National foreword

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The UK participation in its preparation was entrusted to Technical Committee RHE/18, Refrigeration safety, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Summary of pages

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Introduction

This document, prepared by ISO/TC 86/SC 8/WG 7, is a new International Standard. It is consistent with and is intended to complement ISO 817. The purpose of this International Standard is to address the differing performance ratings due to the differences between multiple property formulations, which is a problem especially in international trade. The fluids and properties included in this International Standard represent those for which sufficient high-quality data were available. While the working group recognizes the desirability of including additional fluids, such as the hydrocarbons, and including the transport properties of viscosity and thermal conductivity, the data and models for these were judged insufficient at this time to be worthy of designation as an International Standard. Therefore, the working group decided to prepare the present International Standard, incomplete though it might be, in a timely fashion rather than delay it awaiting additional data. The working group is continuing its efforts to add additional fluids and additional properties to this International Standard. It is anticipated that this International Standard will undergo regular reviews and revisions.

For applications such as performance rating of refrigeration equipment, having all parties adopt a consistent set of properties is more important than absolute accuracy. But consensus is easiest to achieve when high-quality property data are available.

With this in mind, the Working Group has taken as its starting point the results of Annex 18 Thermophysical Properties of the Environmentally Acceptable Refrigerants of the Heat Pump Programme of the International Energy Agency (McLinden and Watanabe[7]). Annex 18 reports the comprehensive evaluations of the available equations of state and recommended formulations for R123, R134a, R32, R125, and R143a. Wide participation was invited in this process, and anyone could submit an equation of state for evaluation. The formulations for R123, R134a, R32, and R143a adopted in this International Standard are the same as those recommend by Annex 18. (The recent equation of state for R125 adopted in this International Standard was shown to be more accurate than the older formulation recommended by Annex 18.)

A similar comparison of mixture models reported by Annex 18 facilitated the dissemination and adoption of a new mixture modelling approach. This model is based on Helmholtz energies for each of the mixture components, and it is the approach used in the NIST REFPROP refrigerant property database (Lemmon *et al.*[5]) and in the extensive tabulation of properties published by the Japan Society of Refrigerating and Air Conditioning Engineers (Tillner-Roth *et al.*[12]). The Lemmon and Jacobsen[2] model (implemented in the REFPROP database) is simpler than the Tillner-Roth *et al.*[12] model in that it avoids the ternary interactions terms required in the Tillner-Roth model, with practically the same representations of the experimental data. For these reasons, as well as the widespread use of REFPROP, the Lemmon and Jacobsen model was adopted as the basis for the mixture properties specified in this International Standard.

The one significant disadvantage of the formulations adopted here is their complexity. In recognition of this, this International Standard allows for “alternative implementations” for the properties. These can take the form of simpler equations of state that may be applicable over limited ranges of conditions or simple correlations of single properties (e.g., expressions for vapour pressure or the enthalpy of the saturated vapour). This International Standard does not restrict the form of such alternative implementations, but it does impose requirements, in the form of allowable tolerances (deviations from the standard values), given in Annex A, which alternative implementations shall satisfy.

The question of allowable tolerances for alternative implementations generated the most controversy among the working group. In the working group discussions, some felt that the tolerances should be fairly large to encompass as many formulations in common use as possible. But others argued that this would defeat the very purpose of this International Standard, which was to harmonize the property values used across the industry. The concept of alternative implementations with their allowable tolerances was not intended to sanction the continued use of “incorrect” data but, rather, to provide for fast, application-specific equations that would be fitted to the properties specified in this International Standard. In the end, fairly strict tolerances were selected. The experiences and recommendations of the European Association of Compressor Manufacturers (ASERCOM) carried significant weight. They had experience with simplified property equations that were fitted

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Refrigerant properties

1 Scope

This International Standard specifies thermophysical properties of several commonly used refrigerants and refrigerant blends.

This International Standard is applicable to the refrigerants R12, R22, R32, R123, R125, R134a, R143a, R152a, R717 (ammonia), and R744 (carbon dioxide) and to the refrigerant blends R404A, R407C, R410A, and R507A. The following properties are included: density, pressure, internal energy, enthalpy, entropy, heat capacity at constant pressure, heat capacity at constant volume, speed of sound, and the Joule-Thomson coefficient, in both single-phase states and along the liquid-vapour saturation boundary. The numerical designation of these refrigerants is that defined in ISO 817.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 817, *Refrigerants — Designation system*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
algorithm
procedure for the computation of refrigerant properties

NOTE An algorithm is most often a computer program. An algorithm may also consist of one or more single-property correlations as allowed under 4.4.

3.2
blend
mixture of two or more chemical compounds

3.3
critical point
state at which the properties of the saturated liquid and those of the saturated vapour become equal

NOTE Separate liquid and vapour phases do not exist above the critical point temperature for a pure fluid. This is more completely referred to as the “gas-liquid critical point” as other “critical points” can be defined.

3.4
equation of state
mathematical equation that is a complete and thermodynamically consistent representation of the thermodynamic properties of a fluid

NOTE An equation of state most commonly expresses pressure or Helmholtz energy as a function of temperature, density, and (for a blend) composition. Other thermodynamic properties are obtained through integration and/or differentiation of the equation of state.

3.5 fluid
refrigerant
substance, present in liquid and/or gaseous states, used for heat transfer in a refrigerating system

NOTE The fluid absorbs heat at a low temperature and low pressure, then releases the heat at a higher temperature and a higher pressure, usually through a change of state.

3.6
liquid-vapour saturation
state at which liquid and vapour phases of a fluid are in thermodynamic equilibrium with each other at a common temperature and pressure

NOTE Such states exist from the triple point to the critical point.

3.7
transport properties
viscosity, thermal conductivity, and diffusion coefficient

3.8
thermodynamic properties
density, pressure, fugacity, internal energy, enthalpy, entropy, Gibbs and Helmholtz energies, heat capacities, speed of sound, and the Joule-Thomson coefficient, in both single-phase states and along the liquid-vapour saturation boundary

3.9
thermophysical properties
all of the thermodynamic, transport, and other miscellaneous properties

3.10
triple point
state at which solid, liquid, and vapour phases of a substance are in thermodynamic equilibrium

4 Calculation of refrigerant properties

4.1 General

This International Standard specifies properties for the refrigerants listed in Clause 1. These properties are derived from experimental measurements. It is not practical, however, to directly reference the experimental data; they may not be available at all conditions of interest and some properties, such as entropy, cannot be measured directly. Furthermore, a simple tabulation, even for properties (such as vapour pressure) that are directly measurable, is not convenient for modern engineering use. Thus, some means to correlate the data is required to allow calculation of the properties at a desired thermodynamic state.

The properties enumerated in this International Standard are calculated from specified equations of state, although alternative algorithms are allowed. The properties themselves constitute this International Standard. The equations of state serve as a convenient means to represent and reproduce the properties. The properties enumerated in the tables in this International Standard thus represent only a subset of the properties specified by this International Standard; the full range of conditions is given for each fluid in

Clause 5. An equation of state is a mathematical equation that is a complete and thermodynamically consistent representation of the thermodynamic properties of a fluid. These equations have been selected based on the following criteria:

a) accuracy in reproducing the available experimental data;

b) applicability over wide ranges of temperature, pressure, and density;

c) proper behavior on extrapolation beyond the available experimental data; and

d) preference has been given to fully documented and published formulations.

4.2 Pure-fluid equations of state

An equation of state for a pure fluid may express the reduced molar Helmholtz energy, A, as a function of temperature and density. The equation is composed of separate terms arising from ideal-gas behaviour (subscript “id”) and a “residual” or “real-fluid” (subscript “r”) contribution as given in Equation (1):

$$\varphi = \frac{A}{RT} = \varphi_{id} + \varphi_{r} \tag{1}$$

where R is the gas constant. Equations of this form may be written on either a molar basis or a mass basis. For a consistent representation in this International Standard, the equations of state originally published on a mass basis have been converted to a molar basis. The “residual” or “real-fluid” contribution is given by Equation (2):

$$\varphi_{r} = \sum_{k}^{N} N_k \tau^{t_k} \delta^{d_k} \exp\left[-\alpha_k (\delta - \varepsilon_k)^{l_k}\right] \exp\left[-\beta_k (\tau - \gamma_k)^{m_k}\right] \tag{2}$$

where

τ is the dimensionless temperature variable T^*/T;

T^* is the reducing parameter which is often equal to the critical parameter;

δ is the dimensionless density variable ρ/ρ^*;

ρ^* is the reducing parameter which is often equal to the critical parameter;

N_k are numerical coefficients fitted to experimental data;

α_k, β_k, ε_k and γ_k are parameters optimized for a particular fluid or group of fluids by a selection algorithm starting with a large bank of terms or by use of a non-linear fitting process;

t_k, d_k, l_k and m_k are exponents optimized for a particular fluid or group of fluids by a selection algorithm starting with a large bank of terms or by use of a non-linear fitting process.

The ideal-gas contribution can be represented in one of several ways. One representation is in terms of the heat capacity of the ideal-gas state, as given in Equation (3):

$$\varphi = \frac{h - s}{RT} - \left(\frac{h}{RT}\right)_{ref} + \frac{s_{ref}}{R} - 1 - \ln\delta + \int_{T_{ref}}^{T} \frac{C_{p,id}}{RT}\,dT - \int_{T_{ref}}^{T} \frac{C_{p,id}}{RT}\,dT + \ln\delta \tag{3}$$

$$h^{id} = RT + R\,p_{ref} + RT\,T + p,id + R\,T + T$$

where

h_{ref} is the arbitrary reference enthalpy for the ideal gas at the reference state specified by T_{ref};

s_{ref} is the arbitrary reference entropy for the ideal gas at the reference state specified by T_{ref} and p_{ref}.

In this International Standard, the h_{ref} and s_{ref} are chosen to yield a reference state for enthalpy of 200 kJ/kg and for entropy of 1 kJ/(kg·K), both for the saturated liquid at 0 °C. Such values of h_{ref} and s_{ref} are informative only; different values, corresponding to different reference state conventions, are acceptable.

The heat capacity of the ideal gas state, $C_{p,id}$ may be represented as a function of temperature by the general form consisting of separate summations of polynomial (empirical) and exponential (theoretical) terms, as given in Equation (4):

$$\frac{C_{p,id}}{R} = c_0 + \sum_k c_k T^{t_k} + \sum_k a_k \left[\frac{u_k}{T}\right]^2 \frac{\exp\left(\frac{u_k}{T}\right)}{\left[\exp\left(\frac{u_k}{T}\right) - 1\right]^2} \qquad (4)$$

where

$$u_k = \frac{b_k}{T}; \qquad (5)$$

c_k, a_k, b_k and t_k are numerical coefficients and exponents fitted to data or derived from theoretical calculations.

A second representation of the ideal-gas contribution is given directly in terms of the Helmholtz free energy, as shown in Equation (6):

$$\varphi_{id} = d_1 + d_2\tau + \ln\delta + d_3 \ln\tau + \sum_k d_k \tau^{t_k} + \sum_k a_k \ln\left[1 - \exp\left(-\tau\lambda_k\right)\right] \qquad (6)$$

where

d_1 and d_2 are adjusted to yield the desired reference state values for the enthalpy and entropy;

d_3, d_k, a_k, λ_k and t_k are either empirical or theoretical parameters.

Equation (6) is functionally equivalent to Equations (3) to (5), and an ideal-gas contribution in the form of Equation (6) may be converted to the heat capacity form as given by Equation (7):

$$\frac{C}{d} = d_1 t_1 t_1 \left(\frac{T}{T^*}\right)^{t_1} + a_1 u_1 u_1

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$$\Psi = \exp\left[C_k \left(\delta - \right)^{\square} - D_k \left(\tau - \right)^{\square} \right] \qquad (12)$$

Equation (9) is added to the normal terms in Equation (1). The N_k, A_k, B_k, C_k, D_k, α_k and β_k are adjustable parameters fitted to data. Among the fluids in this International Standard, only the equation of state for R744
(carbon dioxide) includes these critical region terms.

Alternately, an equation of state may express pressure as an explicit function of temperature and molar density. One form is that of a modified Benedict-Webb-Rubin (MBWR) equation of state, as given in Equation (13):

$$p = \sum_{k=1}^{9} a_k \rho^k + \exp\left(-\rho^2\right) \sum_{k=10}^{15} a_k \rho^{k-2} + \sum_{k=17}^{\text{crit}} a_k \rho^{k-2} \left(\rho - \right)^{\square} \qquad (13)$$

where the a_k are functions of temperature resulting in a total of 32 adjustable parameters that are fitted to the experimental data. For a complete description of the thermodynamic properties, the MBWR equation is combined with an expression for the ideal-gas heat capacity, such as Equation (4) or (5).

In this International Standard, pressure-explicit equations of state [such as Equation (13)] are transformed into the Helmholtz-energy form to maintain a consistent representation. The pressure is related to the Helmholtz energy using the thermodynamic identity shown in Equation (14):

$$p = -\left(\frac{\partial A}{\partial}\right)_{V,T} \qquad (14)$$

Thus, the Helmholtz energy can be evaluated from the pressure by an integration over volume, using Equation (15):

$$A(T, \rho) = \phi_r = \int_{\infty}^{V} \left(\frac{p}{RT} - \rho \right) d \qquad (15)$$

Equation (15) is then combined with an ideal-gas contribution given by Equations (3) to (5) to yield a complete description of the thermodynamic properties. Among the fluids in this International Standard, the equations of state for R123 and R152a have been transformed in this manner.

An equation of state or the ideal-gas heat capacity may also be expressed in other forms, but the forms represented by Equations (1) through (15) encompass all those specified in this International Standard.

Methods for computing pure-fluid thermodynamic properties from an equation of state are given in Annex B.

4.3 Mixture equation of state

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where

x_i is the mole fraction of component i in the n-component mixture;

$x_i \ln x_i$ are terms arising from the entropy of mixing of ideal gases.

The parameters f_3 and f_4 are used to shift the thermodynamic surface such that the reference state for enthalpy is 200 kJ/kg and entropy is 1 kJ/(kg·K) at the saturated liquid at 0 °C, similar to that done for the pure fluids. Setting the parameters f_3 and f_4 to zero corresponds to a reference state based solely on the constituents of the mixture.

