.6
80.0	117.9	3.90	3.83	236.9	491.4	12.70	3.326	5.490	802.3
90.0	108.8	4.05	3.38	270.5	546.2	13.34	3.318	5.464	816.9
100.0	101.1	4.22	3.03	303.9	600.7	13.92	3.309	5.435	832.3
125.0	85.90	4.66	2.39	386.4	735.7	15.12	3.285	5.366	872.7
150.0	74.78	5.13	1.98	467.9	869.1	16.10	3.264	5.314	913.6
175.0	66.25	5.60	1.69	548.6	1001.0	16.91	3.246	5.276	954.1
200.0	59.49	6.08	1.47	628.8	1133.0	17.62	3.232	5.249	993.8
225.0	54.00	6.56	1.31	708.5	1264.0	18.23	3.220	5.231	1033.0
250.0	49.44	7.05	1.18	787.8	1395.0	18.78	3.211	5.217	1070.0
275.0	45.60	7.54	1.07	867.0	1525.0	19.28	3.203	5.207	1107.0
300.0	42.31	8.03	0.980	945.9	1655.0	19.73	3.196	5.200	1143.0
350.0	36.98	9.02	0.840	1103.0	1915.0	20.53	3.186	5.191	1212.0
400.0	32.84	10.0	0.736	1261.0	2174.0	21.23	3.178	5.186	1278.0
450.0	29.53	11.0	0.655	1417.0	2433.0	21.84	3.172	5.183	1341.0
500.0	26.83	12.0	0.590	1574.0	2692.0	22.38	3.168	5.181	1401.0
600.0	22.67	14.0	0.492	1887.0	3210.0	23.33	3.161	5.180	1515.0
700.0	19.63	16.0	0.423	2200.0	3729.0	24.13	3.156	5.181	1622.0
800.0	17.30	18.1	0.370	2513.0	4247.0	24.82	3.153	5.181	1722.0
900.0	15.47	20.1	0.329	2826.0	4765.0	25.43	3.150	5.182	1817.0
1000.0	13.99	22.1	0.297	3138.0	5283.0	25.97	3.148	5.182	1908.0
1100.0	12.76	24.2	0.270	3451.0	5801.0	26.47	3.147	5.183	1994.0
1200.0	11.74	26.2	0.248	3763.0	6319.0	26.92	3.145	5.183	2077.0
1300.0	10.86	28.2	0.229	4076.0	6838.0	27.33	3.144	5.184	2157.0
1400.0	10.11	30.3	0.212	4388.0	7356.0	27.72	3.143	5.184	2234.0
1500.0	9.451	32.3	0.198	4701.0	7875.0	28.08	3.142	5.185	2309.0
				$350.0 \times 10^{+5}$ pascal Isobar					
7.5	253.2	6.60	12.6	13.55	151.8	2.026	2.636	2.918	855.0
8.0	252.3	6.57	12.0	14.42	153.2	2.210	2.516	2.794	853.8
8.5	251.4	6.52	11.8	15.26	154.5	2.377	2.441	2.728	853.6
9.0	250.4	6.47	11.8	16.07	155.8	2.533	2.400	2.707	854.2
9.5	249.5	6.42	11.8	16.87	157.1	2.679	2.387	2.721	855.3
10.0	248.6	6.37	12.0	17.67	158.5	2.820	2.396	2.763	856.7
11.0	246.6	6.25	12.4	19.84	161.8	3.139	2.463	2.907	859.0
12.0	244.6	6.16	12.6	22.15	165.3	3.450	2.577	3.097	860.1
13.0	242.5	6.07	12.7	24.64	169.0	3.754	2.701	3.289	859.7
14.0	240.4	5.99	12.6	27.32	172.9	4.052	2.808	3.453	858.2
15.0	238.3	5.91	12.5	30.15	177.0	4.341	2.882	3.575	856.4
16.0	236.2	5.83	12.4	32.47	180.7	4.576	2.952	3.706	855.7
17.0	234.0	5.76	12.3	34.89	184.4	4.804	3.009	3.821	854.9
18.0	231.9	5.68	12.1	37.39	188.3	5.025	3.055	3.924	854.0
19.0	229.8	5.60	12.0	39.95	192.3	5.240	3.093	4.017	853.0
20.0	227.6	5.53	11.8	42.58	196.3	5.448	3.123	4.102	851.8
21.0	225.5	5.45	11.7	45.26	200.5	5.650	3.148	4.179	850.7
22.0	223.3	5.38	11.5	47.99	204.7	5.846	3.169	4.251	849.4
23.0	221.2	5.31	11.3	50.76	209.0	6.037	3.187	4.319	848.1
24.0	219.1	5.24	11.1	53.58	213.3	6.222	3.201	4.382	846.8
25.0	217.0	5.17	10.9	56.43	217.7	6.402	3.214	4.442	845.4
26.0	214.9	5.11	10.7	59.32	222.2	6.577	3.225	4.499	844.1
28.0	210.7	4.98	10.4	65.19	231.3	6.915	3.244	4.606	841.3

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative 10^5m³ · Pa/kg	Isochore derivative 10^5Pa/K	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg ·K	C_v kJ/kg ·K	C_p kJ/kg ·K	Velocity of sound m/s
30.0	206.5	4.87	10.0	71.17	240.6	7.236	3.259	4.705	838.5
32.0	202.5	4.77	9.65	77.26	250.1	7.543	3.273	4.797	835.9
34.0	198.4	4.67	9.30	83.45	259.8	7.836	3.284	4.882	833.4
36.0	194.5	4.59	8.96	89.71	269.7	8.117	3.294	4.960	831.1
38.0	190.6	4.51	8.63	96.05	279.7	8.387	3.304	5.031	829.0
40.0	186.8	4.45	8.32	102.5	289.8	8.647	3.312	5.096	827.2
45.0	177.8	4.32	7.60	118.7	315.6	9.256	3.329	5.232	824.0
50.0	169.3	4.24	6.96	135.3	342.0	9.812	3.341	5.332	822.6
55.0	161.4	4.20	6.39	152.0	368.9	10.32	3.350	5.402	823.0
60.0	154.1	4.19	5.89	168.8	396.0	10.80	3.355	5.447	824.8
65.0	147.3	4.20	5.45	185.7	423.3	11.23	3.357	5.475	827.8
70.0	141.1	4.23	5.06	202.6	450.7	11.64	3.358	5.489	831.9
75.0	135.3	4.28	4.72	219.6	478.2	12.02	3.356	5.493	836.7
80.0	130.0	4.33	4.42	236.5	505.7	12.37	3.354	5.490	842.2
90.0	120.6	4.47	3.92	270.2	560.5	13.02	3.347	5.472	854.5
100.0	112.4	4.62	3.51	303.7	615.1	13.59	3.337	5.447	868.0
125.0	96.21	5.04	2.78	386.6	750.4	14.80	3.312	5.380	904.6
150.0	84.20	5.49	2.30	468.5	884.2	15.78	3.289	5.326	942.5