The residual part is given by Equation (18):

$$\varphi_{mix,r} = \sum_{i=1}^{n} x_i \varphi_{i,r} + \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} x_i x_j \varphi_{ij,excess} \qquad (18)$$

The first summation in this equation represents the ideal solution; it consists of the real fluid terms for each of the pure fluids multiplied by their respective compositions. The double summation accounts for the "excess" Helmholtz energy or "departure" from ideal solution. The $\varphi_{i,r}$ and $\varphi_{ij,excess}$ functions in Equation (18) are not evaluated at the temperature, T_{mix}, and density, ρ_{mix}, of the mixture, but, rather, at a reduced temperature, τ, and density, δ. The mixing rules for the reducing parameters are given by Equations (19) and (20):

$$\tau = \frac{T^*}{T_{mix}} \qquad (19)$$

where

$$\frac{T^*}{T} = \sum_{i=1}^{n} x_i \frac{T_i^*}{T} + \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} x_i x_j \zeta_{ij}$$

and

$$\delta = \frac{\rho_{mix}^*}{\rho} \qquad (20)$$

where

$$\frac{1}{\rho^*} = \sum_{i=1}^{n} \frac{x_i}{\rho_i^*} + \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} x_i x_j \xi_{ij}$$

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Table 3 — Coefficients and exponents of the critical region terms [Equations (9) to (12)]

k	N_k	a_k	b_k	β_k	A_k	B_k	C_k	D_k
40	– 0,666 422 765 408	3,5	0,875	0,3	0,7	0,3	10	275
41	0,726 086 323 499	3,5	0,925	0,3	0,7	0,3	10	275
42	0,550 686 686 128 × 10^{-1}	3	0,875	0,3	0,7	1	12,5	275

5.2.2 Reducing parameters, molar mass, and gas constant

T^* = 304,128 2 K, ρ^* = 10,624 906 3 mol/l, M = 44,009 8 g/mol, R = 8,314 51 J/(mol·K)

5.2.3 Reference state parameters

T_{ref} = 273,15 K, p_{ref} = 1,0 kPa, h_{ref} = 21 389,328 J/mol, s_{ref} = 155,741 4 J/(mol·K), f_1 = 5,805 551 35, f_2 = 1 555,797 10

Table 3 — Coefficients and exponents of the critical region terms [Equations (9) to (12)]

k	N_k	a_k	b_k	β_k	A_k	B_k	C_k	D_k
40	– 0,666 422 765 408	3,5	0,875	0,3	0,7	0,3	10	275
41	0,726 086 323 499	3,5	0,925	0,3	0,7	0,3	10	275
42	0,550 686 686 128 × 10^{-1}	3	0,875	0,3	0,7	1	12,5	275

5.2.2 Reducing parameters, molar mass, and gas constant

T^* = 304,128 2 K, ρ^* = 10,624 906 3 mol/l, M = 44,009 8 g/mol, R = 8,314 51 J/(mol·K)

5.2.3 Reference state parameters

T_{ref} = 273,15 K, p_{ref} = 1,0 kPa, h_{ref} = 21 389,328 J/mol, s_{ref} = 155,741 4 J/(mol·K), f_1 = 5,805 551 35, f_2 = 1 555,797 10

5.3 R717 — Ammonia

5.3.1 Range of validity

The coefficients are valid within the following ranges:

T_{min} = 195,495 K, T_{max} = 700 K; p_{max} = 1 000 MPa; ρ_{max} = 52,915 mol/l (901 kg/m^3)

Table 5 — Coefficients and exponents of the ideal-gas part [Equations (3) to (5)]

k	c_k	t_k
1	1,887 164 1 × 10^1	– 0,333 333 333 333
2	5,954 993 4 × 10^{-4}	1,5
3	– 7,498 313 1 × 10^{-5}	1,75

Table 6 — Coefficients and exponents of the real-gas part [Equation (2)]

k	N_k	t_k	d_k	l_k	α_k
1	– 1,858 814	1,5	1	0	0
2	0,0455 443 1	– 0,5	2	0	0
3	0,723 854 8	0,5	1	0	0
4	0,012 294 7	1	4	0	0
5	2,141 882 × 10^{-11}	3	15	0	0
6	– 0,014 300 2	0	3	1	1
7	0,344 132 4	3	3	1	1
8	– 0,287 357 1	4	1	1	1
9	0,000 023 525 89	4	8	1	1
10	– 0,034 971 11	5	2	1	1
11	0,0018 311 17	5	8	2	1
12	0,023 978 52	3	1	2	1
13	– 0,040 853 75	6	1	2	1
14	0,237 927 5	8	2	2	1
15	– 0,035 489 72	8	3	2	1
16	– 0,182 372 9	10	2	2	1
17	0,022 815 56	10	4	2	1
18	– 0,006 663 444	5	3	3	1
19	– 0,008 847 486	7,5	1	3	1
20	0,002 272 635	15	2	3	1
21	– 0,000 558 865 5	30	4	3	1

5.3.2 Reducing parameters, molar mass, and gas constant

T^* = 405,4 K, ρ^* = 13,211 777 15 mol/l, M = 17,030 26 g/mol, R = 8,314 471 J/(mol·K)

5.3.3 Reference state parameters

T_{ref} = 273,15 K, p_{ref} = 1,0 kPa, h_{ref} = 25 558,797 J/mol, s_{ref} = 147,991 0 J/(mol·K), f_1 = – 24,401, f_2 = 1 725,271 55

5.3 R717 — Ammonia

5.3.1 Range of validity

The coefficients are valid within the following ranges:

T_{min} = 195,495 K, T_{max} = 700 K; p_{max} = 1 000 MPa; ρ_{max} = 52,915 mol/l (901 kg/m^3)

Table 5 — Coefficients and exponents of the ideal-gas part [Equations (3) to (5)]

k	c_k	t_k
1	1,887 164 1 × 10^1	– 0,333 333 333 333
2	5,954 993 4 × 10^{-4}	1,5
3	– 7,498 313 1 × 10^{-5}	1,75

Table 6 — Coefficients and exponents of the real-gas part [Equation (2)]

k	N_k	t_k	d_k	l_k	α_k
1	– 1,858 814	1,5	1	0	0
2	0,0455 443 1	– 0,5	2	0	0
3	0,723 854 8	0,5	1	0	0
4	0,012 294 7	1	4	0	0
5	2,141 882 × 10^{-11}	3	15	0	0
6	– 0,014 300 2	0	3	1	1
7	0,344 132 4	3	3	1	1
8	– 0,287 357 1	4	1	1	1
9	0,000 023 525 89	4	8	1	1
10	– 0,034 971 11	5	2	1	1
11	0,0018 311 17	5	8	2	1
12	0,023 978 52	3	1	2	1
13	– 0,040 853 75	6	1	2	1
14	0,237 927 5	8	2	2	1
15	– 0,035 489 72	8	3	2	1
16	– 0,182 372 9	10	2	2	1
17	0,022 815 56	10	4	2	1
18	– 0,006 663 444	5	3	3	1
19	– 0,008 847 486	7,5	1	3	1
20	0,002 272 635	15	2	3	1
21	– 0,000 558 865 5	30	4	3	1

5.3.2 Reducing parameters, molar mass, and gas constant

T^* = 405,4 K, ρ^* = 13,211 777 15 mol/l, M = 17,030 26 g/mol, R = 8,314 471 J/(mol·K)

5.3.3 Reference state parameters

T_{ref} = 273,15 K, p_{ref} = 1,0 kPa, h_{ref} = 25 558,797 J/mol, s_{ref} = 147,991 0 J/(mol·K), f_1 = – 24,401, f_2 = 1 725,271 55

Table 7 (*continued*)

	Temp. coefficient K/MPa	Pressure °C	Density MPa	Internal energy kg/m^3	Enthalpy kJ/kg	Entropy kJ/kg	C_v kJ/(kg·K)	C_p kJ/(kg·K)	Sound speed kJ/(kg·K)	J-T m/s
liquid	35,00	1,3508	587,4	363,77	366,07	1,5666	2,7532	4,8771	1271,0	–0,0534
vapour			10,457	1359,16	1488,34	5,2086	2,2272	3,3745	404,63	22,92
liquid	40,00	1,5554	579,4	387,95	390,64	1,6446	2,7484	4,9318	1232,1	–0,0353
vapour			12,034	1360,65	1489,91	5,1549	2,2776	3,5104	404,03	21,52
liquid	45,00	1,7827	571,3	412,35	415,48	1,7220	2,7443	4,9935	1192,7	–0,0152
vapour			13,803	1361,68	1490,83	5,1020	2,3294	3,6593	403,12	20,24
liquid	50,00	2,0340	562,9	437,01	440,62	1,7990	2,7411	5,0635	1152,6	0,0076
vapour			15,785	1362,22	1491,07	5,0497	2,3828	3,8233	401,88	19,06
liquid	55,00	2,3111	554,2	461,93	466,10	1,8758	2,7389	5,1434	1111,7	0,0333
vapour			18,006	1362,22	1490,57	4,9977	2,4377	4,0051	400,29	17,98
liquid	60,00	2,6156	545,2	487,17	491,97	1,9523	2,7379	5,2351	1070,2	0,0626
vapour			20,493	1361,63	1489,27	4,9458	2,4942	4,2084	398,34	16,98
liquid	65,00	2,9491	536,0	512,76	518,26	2,0288	2,7382	5,3411	1027,7	0,0960
vapour			23,280	1360,41	1487,09	4,8939	2,5525	4,4376	396,01	16,05
liquid	70,00	3,3135	526,3	538,75	545,04	2,1054	2,7402	5,4648	984,4	0,1346
vapour			26,407	1358,46	1483,94	4,8415	2,6126	4,6990	393,29	15,19
liquid	75,00	3,7105	516,2	565,19	572,37	2,1823	2,7441	5,6103	940,0	0,1793
vapour			29,923	1355,73	1479,72	4,7885	2,6748	5,0009	390,14	14,39
liquid	80,00	4,1420	505,7	592,15	600,34	2,2596	2,7503	5,7837	894,7	0,2317
vapour			33,888	1352,08	1474,31	4,7344	2,7393	5,3546	386,54	13,65
liquid	85,00	4,6100	494,5	619,72	629,04	2,3377	2,7594	5,9930	848,1	0,2935
vapour			38,376	1347,40	1467,53	4,6789	2,8066	5,7766	382,47	12,94
liquid	90,00	5,1167	482,8	648,01	658,61	2,4168	2,7719	6,2501	800,4	0,3674
vapour			43,484	1341,52	1459,19	4,6213	2,8770	6,2907	377,88	12,27
liquid	95,00	5,6643	470,2	677,14	689,19	2,4973	2,7886	6,5731	751,3	0,4569
vapour			49,340	1334,20	1449,01	4,5612	2,9511	6,9332	372,74	11,63
liquid	100,00	6,2553	456,6	707,30	721,00	2,5797	2,8108	6,9912	700,7	0,5673
vapour			56,117	1325,16	1436,63	4,4975	3,0297	7,7622	366,99	11,01
liquid	105,00	6,8923	441,9	738,75	754,35	2,6647	2,8400	7,5551	648,5	0,7063
vapour			64,063	1313,98	1421,57	4,4291	3,1139	8,8773	360,54	10,40
liquid	110,00	7,5783	425,6	771,88	789,68	2,7533	2,8787	8,3621	594,4	0,8869
vapour			73,550	1300,04	1403,08	4,3542	3,2049	10,4630	353,29	9,78
liquid	115,00	8,3170	407,2	807,31	827,74	2,8474	2,9307	9,6278	537,7	1,1313
vapour			85,182	1282,36	1379,99	4,2702	3,3047	12,9091	345,04	9,15
liquid	120,00	9,1125	385,5	846,28	869,92	2,9502	3,0037	11,9405	477,4	1,4834
vapour			100,068	1259,17	1350,23	4,1719	3,4163	17,2119	335,41	8,47
liquid	125,00	9,9702	357,8	891,82	919,68	3,0702	3,1159	17,6583	411,4	2,0455
vapour			120,728	1226,54	1309,12	4,0483	3,5447	26,9963	323,57	7,69
liquid	130,00	10,8977	312,3	957,12	992,02	3,2437	3,3450	54,2103	333,6	3,1689
vapour			156,766	1169,80	1239,32	3,8571	3,7014	76,4902	306,58	6,62
critical	132,25	11,3330	225,0	1068,82	1119,22	3,5542	c	c	c	5,0513

a Triple point.

b Normal boiling point.

c The values of C_v, C_p, and w at the critical point are not included as part of this International Standard.

Table 7 (*continued*)

	Temp. coefficient K/MPa	Pressure °C	Density MPa	Internal energy kg/m^3	Enthalpy kJ/kg	Entropy kJ/kg	C_v kJ/(kg·K)	C_p kJ/(kg·K)	Sound speed kJ/(kg·K)	J-T m/s
liquid	35,00	1,3508	587,4	363,77	366,07	1,5666	2,7532	4,8771	1271,0	–0,0534
vapour			10,457	1359,16	1488,34	5,2086	2,2272	3,3745	404,63	22,92
liquid	40,00	1,5554	579,4	387,95	390,64	1,6446	2,7484	4,9318	1232,1	–0,0353
vapour			12,034	1360,65	1489,91	5,1549	2,2776	3,5104	404,03	21,52
liquid	45,00	1,7827	571,3	412,35	415,48	1,7220	2,7443	4,9935	1192,7	–0,0152
vapour			13,803	1361,68	1490,83	5,1020	2,3294	3,6593	403,12	20,24
liquid	50,00	2,0340	562,9	437,01	440,62	1,7990	2,7411	5,0635	1152,6	0,0076
vapour			15,785	1362,22	1491,07	5,0497	2,3828	3,8233	401,88	19,06
liquid	55,00	2,3111	554,2	461,93	466,10	1,8758	2,7389	5,1434	1111,7	0,0333
vapour			18,006	1362,22	1490,57	4,9977	2,4377	4,0051	400,29	17,98
liquid	60,00	2,6156	545,2	487,17	491,97	1,9523	2,7379	5,2351	1070,2	0,0626
vapour			20,493	1361,63	1489,27	4,9458	2,4942	4,2084	398,34	16,98
liquid	65,00	2,9491	536,0	512,76	518,26	2,0288	2,7382	5,3411	1027,7	0,0960
vapour			23,280	1360,41	1487,09	4,8939	2,5525	4,4376	396,01	16,05
liquid	70,00	3,3135	526,3	538,75	545,04	2,1054	2,7402	5,4648	984,4	0,1346
vapour			26,407	1358,46	1483,94	4,8415	2,6126	4,6990	393,29	15,19
liquid	75,00	3,7105	516,2	565,19	572,37	2,1823	2,7441	5,6103	940,0	0,1793
vapour			29,923	1355,73	1479,72	4,7885	2,6748	5,0009	390,14	14,39
liquid	80,00	4,1420	505,7	592,15	600,34	2,2596	2,7503	5,7837	894,7	0,2317
vapour			33,888	1352,08	1474,31	4,7344	2,7393	5,3546	386,54	13,65
liquid	85,00	4,6100	494,5	619,72	629,04	2,3377	2,7594	5,9930	848,1	0,2935
vapour			38,376	1347,40	1467,53	4,6789	2,8066	5,7766	382,47	12,94
liquid	90,00	5,1167	482,8	648,01	658,61	2,4168	2,7719	6,2501	800,4	0,3674
vapour			43,484	1341,52	1459,19	4,6213	2,8770	6,2907	377,88	12,27
liquid	95,00	5,6643	470,2	677,14	689,19	2,4973	2,7886	6,5731	751,3	0,4569
vapour			49,340	1334,20	1449,01	4,5612	2,9511	6,9332	372,74	11,63
liquid	100,00	6,2553	456,6	707,30	721,00	2,5797	2,8108	6,9912	700,7	0,5673
vapour			56,117	1325,16	1436,63	4,4975	3,0297	7,7622	366,99	11,01
liquid	105,00	6,8923	441,9	738,75	754,35	2,6647	2,8400	7,5551	648,5	0,7063
vapour			64,063	1313,98	1421,57	4,4291	3,1139	8,8773	360,54	10,40
liquid	110,00	7,5783	425,6	771,88	789,68	2,7533	2,8787	8,3621	594,4	0,8869
vapour			73,550	1300,04	1403,08	4,3542	3,2049	10,4630	353,29	9,78
liquid	115,00	8,3170	407,2	807,31	827,74	2,8474	2,9307	9,6278	537,7	1,1313
vapour			85,182	1282,36	1379,99	4,2702	3,3047	12,9091	345,04	9,15
liquid	120,00	9,1125	385,5	846,28	869,92	2,9502	3,0037	11,9405	477,4	1,4834
vapour			100,068	1259,17	1350,23	4,1719	3,4163	17,2119	335,41	8,47
liquid	125,00	9,9702	357,8	891,82	919,68	3,0702	3,1159	17,6583	411,4	2,0455
vapour			120,728	1226,54	1309,12	4,0483	3,5447	26,9963	323,57	7,69
liquid	130,00	10,8977	312,3	957,12	992,02	3,2437	3,3450	54,2103	333,6	3,1689
vapour			156,766	1169,80	1239,32	3,8571	3,7014	76,4902	306,58	6,62
critical	132,25	11,3330	225,0	1068,82	1119,22	3,5542	c	c	c	5,0513

a Triple point.

b Normal boiling point.

c The values of C_v, C_p, and w at the critical point are not included as part of this International Standard.

Table 7 (*continued*)

	Temp. coefficient K/MPa	Pressure °C	Density MPa	Internal energy kg/m^3	Enthalpy kJ/kg	Entropy kJ/kg	C_v kJ/(kg·K)	C_p kJ/(kg·K)	Sound speed kJ/(kg·K)	J-T m/s
liquid	35,00	1,3508	587,4	363,77	366,07	1,5666	2,7532	4,8771	1271,0	–0,0534
vapour			10,457	1359,16	1488,34	5,2086	2,2272	3,3745	404,63	22,92
liquid	40,00	1,5554	579,4	387,95	390,64	1,6446	2,7484	4,9318	1232,1	–0,0353
vapour			12,034	1360,65	1489,91	5,1549	2,2776	3,5104	404,03	21,52
liquid	45,00	1,7827	571,3	412,35	415,48	1,7220	2,7443	4,9935	1192,7	–0,0152
vapour			13,803	1361,68	1490,83	5,1020	2,3294	3,6593	403,12	20,24
liquid	50,00	2,0340	562,9	437,01	440,62	1,7990	2,7411	5,0635	1152,6	0,0076
vapour			15,785	1362,22	1491,07	5,0497	2,3828	3,8233	401,88	19,06
liquid	55,00	2,3111	554,2	461,93	466,10	1,8758	2,7389	5,1434	1111,7	0,0333
vapour			18,006	1362,22	1490,57	4,9977	2,4377	4,0051	400,29	17,98
liquid	60,00	2,6156	545,2	487,17	491,97	1,9523	2,7379	5,2351	1070,2	0,0626
vapour			20,493	1361,63	1489,27	4,9458	2,4942	4,2084	398,34	16,98
liquid	65,00	2,9491	536,0	512,76	518,26	2,0288	2,7382	5,3411	1027,7	0,0960
vapour			23,280	1360,41	1487,09	4,8939	2,5525	4,4376	396,01	16,05
liquid	70,00	3,3135	526,3	538,75	545,04	2,1054	2,7402	5,4648	984,4	0,1346
vapour			26,407	1358,46	1483,94	4,8415	2,6126	4,6990	393,29	15,19
liquid	75,00	3,7105	516,2	565,19	572,37	2,1823	2,7441	5,6103	940,0	0,1793
vapour			29,923	1355,73	1479,72	4,7885	2,6748	5,0009	390,14	14,39
liquid	80,00	4,1420	505,7	592,15	600,34	2,2596	2,7503	5,7837	894,7	0,2317
vapour			33,888	1352,08	1474,31	4,7344	2,7393	5,3546	386,54	13,65
liquid	85,00	4,6100	494,5	619,72	629,04	2,3377	2,7594	5,9930	848,1	0,2935
vapour			38,376	1347,40	1467,53	4,6789	2,8066	5,7766	382,47	12,94
liquid	90,00	5,1167	482,8	648,01	658,61	2,4168	2,7719	6,2501	800,4	0,3674
vapour			43,484	1341,52	1459,19	4,6213	2,8770	6,2907	377,88	12,27
liquid	95,00	5,6643	470,2	677,14	689,19	2,4973	2,7886	6,5731	751,3	0,4569
vapour			49,340	1334,20	1449,01	4,5612	2,9511	6,9332	372,74	11,63
liquid	100,00	6,2553	456,6	707,30	721,00	2,5797	2,8108	6,9912	700,7	0,5673
vapour			56,117	1325,16	1436,63	4,4975	3,0297	7,7622	366,99	11,01
liquid	105,00	6,8923	441,9	738,75	754,35	2,6647	2,8400	7,5551	648,5	0,7063
vapour			64,063	1313,98	1421,57	4,4291	3,1139	8,8773	360,54	10,40
liquid	110,00	7,5783	425,6	771,88	789,68	2,7533	2,8787	8,3621	594,4	0,8869
vapour			73,550	1300,04	1403,08	4,3542	3,2049	10,4630	353,29	9,78
liquid	115,00	8,3170	407,2	807,31	827,74	2,8474	2,9307	9,6278	537,7	1,1313
vapour			85,182	1282,36	1379,99	4,2702	3,3047	12,9091	345,04	9,15
liquid	120,00	9,1125	385,5	846,28	869,92	2,9502	3,0037	11,9405	477,4	1,4834
vapour			100,068	1259,17	1350,23	4,1719	3,4163	17,2119	335,41	8,47
liquid	125,00	9,9702	357,8	891,82	919,68	3,0702	3,1159	17,6583	411,4	2,0455
vapour			120,728	1226,54	1309,12	4,0483	3,5447	26,9963	323,57	7,69
liquid	130,00	10,8977	312,3	957,12	992,02	3,2437	3,3450	54,2103	333,6	3,1689
vapour			156,766	1169,80	1239,32	3,8571	3,7014	76,4902	306,58	6,62
critical	132,25	11,3330	225,0	1068,82	1119,22	3,5542	c	c	c	5,0513

a Triple point.

b Normal boiling point.

c The values of C_v, C_p, and w at the critical point are not included as part of this International Standard.

Table 10 (*continued*)

	Temp. coefficient °C K/MPa	Pressure MPa	Density kg/m^3	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/(kg·K)	C_v kJ/(kg·K)	C_p kJ/(kg·K)	Sound speed kJ/(kg·K)	J-T m/s
liquid	–60,00	0,0226	1572,3	146,60	146,62	0,7806	0,5442	0,8499	858,5	–0,4703
vapour			1,563	310,14	324,61	1,6156	0,4403	0,5134	129,06	55,03
liquid	–55,00	0,0300	1558,6	150,87	150,88	0,8003	0,5472	0,8553	837,3	–0,4598
vapour			2,029	312,23	327,00	1,6076	0,4477	0,5218	130,15	51,29
liquid	–50,00	0,0391	1544,7	155,15	155,18	0,8197	0,5503	0,8609	816,2	–0,4486
vapour			2,598	314,34	329,39	1,6004	0,4550	0,5302	131,17	47,97
liquid	–45,00	0,0504	1530,7	159,47	159,50	0,8389	0,5535	0,8668	795,3	–0,4366
vapour			3,286	316,45	331,79	1,5940	0,4624	0,5389	132,11	45,01
liquid	–40,00	0,0641	1516,5	163,81	163,86	0,8577	0,5568	0,8730	774,5	–0,4237
vapour			4,108	318,58	334,18	1,5882	0,4697	0,5477	132,99	42,38
liquid	–35,00	0,0806	1502,2	168,19	168,24	0,8763	0,5602	0,8795	753,8	–0,4099
vapour			5,083	320,71	336,56	1,5831	0,4770	0,5568	133,78	40,02
liquid	–30,00	0,1003	1487,7	172,60	172,67	0,8946	0,5636	0,8863	733,3	–0,3951
vapour			6,228	322,84	338,94	1,5784	0,4843	0,5661	134,49	37,90
liquid	–29,75[b]	0,1013	1487,0	172,82	172,89	0,8955	0,5637	0,8866	732,3	–0,3943
vapour			6,289	322,95	339,06	1,5782	0,4847	0,5666	134,52	37,81
liquid	–25,00	0,1235	1473,0	177,04	177,12	0,9127	0,5670	0,8934	712,9	–0,3792
vapour			7,563	324,98	341,30	1,5743	0,4917	0,5757	135,10	36,00
liquid	–20,00	0,1507	1458,1	181,51	181,62	0,9305	0,5705	0,9007	692,5	–0,3620
vapour			9,109	327,11	343,65	1,5706	0,4990	0,5857	135,63	34,29
liquid	–15,00	0,1823	1443,0	186,02	186,15	0,9482	0,5741	0,9085	672,3	–0,3434
vapour			10,889	329,24	345,98	1,5673	0,5064	0,5960	136,05	32,75
liquid	–10,00	0,2188	1427,6	190,57	190,72	0,9656	0,5776	0,9166	652,1	–0,3233
vapour			12,925	331,36	348,29	1,5644	0,5139	0,6068	136,38	31,35
liquid	–5,00	0,2606	1412,0	195,15	195,34	0,9829	0,5812	0,9251	632,0	–0,3015
vapour			15,244	333,47	350,56	1,5618	0,5213	0,6180	136,59	30,09
liquid	0,00	0,3081	1396,1	199,78	200,00	1,0000	0,5849	0,9341	611,9	–0,2777
vapour			17,873	335,56	352,81	1,5594	0,5289	0,6298	136,69	28,94
liquid	5,00	0,3620	1379,8	204,45	204,71	1,0169	0,5885	0,9436	591,9	–0,2516
vapour			20,842	337,64	355,01	1,5573	0,5365	0,6423	136,68	27,91
liquid	10,00	0,4227	1363,2	209,15	209,46	1,0337	0,5922	0,9537	571,8	–0,2230
vapour			24,184	339,70	357,18	1,5554	0,5441	0,6555	136,54	26,97
liquid	15,00	0,4906	1346,3	213,91	214,27	1,0504	0,5960	0,9645	551,8	–0,1915
vapour			27,935	341,73	359,30	1,5537	0,5519	0,6696	136,28	26,11
liquid	20,00	0,5664	1328,9	218,71	219,14	1,0669	0,5997	0,9761	531,7	–0,1565
vapour			32,135	343,73	361,36	1,5521	0,5597	0,6846	135,88	25,34
liquid	25,00	0,6506	1311,0	223,56	224,06	1,0834	0,6036	0,9885	511,5	–0,1176
vapour			36,828	345,70	363,37	1,5506	0,5676	0,7008	135,34	24,65
liquid	30,00	0,7437	1292,7	228,47	229,04	1,0997	0,6075	1,0021	491,3	–0,0740
vapour			42,066	347,63	365,31	1,5492	0,5757	0,7184	134,65	24,02
liquid	35,00	0,8462	1273,8	233,43	234,10	1,1160	0,6114	1,0169	471,0	–0,0248
vapour			47,906	349,51	367,18	1,5478	0,5838	0,7377	133,82	23,46
liquid	40,00	0,9588	1254,3	238,46	239,22	1,1322	0,6155	1,0332	450,5	0,0311
vapour			54,416	351,34	368,96	1,5465	0,5921	0,7589	132,82	22,96
liquid	45,00	1,0821	1234,0	243,55	244,42	1,1484	0,6197	1,0514	429,7	0,0950
vapour			61,673	353,11	370,66	1,5451	0,6006	0,7827	131,65	22,52
liquid	50,00	1,2166	1213,0	248,71	249,71	1,1645	0,6242	1,0719	408,8	0,1688
vapour			69,771	354,81	372,24	1,5437	0,6093	0,8095	130,30	22,14

Table 10 (*continued*)

	Temp. coefficient K/MPa	Pressure °C	Density MPa	Internal energy kg/m^3	Enthalpy kJ/kg	Entropy kJ/kg	C_v kJ/(kg·K)	C_p kJ/(kg·K)	Sound speed kJ/(kg·K)	J-T m/s
liquid	55,00	1,3630	1191,1	253,95	255,10	1,1807	0,6288	1,0953	387,5	0,2549
vapour			78,823	356,42	373,72	1,5421	0,6182	0,8404	128,76	21,81
liquid	60,00	1,5219	1168,1	259,28	260,58	1,1969	0,6338	1,1225	365,9	0,3565
vapour			88,966	357,94	375,05	1,5404	0,6274	0,8763	127,02	21,54
liquid	65,00	1,6941	1144,0	264,71	266,19	1,2131	0,6391	1,1545	343,9	0,4783
vapour			100,375	359,35	376,23	1,5385	0,6370	0,9191	125,07	21,31
liquid	70,00	1,8802	1118,3	270,26	271,94	1,2295	0,6450	1,1931	321,3	0,6264
vapour			113,272	360,62	377,22	1,5363	0,6471	0,9714	122,88	21,14
liquid	75,00	2,0811	1090,9	275,94	277,84	1,2461	0,6517	1,2410	298,1	0,8103
vapour			127,952	361,72	377,99	1,5337	0,6578	1,0370	120,44	21,01
liquid	80,00	2,2975	1061,4	281,78	283,94	1,2629	0,6594	1,3024	274,1	1,0439
vapour			144,822	362,62	378,48	1,5306	0,6693	1,1225	117,73	20,92
liquid	85,00	2,5304	1029,1	287,82	290,27	1,2801	0,6684	1,3844	249,4	1,3495
vapour			164,464	363,26	378,64	1,5268	0,6819	1,2394	114,73	20,85
liquid	90,00	2,7808	993,2	294,11	296,91	1,2978	0,6795	1,5006	223,6	1,7636
vapour			187,766	363,54	378,35	1,5220	0,6961	1,4101	111,41	20,79
liquid	95,00	3,0501	952,2	300,75	303,95	1,3163	0,6936	1,6794	196,9	2,3518
vapour			216,208	363,34	377,45	1,5159	0,7127	1,6835	107,75	20,68
liquid	100,00	3,3399	903,8	307,89	311,58	1,3360	0,7122	1,9963	169,0	3,2470
vapour			252,577	362,38	375,60	1,5076	0,7332	2,1924	103,73	20,41
liquid	105,00	3,6525	842,2	315,90	320,24	1,3581	0,7387	2,7539	139,3	4,7872
vapour			303,473	360,05	372,08	1,4952	0,7610	3,4579	99,28	19,71
liquid	110,00	3,9924	742,7	326,44	331,82	1,3874	0,7870	7,8061	105,3	8,2916
vapour			396,337	353,88	363,95	1,4712	0,8089	11,4400	93,96	17,60
critical	111,97	4,1361	565,0	340,44	347,76	1,4283	c	c	c	13,3694

a Triple point.

b Normal boiling point.

c The values of C_v, C_p, and w at the critical point are not included as part of this International Standard.