175.0	74.91	5.95	1.96	549.6	1017.0	16.60	3.269	5.286	980.6
200.0	67.50	6.42	1.71	630.0	1149.0	17.30	3.252	5.256	1018.0
225.0	61.44	6.89	1.52	710.0	1280.0	17.92	3.239	5.235	1055.0
250.0	56.38	7.37	1.37	789.6	1410.0	18.47	3.228	5.220	1092.0
275.0	52.10	7.85	1.24	868.9	1541.0	18.96	3.219	5.209	1127.0
300.0	48.42	8.33	1.14	948.1	1671.0	19.42	3.211	5.201	1162.0
350.0	42.44	9.31	0.977	1106.0	1931.0	20.22	3.199	5.190	1229.0
400.0	37.77	10.3	0.855	1263.0	2190.0	20.91	3.190	5.184	1293.0
450.0	34.02	11.3	0.761	1420.0	2449.0	21.52	3.183	5.181	1355.0
500.0	30.95	12.3	0.686	1577.0	2708.0	22.07	3.177	5.179	1414.0
600.0	26.21	14.3	0.573	1891.0	3226.0	23.01	3.169	5.178	1526.0
700.0	22.73	16.3	0.492	2204.0	3744.0	23.81	3.164	5.178	1632.0
800.0	20.06	18.3	0.431	2517.0	4262.0	24.50	3.159	5.179	1731.0
900.0	17.95	20.3	0.383	2829.0	4780.0	25.11	3.156	5.180	1825.0
1000.0	16.24	22.3	0.345	3142.0	5298.0	25.66	3.154	5.180	1915.0
1100.0	14.83	24.4	0.314	3455.0	5816.0	26.15	3.152	5.181	2001.0
1200.0	13.64	26.4	0.288	3767.0	6334.0	26.60	3.150	5.182	2083.0
1300.0	12.63	28.4	0.266	4080.0	6852.0	27.02	3.149	5.182	2163.0
1400.0	11.75	30.5	0.247	4393.0	7370.0	27.40	3.148	5.183	2239.0
1500.0	10.99	32.5	0.231	4705.0	7889.0	27.76	3.147	5.183	2313.0
				400.0 × 10^{+5} pascal Isobar					
8.0	259.5	7.24	12.6	17.47	171.6	2.073	2.585	2.847	892.9
8.5	258.6	7.19	12.3	18.31	173.0	2.241	2.461	2.726	892.8
9.0	257.8	7.14	12.2	19.10	174.3	2.395	2.384	2.665	893.6
9.5	256.9	7.09	12.3	19.86	175.5	2.539	2.344	2.650	895.2
10.0	256.1	7.04	12.5	20.61	176.8	2.675	2.335	2.671	897.2
11.0	254.2	6.93	13.0	22.67	180.0	2.985	2.390	2.804	901.3
12.0	252.3	6.83	13.3	24.87	183.4	3.287	2.511	3.001	903.6
13.0	250.3	6.75	13.5	27.26	187.1	3.586	2.648	3.206	904.0
14.0	248.3	6.67	13.4	29.86	191.0	3.880	2.768	3.381	903.0
15.0	246.3	6.60	13.3	32.62	195.0	4.166	2.850	3.509	901.5
16.0	244.3	6.53	13.2	34.86	198.6	4.396	2.925	3.640	901.2
17.0	242.2	6.45	13.1	37.19	202.3	4.621	2.986	3.756	900.8
18.0	240.2	6.38	13.0	39.60	206.1	4.838	3.036	3.859	900.3
19.0	238.2	6.30	12.8	42.08	210.0	5.049	3.077	3.951	899.7
20.0	236.1	6.23	12.7	44.63	214.0	5.254	3.110	4.035	898.9
21.0	234.1	6.16	12.5	47.23	218.1	5.453	3.138	4.111	898.1
22.0	232.1	6.09	12.3	49.88	222.2	5.646	3.161	4.182	897.2
23.0	230.0	6.01	12.2	52.58	226.5	5.833	3.180	4.247	896.2

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^6 m^3 \cdot Pa/kg$	Isochore derivative $10^5 Pa/K$	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
24.0	228.0	5.95	12.0	55.32	230.7	6.015	3.197	4.309	895.1
25.0	226.0	5.88	11.8	58.10	235.1	6.192	3.211	4.367	894.0
26.0	224.0	5.81	11.6	60.92	239.5	6.365	3.224	4.423	892.9
28.0	220.0	5.68	11.2	66.64	248.4	6.696	3.245	4.527	890.4
30.0	216.1	5.56	10.9	72.49	257.6	7.012	3.263	4.623	887.9
32.0	212.2	5.45	10.5	78.45	266.9	7.313	3.278	4.713	885.4
34.0	208.4	5.35	10.1	84.51	276.4	7.602	3.292	4.796	882.9
36.0	204.7	5.26	9.80	90.65	286.1	7.878	3.304	4.874	880.5
38.0	201.0	5.17	9.47	96.88	295.9	8.143	3.314	4.946	878.2
40.0	197.3	5.09	9.15	103.2	305.9	8.399	3.324	5.012	876.1
45.0	188.6	4.93	8.40	119.2	331.3	8.998	3.345	5.155	871.8
50.0	180.3	4.82	7.73	135.5	357.4	9.547	3.360	5.266	869.1
55.0	172.6	4.75	7.13	152.1	383.9	10.05	3.371	5.348	867.9
60.0	165.3	4.71	6.60	168.8	410.8	10.52	3.378	5.406	868.2
65.0	158.5	4.70	6.12	185.7	437.9	10.96	3.382	5.445	869.8
70.0	152.3	4.71	5.70	202.5	465.2	11.36	3.383	5.469	872.4
75.0	146.4	4.74	5.33	219.4	492.6	11.74	3.383	5.481	876.0
80.0	141.0	4.78	5.00	236.3	520.0	12.09	3.381	5.485	880.3
90.0	131.3	4.89	4.43	270.1	574.8	12.74	3.374	5.476	890.5
100.0	122.8	5.02	3.98	303.7	629.5	13.31	3.365	5.456	902.2
125.0	105.8	5.41	3.16	387.0	765.1	14.52	3.338	5.393	935.2
150.0	93.03	5.85	2.61	469.3	899.2	15.50	3.313	5.338	970.4
175.0	83.08	6.30	2.23	550.7	1032.0	16.32	3.291	5.295	1006.0
200.0	75.09	6.75	1.95	631.4	1164.0	17.03	3.273	5.263	1042.0
225.0	68.53	7.22	1.73	711.6	1295.0	17.64	3.258	5.240	1077.0
250.0	63.03	7.69	1.55	791.4	1426.0	18.20	3.245	5.223	1112.0
275.0	58.35	8.16	1.41	871.0	1557.0	18.69	3.234	5.211	1146.0
300.0	54.32	8.64	1.30	950.3	1687.0	19.15	3.225	5.201	1180.0
350.0	47.73	9.60	1.11	1108.0	1946.0	19.95	3.211	5.189	1245.0
400.0	42.56	10.6	0.974	1266.0	2206.0	20.64	3.201	5.183	1308.0
450.0	38.40	11.5	0.867	1423.0	2465.0	21.25	3.193	5.179	1368.0
500.0	34.98	12.5	0.781	1580.0	2724.0	21.79	3.186	5.177	1427.0
600.0	29.69	14.5	0.653	1894.0	3241.0	22.74	3.177	5.176	1537.0
700.0	25.78	16.5	0.561	2207.0	3759.0	23.54	3.171	5.176	1641.0
800.0	22.77	18.5	0.491	2520.0	4276.0	24.23	3.166	5.177	1740.0
900.0	20.40	20.5	0.437	2833.0	4794.0	24.84	3.162	5.178	1833.0
1000.0	18.47	22.5	0.394	3146.0	5312.0	25.38	3.160	5.179	1922.0
1100.0	16.87	24.6	0.358	3459.0	5830.0	25.88	3.157	5.180	2007.0
1200.0	15.53	26.6	0.329	3772.0	6348.0	26.33	3.155	5.180	2089.0
1300.0	14.38	28.6	0.304	4084.0	6866.0	26.74	3.154	5.181	2168.0
1400.0	13.39	30.6	0.282	4397.0	7384.0	27.13	3.152	5.182	2244.0
1500.0	12.53	32.7	0.264	4710.0	7902.0	27.48	3.151	5.182	2318.0
				450.0 × 10^{+5} pascal Isobar					
8.5	265.3	7.85	12.7	21.39	191.0	2.120	2.492	2.739	928.6
9.0	264.5	7.79	12.5	22.17	192.3	2.273	2.375	2.634	929.7
9.5	263.7	7.74	12.6	22.91	193.6	2.414	2.307	2.588	931.6
10.0	262.9	7.68	12.8	23.61	194.8	2.547	2.277	2.587	934.2
11.0	261.1	7.57	13.5	25.56	197.9	2.846	2.318	2.707	940.0
12.0	259.3	7.48	14.0	27.65	201.2	3.140	2.445	2.913	943.8
13.0	257.4	7.40	14.2	29.94	204.8	3.433	2.596	3.132	944.9
14.0	255.4	7.33	14.2	32.46	208.6	3.724	2.729	3.320	944.4
15.0	253.5	7.27	14.0	35.16	212.7	4.008	2.822	3.456	943.3
16.0	251.6	7.19	14.0	37.31	216.2	4.235	2.900	3.587	943.3
17.0	249.6	7.12	13.9	39.56	219.9	4.456	2.965	3.704	943.2
18.0	247.7	7.05	13.8	41.90	223.6	4.671	3.018	3.807	943.0
19.0	245.7	6.98	13.6	44.31	227.5	4.879	3.062	3.899	942.7
20.0	243.7	6.91	13.5	46.78	231.4	5.081	3.098	3.982	942.2

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^6 m^3 \cdot Pa/kg$	Isochore derivative $10^6 Pa/K$	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
21.0	241.8	6.84	13.3	49.32	235.4	5.278	3.128	4.058	941.7
22.0	239.9	6.77	13.1	51.90	239.5	5.468	3.153	4.127	941.1
23.0	237.9	6.70	13.0	54.53	243.7	5.653	3.174	4.192	940.4
24.0	236.0	6.63	12.8	57.21	247.9	5.832	3.192	4.252	939.6
25.0	234.1	6.56	12.6	59.92	252.2	6.007	3.208	4.309	938.7
26.0	232.2	6.49	12.4	62.68	256.5	6.177	3.222	4.363	937.7
28.0	228.4	6.37	12.0	68.28	265.3	6.504	3.246	4.465	935.7
30.0	224.6	6.24	11.6	74.01	274.4	6.816	3.265	4.558	933.4
32.0	220.9	6.13	11.3	79.85	283.6	7.113	3.283	4.646	931.1
34.0	217.2	6.02	10.9	85.80	292.9	7.397	3.298	4.728	928.6
36.0	213.6	5.91	10.6	91.83	302.5	7.669	3.312	4.804	926.2
38.0	210.1	5.82	10.2	97.96	312.2	7.931	3.324	4.876	923.9
40.0	206.6	5.73	9.91	104.2	322.0	8.183	3.336	4.943	921.6
45.0	198.1	5.55	9.15	120.0	347.1	8.774	3.359	5.089	916.6
50.0	190.1	5.41	8.45	136.1	372.8	9.316	3.378	5.206	912.9
55.0	182.5	5.31	7.83	152.5	399.1	9.817	3.391	5.297	910.5
60.0	175.4	5.24	7.27	169.1	425.7	10.28	3.400	5.365	909.5
65.0	168.7	5.21	6.76	185.9	452.7	10.71	3.405	5.413	909.8
70.0	162.4	5.20	6.31	202.7	479.8	11.11	3.408	5.445	911.2
75.0	156.5	5.21	5.91	219.6	507.1	11.49	3.409	5.465	913.5
80.0	151.0	5.23	5.55	236.5	534.5	11.84	3.407	5.475	916.7
90.0	141.1	5.31	4.94	270.3	589.3	12.49	3.401	5.476	924.9
100.0	132.4	5.43	4.44	304.0	644.0	13.07	3.392	5.462	935.0
125.0	114.7	5.79	3.53	387.5	779.8	14.28	3.365	5.405	964.7
150.0	101.3	6.21	2.92	470.1	914.2	15.26	3.337	5.349	997.0
175.0	90.81	6.64	2.50	551.8	1047.0	16.08	3.313	5.304	1031.0
200.0	82.32	7.09	2.18	632.8	1179.0	16.79	3.293	5.270	1065.0
225.0	75.30	7.54	1.93	713.3	1311.0	17.40	3.276	5.245	1099.0
250.0	69.40	8.01	1.74	793.4	1442.0	17.96	3.262	5.226	1132.0
275.0	64.36	8.47	1.58	873.1	1572.0	18.45	3.250	5.212	1165.0
300.0	60.01	8.94	1.45	952.5	1702.0	18.91	3.240	5.202	1198.0
350.0	52.66	9.89	1.25	1111.0	1962.0	19.71	3.224	5.189	1261.0
400.0	47.23	10.8	1.09	1269.0	2221.0	20.40	3.212	5.181	1323.0
450.0	42.68	11.8	0.972	1426.0	2480.0	21.01	3.203	5.177	1382.0
500.0	38.93	12.8	0.876	1583.0	2739.0	21.56	3.196	5.175	1439.0
600.0	33.10	14.8	0.732	1897.0	3257.0	22.50	3.185	5.174	1548.0
700.0	28.79	16.7	0.629	2211.0	3774.0	23.30	3.178	5.174	1651.0
800.0	25.46	18.7	0.551	2524.0	4291.0	23.99	3.172	5.175	1748.0
900.0	22.82	20.7	0.491	2837.0	4809.0	24.60	3.168	5.176	1840.0
1000.0	20.68	22.7	0.442	3150.0	5326.0	25.14	3.165	5.177	1929.0
1100.0	18.90	24.8	0.402	3463.0	5844.0	25.64	3.162	5.178	2013.0