5.5 R22 — Chlorodifluoromethane

5.5.1 Range of validity

The coefficients are valid within the following ranges:

T_{min} = 115,73 K, T_{max} = 550 K; p_{max} = 60 MPa; ρ_{max} = 19,91 mol/l (1 722 kg/m^3)

Table 11 — Coefficients and exponents of the ideal-gas part [Equations (3) to (5)]

k	c_k	t_k	a_k	b_k
0	4,005 261 404 46	—	—	—
1	0,000 120 662 553	1	—	—
2	—	—	1,0	4 352,309 5
3	—	—	1,0	1 935,159 1
4	—	—	1,0	1 887,679 36
5	—	—	1,0	1 694,882 84
6	—	—	1,0	1 605,678 48
7	—	—	1,0	1 162,534 24
8	—	—	1,0	857,512 88
9	—	—	1,0	605,726 38
10	—	—	1,0	530,909 82

Table 12 — Coefficients and exponents of the real-gas part [Equation (2)]

k	N_k	t_k	d_k	l_k	
α_k 1	0,695 645 445 236 × 10^{-1}	–1	1	0	
0					
2	0,252 275 419 999 × 10^{2}	1,75	1	0	0
3	– 0,202 351 148 311 × 10^{3}	2,25	1	0	0
4	0,350 063 090 302 × 10^{3}	2,5	1	0	0
5	– 0,223 134 648 863 × 10^{3}	2,75	1	0	0
6	0,488 345 904 592 × 10^{2}	3	1	0	0
7	0,108 874 958 556 × 10^{-1}	5,5	1	0	0
8	0,590 315 073 614	1,5	2	0	0
9	– 0,689 043 767 432	1,75	2	0	0
10	0,284 224 445 844	3,5	2	0	0
11	0,125 436 457 897	1	3	0	0
12	– 0,113 338 666 416 × 10^{-1}	4,5	3	0	0
13	– 0,631 388 959 17 × 10^{-1}	1,5	4	0	0
14	0,974 021 015 232 × 10^{-2}	0,5	5	0	0
15	– 0,408 406 844 722 × 10^{-3}	4,5	6	0	0
16	0,741 948 773 570 × 10^{-3}	1	7	0	0
17	0,315 912 525 922 × 10^{-3}	4	7	0	0
18	0,876 009 723 338 × 10^{-5}	5	7	0	0
19	– 0,110 343 340 301 × 10^{-3}	– 0,5	8	0	0
20	– 0,705 323 356 879 × 10^{-4}	3,5	8	0	0
21	0,235 850 731 510	5	2	2	1
22	– 0,192 640 494 729	7	2	2	1
23	0,375 218 008 557 × 10^{-2}	12	2	2	1
24	– 0,448 926 036 678 × 10^{-4}	15	2	2	1
25	0,198 120 520 635 × 10^{-1}	3,5	3	3	1
26	– 0,356 958 425 255 × 10^{-1}	3,5	4	2	1
27	0,319 594 161 562 × 10^{-1}	8	4	2	1
28	0,260 284 291 078 × 10^{-5}	15	4	2	1
29	– 0,897 629 021 967 × 10^{-2}	25	4	4	1
30	0,345 482 791 645 × 10^{-1}	3	6	2	1
31	– 0,411 831 711 251 × 10^{-2}	9	6	2	1
32	0,567 428 536 529 × 10^{-2}	19	6	4	1
33	– 0,563 368 989 908 × 10^{-2}	2	8	2	1
34	0,191 384 919 423 × 10^{-2}	7	8	2	1
35	– 0,178 930 036 389 × 10^{-2}	13	8	4	1

5.5.2 Reducing parameters, molar mass, and gas constant

$T^* = 369{,}295$ K, $\rho^* = 6{,}058\ 22$ mol/l, $M = 86{,}468$ g/mol, $R = 8{,}314\ 51$ J/(mol·K)

5.5.3 Reference state parameters

$T_{ref} = 273{,}15$ K, $p_{ref} = 1{,}0$ kPa, $h_{ref} = 35\ 874{,}594$ J/mol, $s_{ref} = 205{,}291\ 5$ J/(mol·K), $f_1 = 4{,}111\ 053\ 69$, $f_2 = 2\ 986{,}449\ 88$

Table 13 — R22 property values along the liquid-vapour saturation boundary

	Temp. coefficient K/MPa	Pressure °C	Density MPa	Internal energy kg/m³	Enthalpy kJ/kg	Entropy kJ/kg	C_v kJ/(kg·K)	C_p kJ/(kg·K)	Sound speed kJ/(kg·K)	J-T m/s
liquid	–157,42[a]	$3{,}795\times10^{-7}$	1721,3	29,60	29,60	0,0761	0,7161	1,0753	1410,9	–0,4446
~~vapour~~			~~$3{,}410\times10^{-5}$~~	~~321,58~~	~~332,71~~	~~2,6952~~	~~0,3292~~	~~0,4253~~	~~119,91~~	~~398,80~~
liquid	–155,00	$6{,}620\times10^{-7}$	1714,9	32,20	32,20	0,0983	0,7139	1,0735	1398,2	–0,4450
~~vapour~~			~~$5{,}827\times10^{-5}$~~	~~322,38~~	~~333,74~~	~~2,6505~~	~~0,3318~~	~~0,4280~~	~~121,05~~	~~380,74~~
liquid	–150,00	$1{,}934\times10^{-6}$	1701,8	37,56	37,56	0,1428	0,7086	1,0696	1371,9	–0,4456
~~vapour~~			~~$1{,}633\times10^{-4}$~~	~~324,05~~	~~335,90~~	~~2,5653~~	~~0,3375~~	~~0,4336~~	~~123,35~~	~~344,75~~
liquid	–145,00	$5{,}141\times10^{-6}$	1688,8	42,90	42,90	0,1853	0,7027	1,0663	1346,3	–0,4456
~~vapour~~			~~$4{,}172\times10^{-4}$~~	~~325,76~~	~~338,08~~	~~2,4887~~	~~0,3433~~	~~0,4394~~	~~125,60~~	~~311,19~~
liquid	–140,00	$1{,}258\times10^{-5}$	1675,8	48,22	48,22	0,2260	0,6972	1,0641	1321,4	–0,4449
~~vapour~~			~~$9{,}826\times10^{-4}$~~	~~327,49~~	~~340,29~~	~~2,4195~~	~~0,3492~~	~~0,4454~~	~~127,78~~	~~280,46~~
liquid	–135,00	$2{,}860\times10^{-5}$	1662,8	53,54	53,54	0,2652	0,6923	1,0628	1296,8	–0,4436
~~vapour~~			~~$2{,}153\times10^{-3}$~~	~~329,25~~	~~342,53~~	~~2,3571~~	~~0,3552~~	~~0,4514~~	~~129,92~~	~~252,63~~
liquid	–130,00	$6{,}091\times10^{-5}$	1649,8	58,85	58,85	0,3030	0,6882	1,0622	1272,4	–0,4417
~~vapour~~			~~$4{,}426\times10^{-3}$~~	~~331,04~~	~~344,80~~	~~2,3005~~	~~0,3614~~	~~0,4576~~	~~132,01~~	~~227,61~~
liquid	–125,00	0,000122	1636,8	64,16	64,16	0,3395	0,6847	1,0620	1248,0	–0,4396
~~vapour~~			~~0,00859~~	~~332,85~~	~~347,10~~	~~2,2492~~	~~0,3676~~	~~0,4639~~	~~134,05~~	~~205,23~~
liquid	–120,00	0,000233	1623,7	69,47	69,47	0,3747	0,6815	1,0619	1223,7	–0,4372
~~vapour~~			~~0,01585~~	~~334,70~~	~~349,42~~	~~2,2027~~	~~0,3739~~	~~0,4703~~	~~136,04~~	~~185,26~~
liquid	–115,00	0,000424	1610,7	74,78	74,78	0,4088	0,6786	1,0618	1199,5	–0,4346
~~vapour~~			~~0,02792~~	~~336,57~~	~~351,77~~	~~2,1603~~	~~0,3803~~	~~0,4768~~	~~137,99~~	~~167,49~~
liquid	–110,00	0,000740	1597,6	80,09	80,09	0,4419	0,6759	1,0616	1175,4	–0,4319
~~vapour~~			~~0,04719~~	~~338,48~~	~~354,15~~	~~2,1217~~	~~0,3868~~	~~0,4834~~	~~139,90~~	~~151,69~~
liquid	–105,00	0,00124	1584,5	85,40	85,40	0,4739	0,6732	1,0614	1151,4	–0,4289
~~vapour~~			~~0,0768~~	~~340,40~~	~~356,55~~	~~2,0865~~	~~0,3934~~	~~0,4902~~	~~141,76~~	~~137,65~~
liquid	–100,00	0,00201	1571,3	90,70	90,71	0,5050	0,6706	1,0612	1127,5	–0,4257
~~vapour~~			~~0,1210~~	~~342,35~~	~~358,97~~	~~2,0543~~	~~0,4000~~	~~0,4972~~	~~143,57~~	~~125,17~~
liquid	–95,00	0,00316	1558,1	96,01	96,01	0,5352	0,6680	1,0611	1103,7	–0,4221
~~vapour~~			~~0,1847~~	~~344,32~~	~~361,40~~	~~2,0249~~	~~0,4067~~	~~0,5044~~	~~145,34~~	~~114,07~~
liquid	–90,00	0,00481	1544,9	101,31	101,32	0,5646	0,6655	1,0612	1080,1	–0,4180
~~vapour~~			~~0,2744~~	~~346,31~~	~~363,85~~	~~1,9980~~	~~0,4136~~	~~0,5118~~	~~147,05~~	~~104,20~~
liquid	–85,00	0,00715	1531,6	106,62	106,63	0,5932	0,6632	1,0616	1056,6	–0,4134
~~vapour~~			~~0,3973~~	~~348,31~~	~~366,31~~	~~1,9734~~	~~0,4206~~	~~0,5195~~	~~148,70~~	~~95,41~~
liquid	–80,00	0,0104	1518,2	111,93	111,94	0,6210	0,6611	1,0624	1033,1	–0,4082
~~vapour~~			~~0,562~~	~~350,33~~	~~368,77~~	~~1,9508~~	~~0,4277~~	~~0,5276~~	~~150,29~~	~~87,58~~
liquid	–75,00	0,0147	1504,7	117,24	117,25	0,6482	0,6592	1,0637	1009,8	–0,4023
~~vapour~~			~~0,779~~	~~352,36~~	~~371,24~~	~~1,9300~~	~~0,4350~~	~~0,5359~~	~~151,82~~	~~80,60~~
liquid	–70,00	0,0205	1491,2	122,56	122,58	0,6747	0,6575	1,0655	986,4	–0,3956
~~vapour~~			~~1,060~~	~~354,39~~	~~373,70~~	~~1,9108~~	~~0,4425~~	~~0,5447~~	~~153,28~~	~~74,36~~
liquid	–65,00	0,0279	1477,5	127,90	127,91	0,7006	0,6562	1,0679	963,2	–0,3881
~~vapour~~			~~1,416~~	~~356,42~~	~~376,15~~	~~1,8932~~	~~0,4502~~	~~0,5539~~	~~154,66~~	~~68,78~~

5.5.2 Reducing parameters, molar mass, and gas constant

$T^* = 369{,}295$ K, $\rho^* = 6{,}058\ 22$ mol/l, $M = 86{,}468$ g/mol, $R = 8{,}314\ 51$ J/(mol·K)

5.5.3 Reference state parameters

$T_{ref} = 273{,}15$ K, $p_{ref} = 1{,}0$ kPa, $h_{ref} = 35\ 874{,}594$ J/mol, $s_{ref} = 205{,}291\ 5$ J/(mol·K), $f_1 = 4{,}111\ 053\ 69$, $f_2 = 2\ 986{,}449\ 88$

Table 13 — R22 property values along the liquid-vapour saturation boundary

	Temp. coefficient K/MPa	Pressure °C	Density MPa	Internal energy kg/m³	Enthalpy kJ/kg	Entropy kJ/kg	C_v kJ/(kg·K)	C_p kJ/(kg·K)	Sound speed kJ/(kg·K)	J-T m/s
liquid	–157,42[a]	$3{,}795\times10^{-7}$	1721,3	29,60	29,60	0,0761	0,7161	1,0753	1410,9	–0,4446
~~vapour~~			~~$3{,}410\times10^{-5}$~~	~~321,58~~	~~332,71~~	~~2,6952~~	~~0,3292~~	~~0,4253~~	~~119,91~~	~~398,80~~
liquid	–155,00	$6{,}620\times10^{-7}$	1714,9	32,20	32,20	0,0983	0,7139	1,0735	1398,2	–0,4450
~~vapour~~			~~$5{,}827\times10^{-5}$~~	~~322,38~~	~~333,74~~	~~2,6505~~	~~0,3318~~	~~0,4280~~	~~121,05~~	~~380,74~~
liquid	–150,00	$1{,}934\times10^{-6}$	1701,8	37,56	37,56	0,1428	0,7086	1,0696	1371,9	–0,4456
~~vapour~~			~~$1{,}633\times10^{-4}$~~	~~324,05~~	~~335,90~~	~~2,5653~~	~~0,3375~~	~~0,4336~~	~~123,35~~	~~344,75~~
liquid	–145,00	$5{,}141\times10^{-6}$	1688,8	42,90	42,90	0,1853	0,7027	1,0663	1346,3	–0,4456
~~vapour~~			~~$4{,}172\times10^{-4}$~~	~~325,76~~	~~338,08~~	~~2,4887~~	~~0,3433~~	~~0,4394~~	~~125,60~~	~~311,19~~
liquid	–140,00	$1{,}258\times10^{-5}$	1675,8	48,22	48,22	0,2260	0,6972	1,0641	1321,4	–0,4449
~~vapour~~			~~$9{,}826\times10^{-4}$~~	~~327,49~~	~~340,29~~	~~2,4195~~	~~0,3492~~	~~0,4454~~	~~127,78~~	~~280,46~~
liquid	–135,00	$2{,}860\times10^{-5}$	1662,8	53,54	53,54	0,2652	0,6923	1,0628	1296,8	–0,4436
~~vapour~~			~~$2{,}153\times10^{-3}$~~	~~329,25~~	~~342,53~~	~~2,3571~~	~~0,3552~~	~~0,4514~~	~~129,92~~	~~252,63~~
liquid	–130,00	$6{,}091\times10^{-5}$	1649,8	58,85	58,85	0,3030	0,6882	1,0622	1272,4	–0,4417
~~vapour~~			~~$4{,}426\times10^{-3}$~~	~~331,04~~	~~344,80~~	~~2,3005~~	~~0,3614~~	~~0,4576~~	~~132,01~~	~~227,61~~
liquid	–125,00	0,000122	1636,8	64,16	64,16	0,3395	0,6847	1,0620	1248,0	–0,4396
~~vapour~~			~~0,00859~~	~~332,85~~	~~347,10~~	~~2,2492~~	~~0,3676~~	~~0,4639~~	~~134,05~~	~~205,23~~
liquid	–120,00	0,000233	1623,7	69,47	69,47	0,3747	0,6815	1,0619	1223,7	–0,4372
~~vapour~~			~~0,01585~~	~~334,70~~	~~349,42~~	~~2,2027~~	~~0,3739~~	~~0,4703~~	~~136,04~~	~~185,26~~
liquid	–115,00	0,000424	1610,7	74,78	74,78	0,4088	0,6786	1,0618	1199,5	–0,4346
~~vapour~~			~~0,02792~~	~~336,57~~	~~351,77~~	~~2,1603~~	~~0,3803~~	~~0,4768~~	~~137,99~~	~~167,49~~
liquid	–110,00	0,000740	1597,6	80,09	80,09	0,4419	0,6759	1,0616	1175,4	–0,4319
~~vapour~~			~~0,04719~~	~~338,48~~	~~354,15~~	~~2,1217~~	~~0,3868~~	~~0,4834~~	~~139,90~~	~~151,69~~
liquid	–105,00	0,00124	1584,5	85,40	85,40	0,4739	0,6732	1,0614	1151,4	–0,4289
~~vapour~~			~~0,0768~~	~~340,40~~	~~356,55~~	~~2,0865~~	~~0,3934~~	~~0,4902~~	~~141,76~~	~~137,65~~
liquid	–100,00	0,00201	1571,3	90,70	90,71	0,5050	0,6706	1,0612	1127,5	–0,4257
~~vapour~~			~~0,1210~~	~~342,35~~	~~358,97~~	~~2,0543~~	~~0,4000~~	~~0,4972~~	~~143,57~~	~~125,17~~
liquid	–95,00	0,00316	1558,1	96,01	96,01	0,5352	0,6680	1,0611	1103,7	–0,4221
~~vapour~~			~~0,1847~~	~~344,32~~	~~361,40~~	~~2,0249~~	~~0,4067~~	~~0,5044~~	~~145,34~~	~~114,07~~
liquid	–90,00	0,00481	1544,9	101,31	101,32	0,5646	0,6655	1,0612	1080,1	–0,4180
~~vapour~~			~~0,2744~~	~~346,31~~	~~363,85~~	~~1,9980~~	~~0,4136~~	~~0,5118~~	~~147,05~~	~~104,20~~
liquid	–85,00	0,00715	1531,6	106,62	106,63	0,5932	0,6632	1,0616	1056,6	–0,4134
~~vapour~~			~~0,3973~~	~~348,31~~	~~366,31~~	~~1,9734~~	~~0,4206~~	~~0,5195~~	~~148,70~~	~~95,41~~
liquid	–80,00	0,0104	1518,2	111,93	111,94	0,6210	0,6611	1,0624	1033,1	–0,4082
~~vapour~~			~~0,562~~	~~350,33~~	~~368,77~~	~~1,9508~~	~~0,4277~~	~~0,5276~~	~~150,29~~	~~87,58~~
liquid	–75,00	0,0147	1504,7	117,24	117,25	0,6482	0,6592	1,0637	1009,8	–0,4023
~~vapour~~			~~0,779~~	~~352,36~~	~~371,24~~	~~1,9300~~	~~0,4350~~	~~0,5359~~	~~151,82~~	~~80,60~~
liquid	–70,00	0,0205	1491,2	122,56	122,58	0,6747	0,6575	1,0655	986,4	–0,3956
~~vapour~~			~~1,060~~	~~354,39~~	~~373,70~~	~~1,9108~~	~~0,4425~~	~~0,5447~~	~~153,28~~	~~74,36~~
liquid	–65,00	0,0279	1477,5	127,90	127,91	0,7006	0,6562	1,0679	963,2	–0,3881
~~vapour~~			~~1,416~~	~~356,42~~	~~376,15~~	~~1,8932~~	~~0,4502~~	~~0,5539~~	~~154,66~~	~~68,78~~