1200.0	17.40	26.8	0.369	3776.0	6362.0	26.09	3.160	5.179	2094.0
1300.0	16.12	28.8	0.341	4089.0	6880.0	26.50	3.158	5.179	2173.0
1400.0	15.02	30.8	0.317	4402.0	7398.0	26.88	3.157	5.180	2249.0
1500.0	14.06	32.8	0.296	4714.0	7916.0	27.24	3.156	5.181	2322.0
				500.0 × 10^{+5} pascal Isobar					
9.0	270.7	8.42	12.8	25.27	210.0	2.163	2.373	2.613	962.8
9.5	269.9	8.36	12.9	25.98	211.2	2.302	2.273	2.532	965.1
10.0	269.1	8.30	13.1	26.66	212.4	2.431	2.221	2.508	968.1
11.0	267.5	8.19	14.0	28.50	215.4	2.720	2.248	2.615	976.0
12.0	265.7	8.10	14.6	30.46	218.6	3.006	2.380	2.829	981.2
13.0	263.8	8.03	14.9	32.66	222.2	3.294	2.545	3.064	983.2
14.0	262.0	7.97	15.0	35.09	226.0	3.581	2.693	3.266	983.2
15.0	260.1	7.91	14.8	37.74	230.0	3.864	2.795	3.410	982.3
16.0	258.2	7.84	14.8	39.82	233.5	4.088	2.877	3.543	982.5
17.0	256.3	7.77	14.7	42.00	237.1	4.306	2.945	3.661	982.7
18.0	254.4	7.70	14.5	44.27	240.8	4.519	3.002	3.764	982.7

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative $10^5 Pa/K$	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v	C_p	Velocity of sound m/s
							kJ/kg·K		
19.0	252.5	7.63	14.4	46.61	244.6	4.725	3.048	3.857	982.6
20.0	250.7	7.56	14.2	49.02	248.5	4.925	3.086	3.939	982.5
21.0	248.8	7.49	14.1	51.49	252.5	5.119	3.118	4.015	982.2
22.0	246.9	7.42	13.9	54.01	256.5	5.307	3.145	4.083	981.8
23.0	245.0	7.36	13.7	56.58	260.6	5.490	3.168	4.147	981.4
24.0	243.2	7.29	13.5	59.20	264.8	5.668	3.187	4.207	980.8
25.0	241.3	7.22	13.3	61.86	269.0	5.841	3.204	4.263	980.1
26.0	239.5	7.16	13.2	64.55	273.3	6.009	3.220	4.316	979.4
28.0	235.8	7.03	12.8	70.05	282.1	6.333	3.246	4.415	977.7
30.0	232.2	6.90	12.4	75.67	291.0	6.640	3.268	4.507	975.7
32.0	228.6	6.78	12.0	81.41	300.1	6.934	3.287	4.592	973.5
34.0	225.1	6.67	11.7	87.25	309.4	7.215	3.304	4.673	971.3
36.0	221.6	6.56	11.3	93.20	318.8	7.484	3.319	4.748	968.9
38.0	218.2	6.46	11.0	99.23	328.3	7.743	3.333	4.819	966.5
40.0	214.9	6.37	10.6	105.3	338.0	7.991	3.346	4.885	964.2
45.0	206.7	6.16	9.85	120.9	362.9	8.576	3.373	5.032	958.8
50.0	198.9	6.00	9.14	136.9	388.3	9.112	3.394	5.153	954.3
55.0	191.5	5.87	8.49	153.2	414.3	9.608	3.410	5.249	950.9
60.0	184.4	5.79	7.90	169.7	440.8	10.07	3.421	5.324	948.9
65.0	177.8	5.73	7.37	186.3	467.5	10.50	3.428	5.380	948.0
70.0	171.6	5.69	6.90	203.1	494.5	10.90	3.432	5.420	948.3
75.0	165.7	5.68	6.47	219.9	521.7	11.27	3.433	5.447	949.5
80.0	160.2	5.69	6.09	236.8	549.0	11.62	3.433	5.463	951.7
90.0	150.1	5.75	5.43	270.6	603.7	12.27	3.427	5.474	958.0
100.0	141.2	5.84	4.88	304.4	658.4	12.84	3.419	5.466	966.5
125.0	123.1	6.17	3.89	388.2	794.5	14.06	3.390	5.415	993.0
150.0	109.2	6.57	3.23	471.1	929.1	15.04	3.361	5.359	1023.0
175.0	98.15	6.99	2.76	553.1	1062.0	15.86	3.336	5.313	1055.0
200.0	89.21	7.43	2.41	634.3	1195.0	16.57	3.314	5.277	1087.0
225.0	81.79	7.87	2.14	715.1	1326.0	17.19	3.295	5.250	1120.0
250.0	75.52	8.32	1.92	795.3	1457.0	17.74	3.280	5.229	1152.0
275.0	70.16	8.78	1.75	875.2	1588.0	18.24	3.266	5.214	1184.0
300.0	65.51	9.24	1.60	954.8	1718.0	18.69	3.255	5.203	1215.0
350.0	57.84	10.2	1.38	1113.0	1978.0	19.49	3.237	5.188	1277.0
400.0	51.78	11.1	1.21	1271.0	2237.0	20.19	3.224	5.180	1337.0
450.0	46.87	12.1	1.08	1429.0	2496.0	20.80	3.214	5.175	1395.0
500.0	42.80	13.0	0.970	1586.0	2755.0	21.34	3.205	5.173	1451.0
600.0	36.46	15.0	0.811	1900.0	3272.0	22.28	3.193	5.171	1558.0
700.0	31.75	17.0	0.697	2214.0	3789.0	23.08	3.185	5.172	1660.0
800.0	28.11	19.0	0.611	2528.0	4306.0	23.77	3.179	5.173	1756.0
900.0	25.22	20.9	0.544	2841.0	4823.0	24.38	3.174	5.174	1848.0
1000.0	22.86	22.9	0.490	3154.0	5341.0	24.93	3.171	5.175	1935.0
1100.0	20.91	25.0	0.446	3467.0	5858.0	25.42	3.168	5.176	2019.0
1200.0	19.26	27.0	0.409	3780.0	6376.0	25.87	3.165	5.177	2100.0
1300.0	17.85	29.0	0.378	4093.0	6894.0	26.28	3.163	5.178	2178.0
1400.0	16.64	31.0	0.352	4406.0	7412.0	26.67	3.162	5.179	2253.0
1500.0	15.57	33.0	0.328	4719.0	7930.0	27.03	3.160	5.179	2326.0
				$600.0 \times 10^{+5}$ pascal Isobar					
11.0	278.9	9.37	14.7	34.45	249.6	2.499	2.106	2.434	1041.0
12.0	277.2	9.29	15.7	36.17	252.6	2.768	2.250	2.666	1049.0
13.0	275.4	9.24	16.3	38.16	256.0	3.044	2.445	2.936	1053.0
14.0	273.6	9.20	16.4	40.44	259.7	3.325	2.624	3.171	1054.0