Table 13 (*continued*)

	Temp. coefficient K/MPa	Pressure °C	Density MPa	Internal energy kg/m^3	Enthalpy kJ/kg	Entropy kJ/kg	C_v kJ/(kg·K)	C_p kJ/(kg·K)	Sound speed kJ/(kg·K)	J-T m/s
liquid	60,00	2,4275	1030,4	275,26	277,61	1,2504	0,7308	1,5392	364,3	0,6730
~~vapour~~			~~111,591~~	~~395,80~~	~~417,55~~	~~1,6705~~	~~0,7335~~	~~1,2872~~	~~147,72~~	~~19,85~~
liquid	65,00	2,7012	1001,4	282,49	285,18	1,2722	0,7384	1,6259	337,0	0,8674
~~vapour~~			~~127,430~~	~~395,87~~	~~417,06~~	~~1,6622~~	~~0,7511~~	~~1,4128~~	~~144,85~~	~~19,32~~
liquid	70,00	2,9974	969,7	290,01	293,10	1,2945	0,7467	1,7434	308,8	1,1199
~~vapour~~			~~145,991~~	~~395,56~~	~~416,09~~	~~1,6529~~	~~0,7702~~	~~1,5837~~	~~141,66~~	~~18,81~~
liquid	75,00	3,3177	934,4	297,91	301,46	1,3177	0,7563	1,9127	279,6	1,4598
~~vapour~~			~~168,158~~	~~394,76~~	~~414,49~~	~~1,6424~~	~~0,7914~~	~~1,8322~~	~~138,11~~	~~18,28~~
liquid	80,00	3,6638	893,7	306,34	310,44	1,3423	0,7680	2,1814	248,8	1,9420
~~vapour~~			~~195,404~~	~~393,26~~	~~412,01~~	~~1,6299~~	~~0,8157~~	~~2,2308~~	~~134,15~~	~~17,70~~
liquid	85,00	4,0378	844,8	315,60	320,38	1,3690	0,7840	2,6821	215,3	2,6843
~~vapour~~			~~230,560~~	~~390,67~~	~~408,19~~	~~1,6142~~	~~0,8450~~	~~2,9841~~	~~129,71~~	~~16,98~~
liquid	90,00	4,4423	780,1	326,39	332,09	1,4001	0,8115	3,9811	177,0	4,0006
~~vapour~~			~~280,625~~	~~386,04~~	~~401,87~~	~~1,5922~~	~~0,8843~~	~~4,9749~~	~~124,64~~	~~15,90~~
liquid	95,00	4,8824	662,9	342,19	349,56	1,4462	0,8918	17,3120	128,0	7,2855
~~vapour~~			~~382,037~~	~~374,50~~	~~387,28~~	~~1,5486~~	~~0,9566~~	~~25,2863~~	~~117,96~~	~~13,40~~
critical	96,15	4,9900	523,8	357,37	366,90	1,4927	c	c	c	10,3661

a Triple point.

b Normal boiling point.

c The values of Cv, Cp, and w at the critical point are not included as part of this International Standard.

5.6 R32 — Difluoromethane

5.6.1 Range of validity

The coefficients are valid within the following ranges:

T_{min} = 136,34 K, T_{max} = 435 K; p_{max} = 70 MPa; ρ_{max} = 27,473 4 mol/l (1 429 kg/m^3)

Table 14 — Coefficients and exponents of the ideal-gas part [Equations (3) to (5)]

k	c_k	a_k	b_k
0	4,004 486	—	—
1	—	1,160 761	798
2	—	2,645 151	4 185
3	—	5,794 987	1 806
4	—	1,129 475	11 510

Table 15 — Coefficients and exponents of the real-gas part [Equation (2)]

k	N_k	t_k	d_k	l_k	α_k
1	1,046 634	0,25	1	0	0
2	– 0,545 116 5	1	2	0	0
3	– 0,002 448 595	– 0,25	5	0	0
4	– 0,048 770 02	– 1	1	0	0
5	0,035 201 58	2	1	0	0
6	0,001 622 75	2	3	0	0
7	0,000 023 772 25	0,75	8	0	0
8	0,029 149	0,25	4	0	0
9	0,003 386 203	18	4	4	1
10	– 0,004 202 444	26	4	3	1
11	0,000 478 202 5	– 1	8	1	1
12	– 0,005 504 323	25	3	4	1
13	– 0,024 183 96	1,75	5	1	1
14	0,420 903 4	4	1	2	1
15	– 0,461 653 7	5	1	2	1
16	– 1,200 513	1	3	1	1
17	– 2,591 55	1,5	1	1	1
18	– 1,400 145	1	2	1	1
19	0,826 301 7	0,5	3	1	1

5.6.2 Reducing parameters, molar mass, and gas constant

$T^* = 351{,}255$ K, $\rho^* = 8{,}150\,084\,6$ mol/l, $M = 52{,}024$ g/mol, $R = 8{,}314\,471$ J/(mol·K)

5.6.3 Reference state parameters

$T_{ref} = 273{,}15$ K, $p_{ref} = 1{,}0$ kPa, $h_{ref} = 28\,204{,}341$ J/mol, $s_{ref} = 171{,}691\,3$ J/(mol·K), $f_1 = 7{,}254\,707\,84$, $f_2 = 2\,231{,}557\,35$

Table 16 — R32 property values along the liquid-vapour saturation boundary

	Temp. coefficient K/MPa	Pressure °C	Density MPa	Internal energy kg/m^3	Enthalpy kJ/kg	Entropy kJ/kg	C_v kJ/(kg·K)	C_p kJ/(kg·K)	Sound speed kJ/(kg·K)	J-T m/s
liquid	–136,81[a]	4,800×10^{-5}	1429,3	–19,07	–19,07	–0,1050	1,0658	1,5925	1414,4	–0,3376
vapour			2,203×10^{-3}	422,52	444,31	3,2937	0,4995	0,6597	169,60	881,12
liquid	–135,00	6,339×10^{-5}	1424,9	–16,19	–16,19	–0,0840	1,0613	1,5900	1404,9	–0,3375
vapour			2,872×10^{-3}	423,42	445,49	3,2579	0,5007	0,6609	170,67	823,35
liquid	–130,00	0,000131	1412,7	–8,26	–8,26	–0,0276	1,0494	1,5835	1378,4	–0,3369
vapour			0,00574	425,90	448,77	3,1651	0,5041	0,6646	173,59	686,24
liquid	–125,00	0,000257	1400,6	–0,36	–0,36	0,0267	1,0380	1,5777	1352,1	–0,3359
vapour			0,01085	428,39	452,05	3,0804	0,5080	0,6689	176,44	576,21
liquid	–120,00	0,000478	1388,4	7,52	7,52	0,0790	1,0274	1,5726	1325,8	–0,3345
vapour			0,01954	430,88	455,33	3,0030	0,5123	0,6738	179,21	487,31
liquid	–115,00	0,000850	1376,1	15,37	15,37	0,1294	1,0173	1,5682	1299,5	–0,3327
vapour			0,03369	433,37	458,60	2,9320	0,5173	0,6796	181,91	415,01
liquid	–110,00	0,00145	1363,8	23,20	23,20	0,1782	1,0079	1,5647	1273,4	–0,3304
vapour			0,0558	435,85	461,86	2,8668	0,5229	0,6863	184,52	355,78
liquid	–105,00	0,00239	1351,5	31,02	31,02	0,2254	0,9991	1,5619	1247,3	–0,3277
vapour			0,0894	438,32	465,10	2,8068	0,5293	0,6940	187,05	306,92
liquid	–100,00	0,00381	1339,0	38,82	38,83	0,2711	0,9910	1,5600	1221,2	–0,3244
vapour			0,1385	440,77	468,31	2,7515	0,5365	0,7030	189,50	266,28
liquid	–95,00	0,00590	1326,5	46,62	46,62	0,3155	0,9834	1,5588	1195,3	–0,3205
vapour			0,2084	443,20	471,48	2,7003	0,5446	0,7134	191,84	232,23
liquid	–90,00	0,00887	1313,9	54,41	54,42	0,3586	0,9764	1,5586	1169,3	–0,3160
vapour			0,3056	445,59	474,61	2,6529	0,5538	0,7254	194,09	203,45
liquid	–85,00	0,0130	1301,2	62,20	62,21	0,4006	0,9700	1,5592	1143,4	–0,3109
vapour			0,438	447,96	477,70	2,6089	0,5641	0,7390	196,24	178,95
liquid	–80,00	0,0187	1288,4	70,00	70,02	0,4415	0,9641	1,5606	1117,5	–0,3051
vapour			0,613	450,29	480,72	2,5679	0,5755	0,7543	198,26	157,95
liquid	–75,00	0,0262	1275,4	77,81	77,83	0,4814	0,9588	1,5630	1091,7	–0,2986
vapour			0,842	452,57	483,68	2,5296	0,5880	0,7714	200,18	139,85
liquid	–70,00	0,0361	1262,4	85,63	85,66	0,5204	0,9540	1,5663	1065,8	–0,2913
vapour			1,135	454,81	486,57	2,4939	0,6015	0,7903	201,96	124,19
liquid	–65,00	0,0488	1249,1	93,46	93,50	0,5585	0,9497	1,5706	1039,9	–0,2831
vapour			1,507	456,99	489,38	2,4604	0,6160	0,8110	203,62	110,58
liquid	–60,00	0,0650	1235,7	101,32	101,38	0,5958	0,9460	1,5758	1014,1	–0,2740
vapour			1,969	459,12	492,11	2,4289	0,6315	0,8335	205,14	98,73
liquid	–55,00	0,0852	1222,1	109,21	109,28	0,6324	0,9427	1,5821	988,2	–0,2640
vapour			2,538	461,19	494,74	2,3993	0,6477	0,8576	206,52	88,40
liquid	–50,00	0,1101	1208,4	117,13	117,22	0,6683	0,9400	1,5895	962,2	–0,2528
vapour			3,232	463,19	497,27	2,3714	0,6646	0,8835	207,75	79,39
liquid	–51,65[b]	0,1013	1212,9	114,51	114,59	0,6565	0,9408	1,5869	970,8	–0,2566
vapour			2,988	462,54	496,45	2,3805	0,6589	0,8748	207,36	82,23
liquid	–45,00	0,1406	1194,4	125,08	125,20	0,7035	0,9377	1,5980	936,3	–0,2404
vapour			4,067	465,13	499,70	2,3450	0,6820	0,9110	208,83	71,52
liquid	–40,00	0,1774	1180,2	133,08	133,23	0,7382	0,9359	1,6077	910,2	–0,2267
vapour			5,065	466,99	502,02	2,3200	0,6998	0,9401	209,74	64,65
liquid	–35,00	0,2214	1165,7	141,12	141,31	0,7723	0,9346	1,6187	884,0	–0,2115
vapour			6,248	468,78	504,21	2,2962	0,7180	0,9709	210,49	58,63
liquid	–30,00	0,2734	1151,0	149,21	149,45	0,8060	0,9338	1,6311	857,8	–0,1947
vapour			7,639	470,48	506,27	2,2735	0,7365	1,0035	211,07	53,37

Table 16 — R32 property values along the liquid-vapour saturation boundary

	Temp. coefficient K/MPa	Pressure °C	Density MPa	Internal energy kg/m^3	Enthalpy kJ/kg	Entropy kJ/kg	C_v kJ/(kg·K)	C_p kJ/(kg·K)	Sound speed kJ/(kg·K)	J-T m/s
liquid	–136,81[a]	4,800×10^{-5}	1429,3	–19,07	–19,07	–0,1050	1,0658	1,5925	1414,4	–0,3376
vapour			2,203×10^{-3}	422,52	444,31	3,2937	0,4995	0,6597	169,60	881,12
liquid	–135,00	6,339×10^{-5}	1424,9	–16,19	–16,19	–0,0840	1,0613	1,5900	1404,9	–0,3375
vapour			2,872×10^{-3}	423,42	445,49	3,2579	0,5007	0,6609	170,67	823,35
liquid	–130,00	0,000131	1412,7	–8,26	–8,26	–0,0276	1,0494	1,5835	1378,4	–0,3369
vapour			0,00574	425,90	448,77	3,1651	0,5041	0,6646	173,59	686,24
liquid	–125,00	0,000257	1400,6	–0,36	–0,36	0,0267	1,0380	1,5777	1352,1	–0,3359
vapour			0,01085	428,39	452,05	3,0804	0,5080	0,6689	176,44	576,21
liquid	–120,00	0,000478	1388,4	7,52	7,52	0,0790	1,0274	1,5726	1325,8	–0,3345
vapour			0,01954	430,88	455,33	3,0030	0,5123	0,6738	179,21	487,31
liquid	–115,00	0,000850	1376,1	15,37	15,37	0,1294	1,0173	1,5682	1299,5	–0,3327
vapour			0,03369	433,37	458,60	2,9320	0,5173	0,6796	181,91	415,01
liquid	–110,00	0,00145	1363,8	23,20	23,20	0,1782	1,0079	1,5647	1273,4	–0,3304
vapour			0,0558	435,85	461,86	2,8668	0,5229	0,6863	184,52	355,78
liquid	–105,00	0,00239	1351,5	31,02	31,02	0,2254	0,9991	1,5619	1247,3	–0,3277
vapour			0,0894	438,32	465,10	2,8068	0,5293	0,6940	187,05	306,92
liquid	–100,00	0,00381	1339,0	38,82	38,83	0,2711	0,9910	1,5600	1221,2	–0,3244
vapour			0,1385	440,77	468,31	2,7515	0,5365	0,7030	189,50	266,28
liquid	–95,00	0,00590	1326,5	46,62	46,62	0,3155	0,9834	1,5588	1195,3	–0,3205
vapour			0,2084	443,20	471,48	2,7003	0,5446	0,7134	191,84	232,23
liquid	–90,00	0,00887	1313,9	54,41	54,42	0,3586	0,9764	1,5586	1169,3	–0,3160
vapour			0,3056	445,59	474,61	2,6529	0,5538	0,7254	194,09	203,45
liquid	–85,00	0,0130	1301,2	62,20	62,21	0,4006	0,9700	1,5592	1143,4	–0,3109
vapour			0,438	447,96	477,70	2,6089	0,5641	0,7390	196,24	178,95
liquid	–80,00	0,0187	1288,4	70,00	70,02	0,4415	0,9641	1,5606	1117,5	–0,3051
vapour			0,613	450,29	480,72	2,5679	0,5755	0,7543	198,26	157,95
liquid	–75,00	0,0262	1275,4	77,81	77,83	0,4814	0,9588	1,5630	1091,7	–0,2986
vapour			0,842	452,57	483,68	2,5296	0,5880	0,7714	200,18	139,85
liquid	–70,00	0,0361	1262,4	85,63	85,66	0,5204	0,9540	1,5663	1065,8	–0,2913
vapour			1,135	454,81	486,57	2,4939	0,6015	0,7903	201,96	124,19
liquid	–65,00	0,0488	1249,1	93,46	93,50	0,5585	0,9497	1,5706	1039,9	–0,2831
vapour			1,507	456,99	489,38	2,4604	0,6160	0,8110	203,62	110,58
liquid	–60,00	0,0650	1235,7	101,32	101,38	0,5958	0,9460	1,5758	1014,1	–0,2740
vapour			1,969	459,12	492,11	2,4289	0,6315	0,8335	205,14	98,73
liquid	–55,00	0,0852	1222,1	109,21	109,28	0,6324	0,9427	1,5821	988,2	–0,2640
vapour			2,538	461,19	494,74	2,3993	0,6477	0,8576	206,52	88,40
liquid	–50,00	0,1101	1208,4	117,13	117,22	0,6683	0,9400	1,5895	962,2	–0,2528
vapour			3,232	463,19	497,27	2,3714	0,6646	0,8835	207,75	79,39
liquid	–51,65[b]	0,1013	1212,9	114,51	114,59	0,6565	0,9408	1,5869	970,8	–0,2566
vapour			2,988	462,54	496,45	2,3805	0,6589	0,8748	207,36	82,23
liquid	–45,00	0,1406	1194,4	125,08	125,20	0,7035	0,9377	1,5980	936,3	–0,2404
vapour			4,067	465,13	499,70	2,3450	0,6820	0,9110	208,83	71,52
liquid	–40,00	0,1774	1180,2	133,08	133,23	0,7382	0,9359	1,6077	910,2	–0,2267
vapour			5,065	466,99	502,02	2,3200	0,6998	0,9401	209,74	64,65
liquid	–35,00	0,2214	1165,7	141,12	141,31	0,7723	0,9346	1,6187	884,0	–0,2115
vapour			6,248	468,78	504,21	2,2962	0,7180	0,9709	210,49	58,63
liquid	–30,00	0,2734	1151,0	149,21	149,45	0,8060	0,9338	1,6311	857,8	–0,1947
vapour			7,639	470,48	506,27	2,2735	0,7365	1,0035	211,07	53,37

Table 16 — R32 property values along the liquid-vapour saturation boundary

	Temp. coefficient K/MPa	Pressure °C	Density MPa	Internal energy kg/m^3	Enthalpy kJ/kg	Entropy kJ/kg	C_v kJ/(kg·K)	C_p kJ/(kg·K)	Sound speed kJ/(kg·K)	J-T m/s
liquid	–136,81[a]	4,800×10^{-5}	1429,3	–19,07	–19,07	–0,1050	1,0658	1,5925	1414,4	–0,3376
vapour			2,203×10^{-3}	422,52	444,31	3,2937	0,4995	0,6597	169,60	881,12
liquid	–135,00	6,339×10^{-5}	1424,9	–16,19	–16,19	–0,0840	1,0613	1,5900	1404,9	–0,3375
vapour			2,872×10^{-3}	423,42	445,49	3,2579	0,5007	0,6609	170,67	823,35
liquid	–130,00	0,000131	1412,7	–8,26	–8,26	–0,0276	1,0494	1,5835	1378,4	–0,3369
vapour			0,00574	425,90	448,77	3,1651	0,5041	0,6646	173,59	686,24
liquid	–125,00	0,000257	1400,6	–0,36	–0,36	0,0267	1,0380	1,5777	1352,1	–0,3359
vapour			0,01085	428,39	452,05	3,0804	0,5080	0,6689	176,44	576,21
liquid	–120,00	0,000478	1388,4	7,52	7,52	0,0790	1,0274	1,5726	1325,8	–0,3345
vapour			0,01954	430,88	455,33	3,0030	0,5123	0,6738	179,21	487,31
liquid	–115,00	0,000850	1376,1	15,37	15,37	0,1294	1,0173	1,5682	1299,5	–0,3327
vapour			0,03369	433,37	458,60	2,9320	0,5173	0,6796	181,91	415,01
liquid	–110,00	0,00145	1363,8	23,20	23,20	0,1782	1,0079	1,5647	1273,4	–0,3304
vapour			0,0558	435,85	461,86	2,8668	0,5229	0,6863	184,52	355,78
liquid	–105,00	0,00239	1351,5	31,02	31,02	0,2254	0,9991	1,5619	1247,3	–0,3277
vapour			0,0894	438,32	465,10	2,8068	0,5293	0,6940	187,05	306,92
liquid	–100,00	0,00381	1339,0	38,82	38,83	0,2711	0,9910	1,5600	1221,2	–0,3244
vapour			0,1385	440,77	468,31	2,7515	0,5365	0,7030	189,50	266,28
liquid	–95,00	0,00590	1326,5	46,62	46,62	0,3155	0,9834	1,5588	1195,3	–0,3205
vapour			0,2084	443,20	471,48	2,7003	0,5446	0,7134	191,84	232,23
liquid	–90,00	0,00887	1313,9	54,41	54,42	0,3586	0,9764	1,5586	1169,3	–0,3160
vapour			0,3056	445,59	474,61	2,6529	0,5538	0,7254	194,09	203,45
liquid	–85,00	0,0130	1301,2	62,20	62,21	0,4006	0,9700	1,5592	1143,4	–0,3109
vapour			0,438	447,96	477,70	2,6089	0,5641	0,7390	196,24	178,95
liquid	–80,00	0,0187	1288,4	70,00	70,02	0,4415	0,9641	1,5606	1117,5	–0,3051
vapour			0,613	450,29	480,72	2,5679	0,5755	0,7543	198,26	157,95
liquid	–75,00	0,0262	1275,4	77,81	77,83	0,4814	0,9588	1,5630	1091,7	–0,2986
vapour			0,842	452,57	483,68	2,5296	0,5880	0,7714	200,18	139,85
liquid	–70,00	0,0361	1262,4	85,63	85,66	0,5204	0,9540	1,5663	1065,8	–0,2913
vapour			1,135	454,81	486,57	2,4939	0,6015	0,7903	201,96	124,19
liquid	–65,00	0,0488	1249,1	93,46	93,50	0,5585	0,9497	1,5706	1039,9	–0,2831
vapour			1,507	456,99	489,38	2,4604	0,6160	0,8110	203,62	110,58
liquid	–60,00	0,0650	1235,7	101,32	101,38	0,5958	0,9460	1,5758	1014,1	–0,2740
vapour			1,969	459,12	492,11	2,4289	0,6315	0,8335	205,14	98,73
liquid	–55,00	0,0852	1222,1	109,21	109,28	0,6324	0,9427	1,5821	988,2	–0,2640
vapour			2,538	461,19	494,74	2,3993	0,6477	0,8576	206,52	88,40
liquid	–50,00	0,1101	1208,4	117,13	117,22	0,6683	0,9400	1,5895	962,2	–0,2528
vapour			3,232	463,19	497,27	2,3714	0,6646	0,8835	207,75	79,39
liquid	–51,65[b]	0,1013	1212,9	114,51	114,59	0,6565	0,9408	1,5869	970,8	–0,2566
vapour			2,988	462,54	496,45	2,3805	0,6589	0,8748	207,36	82,23
liquid	–45,00	0,1406	1194,4	125,08	125,20	0,7035	0,9377	1,5980	936,3	–0,2404
vapour			4,067	465,13	499,70	2,3450	0,6820	0,9110	208,83	71,52
liquid	–40,00	0,1774	1180,2	133,08	133,23	0,7382	0,9359	1,6077	910,2	–0,2267
vapour			5,065	466,99	502,02	2,3200	0,6998	0,9401	209,74	64,65
liquid	–35,00	0,2214	1165,7	141,12	141,31	0,7723	0,9346	1,6187	884,0	–0,2115
vapour			6,248	468,78	504,21	2,2962	0,7180	0,9709	210,49	58,63
liquid	–30,00	0,2734	1151,0	149,21	149,45	0,8060	0,9338	1,6311	857,8	–0,1947
vapour			7,639	470,48	506,27	2,2735	0,7365	1,0035	211,07	53,37

Table 18 — Coefficients and exponents of the real-gas part [Equation (2)]

k	N_k	t_k	d_k	l_k	
α_k					
1	$-0{,}100\,242\,647\,494 \times 10^{2}$	3	0	0	0
2	$-0{,}280\,607\,656\,419$	4	0	0	0
3	$0{,}206\,814\,471\,606 \times 10^{-1}$	5	0	0	0
4	$-0{,}284\,379\,431\,451$	0	1	0	0
5	$0{,}593\,928\,110\,321 \times 10^{1}$	0,5	1	0	0
6	$-0{,}936\,560\,389\,528 \times 10^{1}$	1	1	0	0
7	$0{,}416\,660\,793\,675 \times 10^{1}$	2	1	0	0
8	$-0{,}174\,023\,292\,951 \times 10^{1}$	3	1	0	0
9	$0{,}177\,019\,905\,365$	0	2	0	0
10	$-0{,}154\,721\,692\,26 \times 10^{1}$	1	2	0	0
11	$0{,}161\,820\,495\,59 \times 10^{1}$	2	2	0	0
12	$0{,}288\,903\,529\,383 \times 10^{1}$	3	2	0	0
13	$-0{,}118\,493\,874\,757$	0	3	0	0
14	$0{,}130\,952\,266\,209 \times 10^{1}$	1	3	0	0
15	$-0{,}117\,308\,103\,711 \times 10^{1}$	2	3	0	0
16	$-0{,}128\,125\,131\,950$	1	4	0	0
17	$-0{,}786\,087\,387\,513 \times 10^{-1}$	2	5	0	0
18	$-0{,}816\,000\,499\,305 \times 10^{-1}$	3	5	0	0
19	$0{,}536\,451\,054\,311 \times 10^{-1}$	2	6	0	0
20	$-0{,}680\,078\,211\,929 \times 10^{-2}$	2	7	0	0
21	$0{,}701\,264\,082\,191 \times 10^{-2}$	3	7	0	0
22	$-0{,}901\,762\,397\,311 \times 10^{-3}$	3	8	0	0
23	$0{,}100\,242\,647\,494 \times 10^{2}$	3	0	2	1
24	$0{,}280\,607\,656\,419$	4	0	2	1
25	$-0{,}206\,814\,471\,606 \times 10^{-1}$	5	0	2	1
26	$0{,}798\,923\,878\,145 \times 10^{1}$	3	2	2	1
27	$-0{,}547\,972\,072\,476$	4	2	2	1
28	$-0{,}206\,814\,470\,584 \times 10^{-1}$	5	2	2	1
29	$0{,}249\,142\,724\,365 \times 10^{1}$	3	4	2	1
30	$-0{,}273\,986\,034\,884$	4	4	2	1
31	$0{,}236\,001\,863\,614$	5	4	2	1
32	$0{,}540\,528\,251\,211$	3	6	2	1
33	$-0{,}600\,457\,561\,959 \times 10^{-1}$	4	6	2	1
34	$0{,}786\,672\,874\,826 \times 10^{-1}$	5	6	2	1
35	$0{,}708\,085\,874\,508 \times 10^{-1}$	3	8	2	1
36	$-0{,}150\,114\,389\,748 \times 10^{-1}$	4	8	2	1
37	$0{,}182\,205\,199\,477 \times 10^{-2}$	5	8	2	1
38	$0{,}314\,978\,575\,163 \times 10^{-2}$	3	10	2	1
39	$0{,}784\,455\,573\,794 \times 10^{-2}$	4	10	2	1
40	$0{,}364\,410\,397\,155 \times 10^{-3}$	5	10	2	1

5.7.2 Reducing parameters, molar mass, and gas constant

$T^* = 456{,}831$ K, $\rho^* = 3{,}596\,417$ mol/l, $M = 152{,}931$ g/mol, $R = 8{,}314\,51$ J/(mol·K)

5.7.3 Reference state parameters

$T_{ref} = 273{,}15$ K, $p_{ref} = 1{,}0$ kPa, $h_{ref} = 58\,497{,}533$ J/mol, $s_{ref} = 283{,}936\,5$ J/(mol·K), $f_1 = -8{,}106\,583\,79$, $f_2 = 5\,001{,}445\,51$

Table 19 — R123 property values along the liquid-vapour saturation boundary

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T
	coefficient °C K/MPa	MPa	kg/m³	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	
liquid	–107,15[a]	4,202×10–6	1771,0	98,81	98,81	0,5311	0,6295	0,9289	1243,8	–0,4755
vapour			4,656×10–4	313,47	322,50	1,8786	0,4194	0,4738	100,97	335,67
liquid	–105,00	5,765×10–6	1766,0	100,80	100,80	0,5430	0,6306	0,9280	1235,3	–0,4762
vapour			6,306×10–4	314,38	323,52	1,8675	0,4232	0,4776	101,57	319,10
liquid	–100,00	,161×10–5	1754,5	105,44	105,44	0,5702	0,6321	0,9261	1215,3	–0,4772
vapour			1,233×10–3	316,51	325,93	1,8436	0,4319	0,4863	102,95	284,41
liquid	–95,00	2,233×10–5	1743,2	110,07	110,07	0,5965	0,6328	0,9245	1195,0	–0,4775
vapour			2,306×10–3	318,69	328,38	1,8220	0,4405	0,4949	104,31	254,37
liquid	–90,00	4,120×10–5	1732,0	114,68	114,68	0,6221	0,6333	0,9235	1174,6	–0,4771
vapour			4,138×10–3	320,92	330,87	1,8025	0,4491	0,5035	105,65	228,26
liquid	–85,00	7,317×10–5	1720,8	119,30	119,30	0,6470	0,6338	0,9232	1153,9	–0,4759
vapour			7,154×10–3	323,18	333,41	1,7849	0,4575	0,5119	106,97	205,49
liquid	–80,00	0,000125	1709,6	123,92	123,92	0,6712	0,6346	0,9236	1133,1	–0,4740
vapour			0,01195	325,49	335,98	1,7691	0,4658	0,5202	108,27	185,55
liquid	–75,00	0,000208	1698,5	128,54	128,54	0,6948	0,6356	0,9247	1112,1	–0,4714
vapour			0,01935	327,83	338,60	1,7549	0,4740	0,5285	109,55	168,05
liquid	–70,00	0,000336	1687,4	133,17	133,17	0,7179	0,6371	0,9266	1091,1	–0,4681
vapour			0,03045	330,21	341,25	1,7422	0,4821	0,5367	110,81	152,63
liquid	–65,00	0,000528	1676,2	137,80	137,80	0,7404	0,6388	0,9290	1069,9	–0,4643
vapour			0,04666	332,63	343,94	1,7307	0,4902	0,5448	112,06	139,01
liquid	–60,00	0,000808	1665,1	142,46	142,46	0,7625	0,6410	0,9320	1048,7	–0,4599
vapour			0,06977	335,09	346,66	1,7206	0,4982	0,5529	113,27	126,94
liquid	–55,00	0,00121	1653,9	147,13	147,13	0,7842	0,6435	0,9354	1027,6	–0,4550
vapour			0,1020	337,58	349,42	1,7115	0,5061	0,5610	114,47	116,22
liquid	–50,00	0,00177	1642,6	151,81	151,81	0,8054	0,6462	0,9393	1006,4	–0,4496
vapour			0,1461	340,11	352,21	1,7034	0,5139	0,5690	115,64	106,68
liquid	–45,00	0,00254	1631,3	156,52	156,52	0,8263	0,6493	0,9435	985,3	–0,4437
vapour			0,2052	342,66	355,03	1,6964	0,5217	0,5770	116,78	98,17
liquid	–40,00	0,00358	1620,0	161,25	161,25	0,8468	0,6526	0,9480	964,3	–0,4375
vapour			0,2831	345,25	357,88	1,6901	0,5295	0,5850	117,90	90,55
liquid	–35,00	0,00495	1608,5	166,00	166,00	0,8669	0,6561	0,9528	943,4	–0,4309
vapour			0,3843	347,87	360,75	1,6847	0,5372	0,5931	118,98	83,73
liquid	–30,00	0,00675	1597,0	170,77	170,78	0,8868	0,6597	0,9578	922,6	–0,4239
vapour			0,5136	350,51	363,65	1,6800	0,5448	0,6011	120,03	77,60
liquid	–25,00	0,00906	1585,4	175,58	175,58	0,9063	0,6635	0,9629	901,9	–0,4166
vapour			0,6767	353,19	366,57	1,6760	0,5525	0,6092	121,04	72,09
liquid	–20,00	0,0120	1573,8	180,40	180,41	0,9256	0,6674	0,9682	881,3	–0,4088
vapour			0,880	355,88	369,52	1,6726	0,5601	0,6174	122,01	67,13
liquid	–15,00	0,0157	1562,0	185,26	185,27	0,9446	0,6714	0,9735	860,9	–0,4007
vapour			1,130	358,60	372,47	1,6698	0,5677	0,6256	122,94	62,65