15.0	271.8	9.15	16.3	42.97	263.7	3.606	2.749	3.336	1054.0
16.0	270.0	9.09	16.2	44.92	267.1	3.826	2.837	3.472	1054.0
17.0	268.2	9.02	16.1	46.97	270.6	4.040	2.910	3.592	1055.0
18.0	266.5	8.95	16.0	49.12	274.3	4.248	2.972	3.698	1055.0
19.0	264.7	8.88	15.9	51.34	278.0	4.451	3.022	3.791	1056.0

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^6 m^3 \cdot Pa/kg$	Isochore derivative $10^5 Pa/K$	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
20.0	262.9	8.82	15.7	53.64	281.9	4.647	3.065	3.875	1056.0
21.0	261.1	8.75	15.5	56.00	285.8	4.838	3.100	3.950	1056.0
22.0	259.3	8.69	15.4	58.41	289.8	5.024	3.131	4.019	1056.0
23.0	257.6	8.62	15.2	60.88	293.8	5.204	3.157	4.082	1056.0
24.0	255.8	8.56	15.0	63.39	297.9	5.379	3.179	4.141	1056.0
25.0	254.1	8.49	14.8	65.95	302.1	5.549	3.199	4.196	1055.0
26.0	252.3	8.43	14.6	68.54	306.3	5.714	3.216	4.248	1055.0
28.0	248.9	8.30	14.2	73.85	314.9	6.033	3.247	4.344	1054.0
30.0	245.5	8.18	13.8	79.29	323.7	6.336	3.272	4.432	1052.0
32.0	242.1	8.06	13.4	84.85	332.6	6.624	3.295	4.515	1051.0
34.0	238.8	7.94	13.0	90.53	341.7	6.900	3.315	4.592	1049.0
36.0	235.6	7.83	12.7	96.31	351.0	7.165	3.333	4.664	1047.0
38.0	232.4	7.72	12.3	102.2	360.4	7.419	3.350	4.733	1044.0
40.0	229.2	7.62	12.0	108.1	369.9	7.663	3.365	4.797	1042.0
45.0	221.5	7.38	11.1	123.4	394.3	8.237	3.398	4.942	1036.0
50.0	214.1	7.18	10.4	139.1	419.3	8.764	3.425	5.065	1031.0
55.0	207.0	7.02	9.71	155.1	444.9	9.252	3.445	5.168	1026.0
60.0	200.3	6.89	9.08	171.4	471.0	9.705	3.460	5.251	1022.0
65.0	193.8	6.79	8.51	187.8	497.4	10.13	3.470	5.317	1020.0
70.0	187.7	6.71	7.99	204.5	524.1	10.52	3.476	5.368	1018.0
75.0	181.9	6.66	7.53	221.2	551.0	10.90	3.480	5.405	1017.0
80.0	176.4	6.64	7.10	238.1	578.1	11.25	3.481	5.432	1018.0
90.0	166.3	6.64	6.36	271.8	632.6	11.89	3.478	5.461	1021.0
100.0	157.2	6.68	5.74	305.6	687.3	12.46	3.470	5.466	1026.0
125.0	138.3	6.94	4.60	389.9	823.6	13.68	3.440	5.431	1047.0
150.0	123.6	7.29	3.82	473.3	958.7	14.67	3.409	5.378	1072.0
175.0	111.8	7.68	3.27	555.8	1093.0	15.49	3.380	5.329	1101.0
200.0	102.1	8.10	2.86	637.6	1225.0	16.20	3.354	5.290	1130.0
225.0	93.99	8.52	2.54	718.7	1357.0	16.82	3.333	5.259	1160.0
250.0	87.10	8.96	2.29	799.4	1488.0	17.37	3.314	5.236	1190.0
275.0	81.16	9.40	2.08	879.7	1619.0	17.87	3.299	5.218	1219.0
300.0	75.99	9.85	1.91	959.6	1749.0	18.33	3.285	5.205	1249.0
350.0	67.40	10.8	1.64	1119.0	2009.0	19.13	3.264	5.187	1307.0
400.0	60.55	11.7	1.44	1277.0	2268.0	19.82	3.247	5.177	1365.0
450.0	54.97	12.6	1.28	1435.0	2527.0	20.43	3.235	5.171	1420.0
500.0	50.32	13.6	1.16	1593.0	2785.0	20.97	3.225	5.168	1474.0
600.0	43.02	15.5	0.967	1907.0	3302.0	21.91	3.210	5.166	1579.0
700.0	37.57	17.4	0.831	2221.0	3819.0	22.71	3.200	5.167	1677.0
800.0	33.33	19.4	0.729	2535.0	4335.0	23.40	3.192	5.168	1772.0
900.0	29.95	21.4	0.650	2849.0	4852.0	24.01	3.187	5.170	1861.0
1000.0	27.18	23.3	0.586	3162.0	5369.0	24.55	3.182	5.171	1948.0
1100.0	24.89	25.3	0.533	3475.0	5886.0	25.05	3.178	5.173	2030.0
1200.0	22.94	27.3	0.490	3789.0	6404.0	25.50	3.175	5.174	2110.0
1300.0	21.28	29.3	0.452	4102.0	6921.0	25.91	3.173	5.175	2187.0
1400.0	19.84	31.3	0.420	4415.0	7439.0	26.30	3.171	5.176	2262.0
1500.0	18.59	33.3	0.393	4728.0	7956.0	26.65	3.169	5.177	2334.0
				$700.0 \times 10^{+5}$ pascal Isobar					
12.0	287.4	10.4	16.6	41.95	285.5	2.561	2.118	2.501	1110.0
13.0	285.6	10.4	17.4	43.72	288.8	2.825	2.345	2.810	1116.0
14.0	283.9	10.4	17.7	45.83	292.4	3.100	2.558	3.083	1118.0
15.0	282.1	10.4	17.6	48.24	296.4	3.379	2.709	3.274	1119.0
16.0	280.4	10.3	17.6	50.08	299.8	3.595	2.802	3.414	1120.0
17.0	278.7	10.2	17.5	52.02	303.2	3.806	2.880	3.537	1120.0
18.0	276.9	10.1	17.4	54.06	306.8	4.011	2.946	3.646	1121.0
19.0	275.2	10.1	17.3	56.18	310.5	4.211	3.001	3.742	1121.0
20.0	273.5	10.0	17.1	58.38	314.3	4.405	3.047	3.827	1121.0
21.0	271.8	9.95	16.9	60.64	318.2	4.594	3.086	3.904	1122.0

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative $10^5 Pa/K$	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
22.0	270.1	9.88	16.7	62.96	322.1	4.777	3.119	3.974	1122.0
23.0	268.4	9.82	16.5	65.33	326.1	4.955	3.147	4.037	1122.0
24.0	266.7	9.76	16.3	67.76	330.2	5.128	3.172	4.096	1122.0
25.0	265.1	9.70	16.1	70.23	334.3	5.296	3.194	4.151	1122.0
26.0	263.4	9.64	15.9	72.74	338.5	5.460	3.214	4.202	1122.0
28.0	260.1	9.51	15.5	77.89	347.0	5.775	3.248	4.297	1122.0
30.0	256.9	9.39	15.1	83.17	355.7	6.075	3.277	4.383	1121.0
32.0	253.7	9.27	14.7	88.59	364.5	6.360	3.303	4.463	1119.0
34.0	250.5	9.16	14.3	94.12	373.5	6.633	3.326	4.538	1118.0
36.0	247.4	9.04	13.9	99.8	382.7	6.894	3.347	4.608	1116.0
38.0	244.4	8.93	13.6	105.5	391.9	7.145	3.366	4.675	1114.0
40.0	241.4	8.83	13.2	111.3	401.4	7.387	3.384	4.737	1112.0
45.0	234.0	8.58	12.3	126.3	425.4	7.953	3.422	4.879	1106.0
50.0	227.0	8.35	11.5	141.7	450.1	8.474	3.453	5.001	1100.0
55.0	220.2	8.16	10.8	157.5	475.4	8.955	3.477	5.105	1094.0
60.0	213.7	7.99	10.2	173.6	501.1	9.403	3.496	5.191	1090.0
65.0	207.5	7.86	9.55	189.9	527.3	9.822	3.509	5.262	1086.0
70.0	201.6	7.75	9.00	206.5	553.7	10.21	3.518	5.319	1082.0
75.0	195.9	7.67	8.50	223.1	580.4	10.58	3.524	5.364	1080.0
80.0	190.5	7.61	8.04	239.9	607.4	10.93	3.527	5.399	1079.0
90.0	180.4	7.55	7.23	273.6	661.6	11.57	3.526	5.441	1079.0
100.0	171.3	7.54	6.55	307.4	716.1	12.14	3.519	5.459	1082.0
125.0	152.0	7.71	5.28	392.0	852.5	13.36	3.489	5.442	1097.0
150.0	136.7	8.01	4.40	475.8	987.9	14.35	3.455	5.394	1118.0
175.0	124.3	8.37	3.77	558.8	1122.0	15.18	3.423	5.345	1143.0
200.0	114.0	8.76	3.30	641.1	1255.0	15.89	3.395	5.304	1170.0
225.0	105.3	9.17	2.93	722.7	1387.0	16.51	3.370	5.270	1197.0
250.0	97.89	9.59	2.64	803.7	1519.0	17.06	3.349	5.244	1225.0
275.0	91.47	10.0	2.40	884.3	1650.0	17.56	3.331	5.223	1253.0
300.0	85.85	10.4	2.20	964.6	1780.0	18.02	3.316	5.208	1281.0
350.0	76.46	11.3	1.89	1124.0	2040.0	18.82	3.290	5.187	1336.0
400.0	68.92	12.2	1.66	1283.0	2299.0	19.51	3.271	5.174	1391.0
450.0	62.73	13.1	1.48	1441.0	2557.0	20.12	3.256	5.168	1444.0
500.0	57.55	14.1	1.34	1599.0	2816.0	20.66	3.244	5.164	1497.0
600.0	49.39	16.0	1.12	1914.0	3332.0	21.60	3.227	5.161	1598.0
700.0	43.23	17.9	0.964	2229.0	3848.0	22.40	3.215	5.162	1694.0
800.0	38.43	19.8	0.846	2543.0	4364.0	23.09	3.206	5.164	1786.0
900.0	34.58	21.8	0.754	2857.0	4881.0	23.70	3.199	5.166	1875.0
1000.0	31.43	23.7	0.680	3170.0	5397.0	24.24	3.193	5.167	1960.0
1100.0	28.80	25.7	0.620	3484.0	5914.0	24.73	3.189	5.169	2041.0
1200.0	26.58	27.7	0.569	3798.0	6431.0	25.18	3.186	5.171	2120.0
1300.0	24.67	29.7	0.526	4111.0	6948.0	25.60	3.183	5.172	2196.0
1400.0	23.02	31.7	0.489	4425.0	7466.0	25.98	3.180	5.173	2270.0
1500.0	21.57	33.7	0.457	4738.0	7983.0	26.34	3.178	5.174	2341.0
				800.0 × 10^{+5} pascal Isobar					
13.0	294.8	11.5	18.3	49.31	320.7	2.631	2.242	2.678	1173.0
14.0	293.0	11.5	18.9	51.24	324.3	2.899	2.492	2.994	1177.0
15.0	291.2	11.6	18.9	53.53	328.2	3.176	2.671	3.216	1179.0
16.0	289.6	11.5	18.8	55.26	331.5	3.389	2.769	3.360	1179.0
17.0	287.9	11.4	18.8	57.11	335.0	3.596	2.852	3.488	1180.0
18.0	286.3	11.3	18.7	59.05	338.5	3.799	2.922	3.601	1180.0
19.0	284.6	11.2	18.6	61.08	342.2	3.996	2.981	3.700	1181.0
20.0	283.0	11.2	18.4	63.18	345.9	4.188	3.031	3.789	1181.0
21.0	281.3	11.1	18.2	65.36	349.7	4.375	3.073	3.868	1182.0
22.0	279.7	11.0	18.0	67.60	353.6	4.557	3.109	3.939	1182.0
23.0	278.1	11.0	17.8	69.89	357.6	4.733	3.140	4.004	1183.0

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative $10^5 Pa/K$	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
24.0	276.4	10.9	17.6	72.24	361.6	4.905	3.167	4.064	1183.0
25.0	274.8	10.8	17.4	74.63	365.7	5.072	3.192	4.119	1183.0
26.0	273.2	10.8	17.2	77.07	369.9	5.235	3.213	4.171	1183.0
28.0	270.0	10.7	16.8	82.07	378.3	5.547	3.251	4.265	1183.0
30.0	266.9	10.6	16.4	87.22	386.9	5.845	3.283	4.351	1183.0
32.0	263.8	10.4	15.9	92.51	395.7	6.128	3.312	4.430	1182.0
34.0	260.8	10.3	15.5	97.92	404.6	6.399	3.337	4.503	1180.0
36.0	257.8	10.2	15.1	103.4	413.7	6.658	3.360	4.572	1179.0
38.0	254.9	10.1	14.7	109.1	422.9	6.907	3.382	4.636	1177.0
40.0	252.0	10.0	14.3	114.8	432.3	7.146	3.402	4.697	1175.0
45.0	245.0	9.74	13.4	129.5	456.1	7.708	3.445	4.835	1169.0
50.0	238.2	9.50	12.6	144.7	480.6	8.223	3.480	4.955	1163.0
55.0	231.7	9.29	11.8	160.3	505.6	8.701	3.508	5.057	1157.0
60.0	225.4	9.10	11.2	176.3	531.1	9.144	3.530	5.144	1151.0
65.0	219.4	8.94	10.5	192.5	557.0	9.559	3.546	5.217	1146.0