Table 19 (*continued*)

	Temp. coefficient K/MPa	Pressure °C	Density MPa	Internal energy kg/m³	Enthalpy kJ/kg	Entropy kJ/kg	C_v kJ/(kg·K)	C_p kJ/(kg·K)	Sound speed kJ/(kg·K)	J-T m/s
liquid	–10,00	0,0202	1550,1	190,14	190,15	0,9633	0,6755	0,9790	840,7	–0,3923
vapour			1,435	361,34	375,45	1,6675	0,5753	0,6339	123,82	58,60
liquid	–5,00	0,0258	1538,2	195,04	195,06	0,9818	0,6797	0,9846	820,6	–0,3834
vapour			1,802	364,10	378,44	1,6656	0,5828	0,6423	124,66	54,93
liquid	0,00	0,0326	1526,1	199,98	200,00	1,0000	0,6839	0,9902	800,7	–0,3740
vapour			2,242	366,87	381,44	1,6642	0,5904	0,6508	125,44	51,61
liquid	5,00	0,0408	1513,9	204,94	204,97	1,0180	0,6881	0,9959	780,9	–0,3643
vapour			2,762	369,67	384,44	1,6633	0,5979	0,6594	126,17	48,60
liquid	10,00	0,0506	1501,6	209,93	209,97	1,0358	0,6924	1,0017	761,3	–0,3540
vapour			3,374	372,47	387,46	1,6626	0,6055	0,6682	126,84	45,86
liquid	15,00	0,0621	1489,2	214,95	214,99	1,0534	0,6967	1,0076	741,9	–0,3431
vapour			4,088	375,29	390,48	1,6624	0,6130	0,6771	127,45	43,37
liquid	20,00	0,0756	1476,6	220,00	220,05	1,0707	0,7011	1,0135	722,6	–0,3316
vapour			4,917	378,12	393,49	1,6624	0,6206	0,6861	127,99	41,10
liquid	25,00	0,0914	1463,9	225,08	225,14	1,0879	0,7054	1,0196	703,4	–0,3195
vapour			5,872	380,95	396,51	1,6627	0,6281	0,6953	128,47	39,03
liquid	27,82[b]	0,1013	1456,6	227,96	228,03	1,0975	0,7079	1,0230	692,7	–0,3123
vapour			6,471	382,56	398,22	1,6630	0,6324	0,7006	128,71	37,95
liquid	30,00	0,1096	1451,0	230,18	230,26	1,1049	0,7097	1,0257	684,4	–0,3066
vapour			6,966	383,80	399,53	1,6633	0,6357	0,7047	128,88	37,15
liquid	35,00	0,1305	1438,0	235,32	235,41	1,1217	0,7141	1,0320	665,5	–0,2929
vapour			8,213	386,64	402,54	1,6641	0,6432	0,7144	129,21	35,43
liquid	40,00	0,1545	1424,8	240,48	240,59	1,1383	0,7185	1,0385	646,8	–0,2782
vapour			9,630	389,49	405,54	1,6651	0,6508	0,7243	129,46	33,86
liquid	45,00	0,1817	1411,4	245,68	245,81	1,1548	0,7229	1,0451	628,2	–0,2625
vapour			11,230	392,35	408,53	1,6662	0,6583	0,7344	129,64	32,42
liquid	50,00	0,2125	1397,8	250,91	251,06	1,1711	0,7273	1,0519	609,6	–0,2456
vapour			13,031	395,20	411,50	1,6676	0,6659	0,7448	129,73	31,11
liquid	55,00	0,2471	1384,0	256,17	256,34	1,1873	0,7317	1,0589	591,2	–0,2274
vapour			15,051	398,04	414,46	1,6691	0,6735	0,7556	129,73	29,91
liquid	60,00	0,2859	1370,0	261,46	261,67	1,2033	0,7362	1,0663	572,9	–0,2076
vapour			17,311	400,88	417,40	1,6707	0,6811	0,7667	129,64	28,82
liquid	65,00	0,3292	1355,7	266,78	267,03	1,2191	0,7406	1,0740	554,6	–0,1861
vapour			19,830	403,72	420,31	1,6725	0,6887	0,7783	129,46	27,82
liquid	70,00	0,3772	1341,2	272,14	272,42	1,2349	0,7451	1,0820	536,4	–0,1627
vapour			22,632	406,54	423,20	1,6743	0,6963	0,7904	129,17	26,92
liquid	75,00	0,4304	1326,4	277,54	277,86	1,2505	0,7497	1,0906	518,2	–0,1370
vapour			25,743	409,34	426,06	1,6762	0,7040	0,8030	128,79	26,09
liquid	80,00	0,4891	1311,2	282,98	283,35	1,2660	0,7542	1,0996	500,0	–0,1087
vapour			29,188	412,14	428,89	1,6781	0,7117	0,8162	128,30	25,34
liquid	85,00	0,5536	1295,7	288,45	288,88	1,2814	0,7589	1,1093	481,9	–0,0773
vapour			33,000	414,91	431,68	1,6801	0,7194	0,8302	127,69	24,66
liquid	90,00	0,6242	1279,9	293,97	294,45	1,2967	0,7636	1,1197	463,8	–0,0425
vapour			37,213	417,65	434,43	1,6822	0,7272	0,8450	126,97	24,05
liquid	95,00	0,7014	1263,6	299,53	300,08	1,3120	0,7683	1,1310	445,6	–0,0036
vapour			41,863	420,37	437,13	1,6842	0,7350	0,8609	126,12	23,51
liquid	100,00	0,7855	1246,9	305,14	305,77	1,3271	0,7731	1,1433	427,5	0,0402
vapour			46,996	423,06	439,77	1,6862	0,7429	0,8780	125,14	23,03
liquid	105,00	0,8769	1229,7	310,80	311,51	1,3422	0,7781	1,1568	409,2	0,0896
vapour			52,661	425,71	442,36	1,6882	0,7509	0,8965	124,02	22,61

Table 19 (*continued*)

	Temp. coefficient K/MPa	Pressure °C	Density MPa	Internal energy kg/m³	Enthalpy kJ/kg	Entropy kJ/kg	C_v kJ/(kg·K)	C_p kJ/(kg·K)	Sound speed kJ/(kg·K)	J-T m/s
liquid	–10,00	0,0202	1550,1	190,14	190,15	0,9633	0,6755	0,9790	840,7	–0,3923
vapour			1,435	361,34	375,45	1,6675	0,5753	0,6339	123,82	58,60
liquid	–5,00	0,0258	1538,2	195,04	195,06	0,9818	0,6797	0,9846	820,6	–0,3834
vapour			1,802	364,10	378,44	1,6656	0,5828	0,6423	124,66	54,93
liquid	0,00	0,0326	1526,1	199,98	200,00	1,0000	0,6839	0,9902	800,7	–0,3740
vapour			2,242	366,87	381,44	1,6642	0,5904	0,6508	125,44	51,61
liquid	5,00	0,0408	1513,9	204,94	204,97	1,0180	0,6881	0,9959	780,9	–0,3643
vapour			2,762	369,67	384,44	1,6633	0,5979	0,6594	126,17	48,60
liquid	10,00	0,0506	1501,6	209,93	209,97	1,0358	0,6924	1,0017	761,3	–0,3540
vapour			3,374	372,47	387,46	1,6626	0,6055	0,6682	126,84	45,86
liquid	15,00	0,0621	1489,2	214,95	214,99	1,0534	0,6967	1,0076	741,9	–0,3431
vapour			4,088	375,29	390,48	1,6624	0,6130	0,6771	127,45	43,37
liquid	20,00	0,0756	1476,6	220,00	220,05	1,0707	0,7011	1,0135	722,6	–0,3316
vapour			4,917	378,12	393,49	1,6624	0,6206	0,6861	127,99	41,10
liquid	25,00	0,0914	1463,9	225,08	225,14	1,0879	0,7054	1,0196	703,4	–0,3195
vapour			5,872	380,95	396,51	1,6627	0,6281	0,6953	128,47	39,03
liquid	27,82[b]	0,1013	1456,6	227,96	228,03	1,0975	0,7079	1,0230	692,7	–0,3123
vapour			6,471	382,56	398,22	1,6630	0,6324	0,7006	128,71	37,95
liquid	30,00	0,1096	1451,0	230,18	230,26	1,1049	0,7097	1,0257	684,4	–0,3066
vapour			6,966	383,80	399,53	1,6633	0,6357	0,7047	128,88	37,15
liquid	35,00	0,1305	1438,0	235,32	235,41	1,1217	0,7141	1,0320	665,5	–0,2929
vapour			8,213	386,64	402,54	1,6641	0,6432	0,7144	129,21	35,43
liquid	40,00	0,1545	1424,8	240,48	240,59	1,1383	0,7185	1,0385	646,8	–0,2782
vapour			9,630	389,49	405,54	1,6651	0,6508	0,7243	129,46	33,86
liquid	45,00	0,1817	1411,4	245,68	245,81	1,1548	0,7229	1,0451	628,2	–0,2625
vapour			11,230	392,35	408,53	1,6662	0,6583	0,7344	129,64	32,42
liquid	50,00	0,2125	1397,8	250,91	251,06	1,1711	0,7273	1,0519	609,6	–0,2456
vapour			13,031	395,20	411,50	1,6676	0,6659	0,7448	129,73	31,11
liquid	55,00	0,2471	1384,0	256,17	256,34	1,1873	0,7317	1,0589	591,2	–0,2274
vapour			15,051	398,04	414,46	1,6691	0,6735	0,7556	129,73	29,91
liquid	60,00	0,2859	1370,0	261,46	261,67	1,2033	0,7362	1,0663	572,9	–0,2076
vapour			17,311	400,88	417,40	1,6707	0,6811	0,7667	129,64	28,82
liquid	65,00	0,3292	1355,7	266,78	267,03	1,2191	0,7406	1,0740	554,6	–0,1861
vapour			19,830	403,72	420,31	1,6725	0,6887	0,7783	129,46	27,82
liquid	70,00	0,3772	1341,2	272,14	272,42	1,2349	0,7451	1,0820	536,4	–0,1627
vapour			22,632	406,54	423,20	1,6743	0,6963	0,7904	129,17	26,92
liquid	75,00	0,4304	1326,4	277,54	277,86	1,2505	0,7497	1,0906	518,2	–0,1370
vapour			25,743	409,34	426,06	1,6762	0,7040	0,8030	128,79	26,09
liquid	80,00	0,4891	1311,2	282,98	283,35	1,2660	0,7542	1,0996	500,0	–0,1087
vapour			29,188	412,14	428,89	1,6781	0,7117	0,8162	128,30	25,34
liquid	85,00	0,5536	1295,7	288,45	288,88	1,2814	0,7589	1,1093	481,9	–0,0773
vapour			33,000	414,91	431,68	1,6801	0,7194	0,8302	127,69	24,66
liquid	90,00	0,6242	1279,9	293,97	294,45	1,2967	0,7636	1,1197	463,8	–0,0425
vapour			37,213	417,65	434,43	1,6822	0,7272	0,8450	126,97	24,05
liquid	95,00	0,7014	1263,6	299,53	300,08	1,3120	0,7683	1,1310	445,6	–0,0036
vapour			41,863	420,37	437,13	1,6842	0,7350	0,8609	126,12	23,51
liquid	100,00	0,7855	1246,9	305,14	305,77	1,3271	0,7731	1,1433	427,5	0,0402
vapour			46,996	423,06	439,77	1,6862	0,7429	0,8780	125,14	23,03
liquid	105,00	0,8769	1229,7	310,80	311,51	1,3422	0,7781	1,1568	409,2	0,0896
vapour			52,661	425,71	442,36	1,6882	0,7509	0,8965	124,02	22,61

Table 20 — Coefficients and exponents of the ideal-gas part [Equations (3) to (5)]

k	c_k	t_k	a_k	b_k
1	3,063 0	0,1	—	—
2	—	—	2,303	314,0
3	—	—	5,086	756,0
4	—	—	7,300	1 707,0

Table 21 — Coefficients and exponents of the real-gas part [Equation (2)]

k	N_k	t_k	d_k	l_k	α_k	m_k	β_k	γ_k	ε_k
1	5,280 760	0,669	1	0	0	—	—	—	—
2	− 8,676 580	1,05	1	0	0	—	—	—	—
3	0,750 112 7	2,75	1	0	0	—	—	—	—
4	0,759 002 3	0,956	2	0	0	—	—	—	—
5	0,014 518 99	1,00	4	0	0	—	—	—	—
6	4,777 189	2,00	1	1	1	—	—	—	—
7	− 3,330 988	2,75	1	1	1	—	—	—	—
8	3,775 673	2,38	2	1	1	—	—	—	—
9	− 2,290 919	3,37	2	1	1	—	—	—	—
10	0,888 826 8	3,47	3	1	1	—	—	—	—
11	− 0,623 486 4	2,63	4	1	1	—	—	—	—
12	− 0,041 272 63	3,45	5	1	1	—	—	—	—
13	− 0,084 553 89	0,72	1	2	1	—	—	—	—
14	− 0,130 875 2	4,23	5	2	1	—	—	—	—
15	0,008 344 962	0,20	1	3	1	—	—	—	—
16	− 1,532 005	4,5	2	2	1	1,7	1	0	0
17	− 0,058 836 49	29,0	3	3	1	7,0	1	0	0
18	0,022 966 58	24,0	5	3	1	6,0	1	0	0

5.8.2 Reducing parameters, molar mass, and gas constant

$T^* = 339{,}173$ K, $\rho^* = 4{,}779$ mol/l, $M = 120{,}021\ 4$ g/mol, $R = 8{,}314\ 472$ J/(mol·K)