70.0	213.7	8.80	9.93	208.9	583.3	9.948	3.558	5.278	1142.0
75.0	208.1	8.69	9.40	225.4	609.8	10.31	3.566	5.327	1139.0
80.0	202.8	8.60	8.91	242.1	636.5	10.66	3.570	5.366	1137.0
90.0	192.9	8.47	8.05	275.8	690.5	11.29	3.572	5.419	1134.0
100.0	183.8	8.42	7.32	309.7	744.8	11.87	3.566	5.446	1134.0
125.0	164.4	8.49	5.92	394.4	881.1	13.08	3.537	5.447	1144.0
150.0	148.6	8.73	4.95	478.6	1017.0	14.07	3.501	5.407	1161.0
175.0	135.7	9.05	4.25	562.1	1151.0	14.90	3.466	5.360	1183.0
200.0	125.0	9.42	3.72	644.8	1285.0	15.62	3.435	5.317	1207.0
225.0	115.8	9.81	3.31	726.8	1417.0	16.24	3.408	5.281	1233.0
250.0	108.0	10.2	2.98	808.2	1549.0	16.80	3.384	5.252	1258.0
275.0	101.2	10.6	2.71	889.2	1680.0	17.29	3.364	5.229	1285.0
300.0	95.16	11.0	2.49	969.7	1810.0	17.75	3.346	5.211	1311.0
350.0	85.07	11.9	2.14	1130.0	2070.0	18.55	3.317	5.187	1364.0
400.0	76.92	12.8	1.88	1289.0	2329.0	19.24	3.295	5.172	1416.0
450.0	70.19	13.7	1.68	1448.0	2588.0	19.85	3.278	5.164	1467.0
500.0	64.53	14.6	1.52	1606.0	2846.0	20.39	3.264	5.160	1518.0
600.0	55.56	16.4	1.27	1922.0	3362.0	21.33	3.244	5.157	1616.0
700.0	48.76	18.3	1.10	2236.0	3877.0	22.13	3.230	5.157	1710.0
800.0	43.43	20.2	0.962	2551.0	4393.0	22.82	3.219	5.159	1801.0
900.0	39.14	22.2	0.858	2865.0	4909.0	23.43	3.211	5.161	1887.0
1000.0	35.61	24.1	0.774	3179.0	5425.0	23.97	3.205	5.164	1971.0
1100.0	32.67	26.1	0.705	3493.0	5942.0	24.46	3.200	5.166	2051.0
1200.0	30.17	28.0	0.647	3807.0	6458.0	24.91	3.196	5.167	2129.0
1300.0	28.02	30.0	0.599	4120.0	6975.0	25.33	3.192	5.169	2204.0
1400.0	26.16	32.0	0.557	4434.0	7492.0	25.71	3.190	5.170	2277.0
1500.0	24.53	34.0	0.520	4748.0	8009.0	26.07	3.187	5.172	2348.0
				900.0 × 10^{+5} pascal Isobar					
14.0	301.3	12.7	19.8	56.65	355.4	2.718	2.423	2.899	1232.0
15.0	299.5	12.7	19.9	58.80	359.4	2.993	2.635	3.155	1235.0
16.0	297.9	12.6	20.0	60.45	362.6	3.202	2.737	3.306	1235.0
17.0	296.3	12.5	19.9	62.20	366.0	3.406	2.825	3.440	1235.0
18.0	294.7	12.4	19.9	64.06	369.5	3.606	2.900	3.558	1235.0
19.0	293.1	12.4	19.8	66.01	373.1	3.802	2.963	3.662	1236.0
20.0	291.5	12.3	19.6	68.03	376.8	3.992	3.016	3.754	1236.0
21.0	289.9	12.2	19.5	70.13	380.6	4.177	3.061	3.836	1237.0
22.0	288.3	12.1	19.3	72.29	384.4	4.357	3.100	3.910	1238.0
23.0	286.7	12.1	19.1	74.51	388.4	4.533	3.134	3.977	1238.0
24.0	285.2	12.0	18.9	76.78	392.4	4.703	3.164	4.038	1239.0
25.0	283.6	12.0	18.7	79.11	396.5	4.869	3.190	4.095	1239.0
26.0	282.0	11.9	18.4	81.48	400.6	5.031	3.214	4.148	1239.0
28.0	279.0	11.8	18.0	86.35	409.0	5.342	3.255	4.243	1239.0

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative $10^5 Pa/K$	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
30.0	275.9	11.7	17.5	91.38	417.6	5.637	3.290	4.329	1239.0
32.0	272.9	11.6	17.1	96.55	426.3	5.919	3.321	4.408	1238.0
34.0	270.0	11.4	16.7	101.9	435.2	6.189	3.349	4.480	1237.0
36.0	267.1	11.3	16.2	107.3	444.2	6.447	3.374	4.548	1236.0
38.0	264.3	11.2	15.8	112.8	453.4	6.694	3.398	4.611	1234.0
40.0	261.5	11.1	15.4	118.5	462.6	6.932	3.420	4.671	1232.0
45.0	254.7	10.9	14.5	133.0	486.3	7.491	3.468	4.806	1227.0
50.0	248.2	10.6	13.6	148.0	510.7	8.003	3.507	4.922	1221.0
55.0	241.9	10.4	12.8	163.4	535.5	8.477	3.538	5.023	1214.0
60.0	235.8	10.2	12.1	179.2	560.9	8.918	3.563	5.109	1208.0
65.0	230.0	10.0	11.4	195.3	586.6	9.330	3.582	5.182	1203.0
70.0	224.4	9.84	10.8	211.6	612.7	9.716	3.596	5.244	1198.0
75.0	219.0	9.71	10.2	228.1	639.0	10.08	3.606	5.295	1194.0
80.0	213.9	9.59	9.73	244.8	665.6	10.42	3.612	5.337	1190.0
90.0	204.1	9.42	8.81	278.4	719.3	11.06	3.615	5.397	1186.0
100.0	195.1	9.31	8.03	312.2	773.5	11.63	3.611	5.432	1184.0
125.0	175.6	9.28	6.54	397.1	909.6	12.84	3.583	5.449	1188.0
150.0	159.6	9.46	5.48	481.7	1046.0	13.83	3.545	5.417	1202.0
175.0	146.4	9.74	4.71	565.6	1180.0	14.66	3.508	5.373	1221.0
200.0	135.2	10.1	4.13	648.7	1314.0	15.38	3.474	5.329	1243.0
225.0	125.7	10.4	3.68	731.1	1447.0	16.00	3.445	5.291	1266.0
250.0	117.5	10.8	3.32	812.9	1579.0	16.56	3.419	5.260	1290.0
275.0	110.3	11.2	3.02	894.2	1710.0	17.06	3.396	5.235	1315.0
300.0	104.0	11.6	2.78	975.0	1841.0	17.51	3.376	5.215	1340.0
350.0	93.28	12.5	2.39	1136.0	2101.0	18.32	3.344	5.188	1390.0
400.0	84.59	13.3	2.10	1296.0	2359.0	19.01	3.320	5.171	1440.0
450.0	77.37	14.2	1.87	1455.0	2618.0	19.62	3.300	5.161	1489.0
500.0	71.28	15.1	1.69	1613.0	2876.0	20.16	3.284	5.156	1538.0
600.0	61.56	16.9	1.42	1929.0	3391.0	21.10	3.261	5.152	1633.0
700.0	54.15	18.8	1.22	2244.0	3906.0	21.89	3.245	5.152	1725.0
800.0	48.32	20.6	1.08	2559.0	4421.0	22.58	3.233	5.154	1814.0
900.0	43.61	22.6	0.960	2873.0	4937.0	23.19	3.224	5.157	1899.0
1000.0	39.73	24.5	0.866	3187.0	5453.0	23.73	3.217	5.160	1982.0
1100.0	36.48	26.4	0.790	3502.0	5969.0	24.22	3.211	5.162	2061.0
1200.0	33.71	28.4	0.725	3816.0	6485.0	24.67	3.206	5.164	2138.0
1300.0	31.34	30.3	0.671	4130.0	7002.0	25.09	3.202	5.166	2212.0
1400.0	29.27	32.3	0.624	4443.0	7518.0	25.47	3.199	5.168	2284.0
1500.0	27.46	34.3	0.583	4757.0	8035.0	25.83	3.196	5.169	2355.0
				$1000 \times 10^{+5}$ pascal Isobar					
14.0	308.8	13.8	20.4	62.06	385.9	2.555	2.350	2.794	1282.0
15.0	307.0	13.9	20.7	64.06	389.8	2.827	2.596	3.089	1286.0
16.0	305.5	13.8	20.9	65.63	393.0	3.032	2.704	3.247	1286.0
17.0	303.9	13.7	20.9	67.31	396.3	3.233	2.797	3.388	1286.0
18.0	302.4	13.6	20.9	69.08	399.8	3.430	2.877	3.513	1287.0
19.0	300.8	13.5	20.9	70.95	403.3	3.623	2.944	3.623	1287.0
20.0	299.3	13.4	20.7	72.90	407.0	3.811	3.001	3.720	1288.0
21.0	297.7	13.3	20.6	74.93	410.8	3.995	3.050	3.806	1288.0
22.0	296.2	13.2	20.4	77.02	414.6	4.174	3.092	3.883	1289.0
23.0	294.7	13.2	20.2	79.17	418.5	4.348	3.128	3.953	1289.0
24.0	293.1	13.1	20.0	81.38	422.5	4.518	3.160	4.017	1290.0
25.0	291.6	13.0	19.8	83.64	426.6	4.683	3.189	4.075	1290.0
26.0	290.1	13.0	19.6	85.95	430.7	4.844	3.214	4.130	1291.0
28.0	287.1	12.9	19.1	90.70	439.0	5.153	3.259	4.227	1291.0
30.0	284.1	12.7	18.7	95.63	447.6	5.448	3.297	4.315	1291.0
32.0	281.2	12.6	18.2	100.7	456.3	5.729	3.331	4.393	1291.0
34.0	278.4	12.5	17.8	105.9	465.2	5.998	3.361	4.466	1290.0
36.0	275.5	12.4	17.3	111.2	474.2	6.255	3.389	4.533	1289.0

Thermodynamic properties of helium 4—Continued

Temperature K	Density kg/m³	Isotherm derivative $10^5 m^3 \cdot Pa/kg$	Isochore derivative $10^5 Pa/K$	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg·K	C_v kJ/kg·K	C_p kJ/kg·K	Velocity of sound m/s
38.0	272.8	12.3	16.9	116.7	483.3	6.502	3.415	4.596	1287.0
40.0	270.1	12.2	16.5	122.2	492.5	6.739	3.438	4.654	1285.0
45.0	263.5	11.9	15.5	136.6	516.1	7.295	3.490	4.787	1280.0
50.0	257.1	11.7	14.5	151.4	540.4	7.805	3.533	4.901	1274.0
55.0	251.0	11.5	13.7	166.8	565.1	8.277	3.568	4.999	1268.0
60.0	245.2	11.3	13.0	182.4	590.3	8.716	3.595	5.084	1261.0
65.0	239.5	11.1	12.3	198.4	615.9	9.126	3.617	5.156	1255.0
70.0	234.1	10.9	11.6	214.7	641.9	9.510	3.633	5.218	1250.0
75.0	228.8	10.7	11.0	231.1	668.1	9.872	3.644	5.269	1245.0
80.0	223.8	10.6	10.5	247.7	694.6	10.21	3.652	5.313	1241.0
90.0	214.2	10.4	9.53	281.2	748.0	10.84	3.658	5.377	1234.0
100.0	205.4	10.2	8.71	315.1	802.0	11.41	3.655	5.417	1230.0
125.0	185.9	10.1	7.12	400.2	938.0	12.63	3.628	5.447	1230.0
150.0	169.8	10.2	5.99	485.0	1074.0	13.62	3.589	5.424	1240.0
175.0	156.3	10.4	5.16	569.3	1209.0	14.45	3.550	5.383	1256.0
200.0	144.9	10.7	4.53	652.7	1343.0	15.17	3.514	5.340	1276.0
225.0	135.0	11.1	4.04	735.5	1476.0	15.79	3.482	5.302	1297.0
250.0	126.5	11.4	3.64	817.7	1608.0	16.35	3.453	5.269	1320.0
275.0	119.0	11.8	3.32	899.3	1740.0	16.85	3.429	5.242	1343.0
300.0	112.4	12.2	3.05	980.5	1870.0	17.31	3.407	5.220	1367.0
350.0	101.1	13.0	2.63	1142.0	2130.0	18.11	3.372	5.189	1414.0
400.0	91.96	13.8	2.31	1302.0	2389.0	18.80	3.344	5.170	1462.0
450.0	84.30	14.7	2.06	1461.0	2648.0	19.41	3.322	5.158	1510.0
500.0	77.81	15.6	1.87	1620.0	2905.0	19.95	3.305	5.152	1557.0
600.0	67.40	17.3	1.57	1937.0	3420.0	20.89	3.278	5.147	1650.0
700.0	59.43	19.2	1.35	2252.0	3935.0	21.68	3.260	5.147	1740.0
800.0	53.12	21.0	1.19	2567.0	4450.0	22.37	3.247	5.150	1827.0
900.0	48.01	22.9	1.06	2882.0	4965.0	22.98	3.236	5.153	1911.0
1000.0	43.78	24.8	0.958	3196.0	5480.0	23.52	3.228	5.156	1992.0
1100.0	40.24	26.8	0.873	3511.0	5996.0	24.01	3.222	5.158	2070.0
1200.0	37.22	28.7	0.803	3825.0	6512.0	24.46	3.217	5.161	2146.0
1300.0	34.61	30.7	0.742	4139.0	7028.0	24.87	3.212	5.163	2220.0
1400.0	32.35	32.6	0.691	4453.0	7544.0	25.26	3.208	5.165	2291.0
1500.0	30.36	34.6	0.646	4767.0	8061.0	25.61	3.205	5.166	2361.000

*Denotes boundary of a phase change.