5.8.3 Reference state parameters

$T_{ref} = 273{,}5$ K, $p_{ref} = 1{,}0$ kPa, $h_{ref} = 41\ 266{,}386$ J/mol, $s_{ref} = 236{,}119\ 5$ J/(mol·K), $f_1 = 29{,}876\ 674\ 5$, $f_2 = 3\ 013{,}226\ 7$

Table 22 — R125 property values along the liquid-vapour saturation boundary

	Temp. coefficient K/MPa	Pressure °C	Density MPa	Internal energy kg/m³	Enthalpy kJ/kg	Entropy kJ/kg	C_v kJ/(kg·K)	C_p kJ/(kg·K)	Sound speed kJ/(kg·K)	J-T m/s
liquid	–100,63[a]	0,00291	1690,7	87,13	87,13	0,4902	0,6776	1,0346	932,6	–0,3837
vapour			0,2446	265,48	277,39	1,5931	0,4984	0,5689	116,43	90,26
liquid	–100,00	0,00309	1688,7	87,78	87,78	0,4940	0,6781	1,0351	929,2	–0,3830
vapour			0,2583	265,79	277,74	1,5911	0,4997	0,5703	116,61	89,08
liquid	–95,00	0,00481	1672,5	92,97	92,97	0,5235	0,6818	1,0396	903,2	–0,3766
vapour			0,3918	268,25	280,54	1,5764	0,5099	0,5810	118,03	80,43
liquid	–90,00	0,00729	1656,2	98,18	98,18	0,5524	0,6860	1,0450	877,5	–0,3694
vapour			0,5779	270,75	283,36	1,5634	0,5201	0,5919	119,39	72,87
liquid	–85,00	0,0107	1639,9	103,42	103,42	0,5806	0,6906	1,0512	852,3	–0,3614
vapour			0,831	273,28	286,20	1,5520	0,5304	0,6031	120,69	66,26
liquid	–80,00	0,0155	1623,4	108,69	108,70	0,6082	0,6955	1,0581	827,5	–0,3525
vapour			1,169	275,83	289,06	1,5421	0,5409	0,6146	121,92	60,44
liquid	–75,00	0,0218	1606,7	114,00	114,01	0,6354	0,7006	1,0656	802,9	–0,3428
vapour			1,610	278,41	291,94	1,5333	0,5514	0,6264	123,07	55,33
liquid	–70,00	0,0301	1589,9	119,34	119,36	0,6620	0,7060	1,0736	778,6	–0,3323
vapour			2,177	281,01	294,83	1,5257	0,5620	0,6385	124,13	50,81
liquid	–65,00	0,0408	1572,9	124,73	124,75	0,6882	0,7115	1,0822	754,5	–0,3208
vapour			2,892	283,62	297,71	1,5191	0,5727	0,6511	125,11	46,82
liquid	–60,00	0,0543	1555,7	130,16	130,19	0,7140	0,7171	1,0912	730,6	–0,3083
vapour			3,783	286,24	300,60	1,5135	0,5836	0,6641	125,98	43,28
liquid	–55,00	0,0713	1538,2	135,63	135,68	0,7394	0,7229	1,1007	706,8	–0,2947
vapour			4,879	288,88	303,48	1,5086	0,5946	0,6776	126,75	40,14
liquid	–50,00	0,0922	1520,5	141,15	141,21	0,7644	0,7288	1,1107	683,2	–0,2799
vapour			6,211	291,51	306,35	1,5044	0,6058	0,6916	127,41	37,35
liquid	–48,09[b]	0,1013	1513,6	143,27	143,34	0,7739	0,7311	1,1146	674,2	–0,2738
vapour			6,790	292,52	307,44	1,5030	0,6101	0,6971	127,63	36,36
liquid	–45,00	0,1176	1502,4	146,72	146,80	0,7891	0,7349	1,1212	659,6	–0,2636
vapour			7,814	294,15	309,20	1,5009	0,6171	0,7063	127,94	34,86
liquid	–40,00	0,1483	1484,0	152,34	152,44	0,8134	0,7410	1,1323	636,1	–0,2458
vapour			9,725	296,79	312,03	1,4980	0,6286	0,7216	128,35	32,65
liquid	–35,00	0,1849	1465,3	158,01	158,14	0,8375	0,7473	1,1440	612,6	–0,2262
vapour			11,985	299,41	314,84	1,4955	0,6402	0,7376	128,61	30,67
liquid	–30,00	0,2281	1446,1	163,74	163,90	0,8614	0,7537	1,1565	589,1	–0,2044
vapour			14,639	302,03	317,61	1,4935	0,6520	0,7545	128,73	28,91
liquid	–25,00	0,2786	1426,5	169,53	169,73	0,8849	0,7602	1,1698	565,7	–0,1803
vapour			17,736	304,63	320,34	1,4919	0,6640	0,7724	128,70	27,33
liquid	–20,00	0,3373	1406,4	175,38	175,62	0,9083	0,7668	1,1840	542,2	–0,1532
vapour			21,331	307,22	323,03	1,4906	0,6761	0,7912	128,50	25,91
liquid	–15,00	0,4050	1385,8	181,30	181,59	0,9314	0,7736	1,1994	518,7	–0,1228
vapour			25,486	309,78	325,67	1,4895	0,6882	0,8112	128,11	24,66
liquid	–10,00	0,4825	1364,5	187,29	187,64	0,9544	0,7805	1,2161	495,2	–0,0883
vapour			30,271	312,30	328,24	1,4887	0,7003	0,8324	127,54	23,55
liquid	–5,00	0,5707	1342,6	193,35	193,77	0,9773	0,7876	1,2344	471,6	–0,0489
vapour			35,768	314,79	330,74	1,4881	0,7122	0,8550	126,77	22,61
liquid	0,00	0,6705	1319,8	199,49	200,00	1,0000	0,7948	1,2547	448,0	–0,0036
vapour			42,070	317,22	333,16	1,4875	0,7240	0,8797	125,80	21,81
liquid	5,00	0,7829	1296,2	205,72	206,33	1,0226	0,8021	1,2773	424,3	0,0492
vapour			49,291	319,59	335,47	1,4869	0,7359	0,9073	124,60	21,15

Table 22 (*continued*)

	Temp. coefficient K/MPa	Pressure °C	Density MPa	Internal energy kg/m^3	Enthalpy kJ/kg	Entropy kJ/kg	C_v kJ/(kg·K)	C_p kJ/(kg·K)	Sound speed kJ/(kg·K)	J-T m/s
liquid	10,00	0,9088	1271,5	212,05	212,76	1,0452	0,8095	1,3029	400,4	0,1113
vapour			57,564	321,87	337,66	1,4863	0,7483	0,9392	123,17	20,61
liquid	15,00	1,0492	1245,6	218,48	219,32	1,0678	0,8172	1,3323	376,3	0,1851
vapour			67,054	324,06	339,71	1,4856	0,7617	0,9770	121,49	20,18
liquid	20,00	1,2052	1218,3	225,03	226,02	1,0904	0,8252	1,3666	352,0	0,2742
vapour			77,966	326,12	341,58	1,4846	0,7764	1,0230	119,55	19,83
liquid	25,00	1,3779	1189,4	231,71	232,87	1,1131	0,8335	1,4074	327,4	0,3835
vapour			90,557	328,05	343,26	1,4834	0,7928	1,0798	117,32	19,53
liquid	30,00	1,5685	1158,4	238,55	239,91	1,1359	0,8425	1,4575	302,4	0,5202
vapour			105,170	329,80	344,71	1,4817	0,8111	1,1517	114,78	19,29
liquid	35,00	1,7783	1125,0	245,57	247,16	1,1591	0,8522	1,5209	276,9	0,6956
vapour			122,270	331,33	345,88	1,4794	0,8315	1,2452	111,88	19,08
liquid	40,00	2,0085	1088,4	252,82	254,67	1,1826	0,8630	1,6052	250,8	0,9282
vapour			142,522	332,60	346,69	1,4764	0,8542	1,3716	108,58	18,91
liquid	45,00	2,2607	1047,7	260,36	262,52	1,2067	0,8755	1,7244	223,8	1,2501
vapour			166,954	333,50	347,05	1,4724	0,8796	1,5535	104,82	18,78
liquid	50,00	2,5368	1001,1	268,29	270,83	1,2318	0,8907	1,9102	195,6	1,7247
vapour			197,293	333,89	346,75	1,4667	0,9083	1,8425	100,51	18,67
liquid	55,00	2,8389	945,4	276,82	279,83	1,2585	0,9106	2,2517	165,3	2,4948
vapour			236,916	333,46	345,44	1,4584	0,9421	2,3860	95,57	18,51
liquid	60,00	3,1703	872,1	286,46	290,10	1,2884	0,9411	3,1392	131,5	3,9752
vapour			294,367	331,44	342,21	1,4448	0,9856	3,8329	89,84	18,06
liquid	65,00	3,5370	735,1	300,06	304,88	1,3311	1,0139	13,6692	90,0	8,2955
vapour			416,565	323,75	332,24	1,4120	1,0604	20,0735	82,63	15,85
critical	66,02	3,6177	573,6	311,75	318,06	1,3696	c	c	c	12,3608

a Triple point.
b Normal boiling point.
c The values of C_v, C_p, and w at the critical point are not included as part of this International Standard.

5.9 R134a — 1,1,1,2–tetrafluoroethane

5.9.1 Range of validity

The coefficients are valid within the following ranges:

T_{min} = 169,85 K, T_{max} = 455 K; p_{max} = 70 MPa; ρ_{max} = 15,6 mol/l (1 592 kg/m^3)

Table 23 — Coefficients and exponents of the ideal-gas part [Equations (3) to (5)]

k	c_k	t_k
0	– 0,629 789	—
1	3,770 180 8 × 10^{-1}	0,5
2	6,058 548 9 × 10^{-2}	0,75

Table 24 — Coefficients and exponents of the real-gas part [Equation (2)]

k	N_k	t_k	d_k	l_k	α_k
1	0,055 868 17	– 0,5	2	0	0
2	0,498 223	0	1	0	0
3	0,024 586 98	0	3	0	0
4	0,000 857 014 5	0	6	0	0
5	0,000 478 858 4	1,5	6	0	0
6	– 1,800 808	1,5	1	0	0
7	0,267 164 1	2	1	0	0
8	– 0,047 816 52	2	2	0	0
9	0,014 239 87	1	5	1	1
10	0,332 406 2	3	2	1	1
11	– 0,007 485 907	5	2	1	1
12	0,000 101 726 3	1	4	2	1
13	– 0,518 456 7	5	1	2	1
14	– 0,086 922 88	5	4	2	1
15	0,205 714 4	6	1	2	1
16	– 0,005 000 457	10	2	2	1
17	0,000 460 326 2	10	4	2	1
18	– 0,003 497 836	10	1	3	1
19	0,006 995 038	18	5	3	1
20	– 0,014 521 84	22	3	3	1
21	– 0,000 128 545 8	50	10	4	1

5.9.2 Reducing parameters, molar mass, and gas constant

$T^* = 374{,}18$ K, $\rho^* = 4{,}978\,830\,171$ mol/l, $M = 102{,}032$ g/mol, $R = 8{,}314\,471$ J/(mol·K)

5.9.3 Reference state parameters

$T_{ref} = 273{,}15$ K, $p_{ref} = 1{,}0$ kPa, $h_{ref} = 41\,433{,}397$ J/mol, $s_{ref} = 225{,}535\,3$ J/(mol·K), $f_1 = -12{,}280\,800\,2$, $f_2 = 3\,385{,}257\,07$

Table 25 — R134a property values along the liquid-vapour saturation boundary

	Temp. coefficient °C K/MPa	Pressure MPa	Density kg/m³	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/kg	C_v kJ/(kg·K)	C_p kJ/(kg·K)	Sound speed kJ/(kg·K)	J-T m/s
liquid	–103,30[a]	0,000390	1591,1	71,45	71,46	0,4126	0,7922	1,1838	1120,0	–0,3815
vapour		0,02817	321,11	334,94	1,9639	0,5030	0,5853	126,79	373,57	
liquid	–100,00	0,000559	1582,4	75,36	75,36	0,4354	0,7912	1,1842	1103,2	–0,3793
vapour		0,03969	322,76	336,85	1,9456	0,5107	0,5932	127,87	318,13	
liquid	–95,00	0,000939	1569,1	81,29	81,29	0,4691	0,7910	1,1861	1077,7	–0,3753
vapour		0,06479	325,29	339,78	1,9201	0,5224	0,6052	129,47	253,65	
liquid	–90,00	0,00152	1555,8	87,22	87,23	0,5020	0,7920	1,1892	1052,3	–0,3707
vapour		0,1024	327,87	342,76	1,8972	0,5341	0,6173	131,03	206,26	
liquid	–85,00	0,00240	1542,5	93,18	93,18	0,5341	0,7940	1,1933	1027,0	–0,3656
vapour		0,1570	330,49	345,77	1,8766	0,5457	0,6294	132,56	170,88	
liquid	–80,00	0,00367	1529,0	99,16	99,16	0,5654	0,7968	1,1981	1001,8	–0,3599
vapour		0,2343	333,15	348,83	1,8580	0,5573	0,6417	134,04	144,05	
liquid	–75,00	0,00548	1515,5	105,16	105,17	0,5961	0,8002	1,2036	976,8	–0,3536
vapour		0,3412	335,85	351,91	1,8414	0,5689	0,6540	135,47	123,38	
liquid	–70,00	0,00798	1501,9	111,19	111,20	0,6262	0,8040	1,2096	952,0	–0,3469
vapour		0,4857	338,59	355,02	1,8264	0,5806	0,6665	136,84	107,19	
liquid	–65,00	0,0114	1488,2	117,26	117,26	0,6557	0,8082	1,2161	927,4	–0,3396
vapour		0,677	341,35	358,16	1,8130	0,5923	0,6793	138,16	94,32	
liquid	–60,00	0,0159	1474,3	123,35	123,36	0,6846	0,8127	1,2230	903,0	–0,3318
vapour		0,927	344,15	361,31	1,8010	0,6040	0,6924	139,41	83,91	
liquid	–55,00	0,0218	1460,4	129,48	129,50	0,7131	0,8175	1,2304	878,8	–0,3234
vapour		1,246	346,96	364,48	1,7902	0,6159	0,7058	140,59	75,36	
liquid	–50,00	0,0295	1446,3	135,65	135,67	0,7410	0,8224	1,2381	854,7	–0,3143
vapour		1,650	349,80	367,65	1,7806	0,6280	0,7197	141,69	68,25	
liquid	–45,00	0,0391	1432,1	141,86	141,89	0,7685	0,8276	1,2462	830,9	–0,3046
vapour		2,152	352,65	370,83	1,7720	0,6402	0,7341	142,70	62,23	
liquid	–40,00	0,0512	1417,7	148,11	148,14	0,7956	0,8328	1,2546	807,2	–0,2941
vapour		2,769	355,51	374,00	1,7643	0,6526	0,7490	143,63	57,08	
liquid	–35,00	0,0661	1403,1	154,40	154,44	0,8223	0,8382	1,2635	783,7	–0,2828
vapour		3,521	358,38	377,17	1,7575	0,6652	0,7646	144,45	52,63	
liquid	–30,00	0,0844	1388,4	160,73	160,79	0,8486	0,8438	1,2729	760,3	–0,2706
vapour		4,426	361,25	380,32	1,7515	0,6781	0,7809	145,18	48,74	
liquid	–26,07[b]	0,1013	1376,7	165,74	165,81	0,8690	0,8482	1,2805	742,0	–0,2602
vapour		5,258	363,51	382,78	1,7472	0,6884	0,7942	145,67	46,01	
liquid	–25,00	0,1064	1373,4	167,11	167,19	0,8746	0,8494	1,2827	737,0	–0,2573
vapour		5,506	364,12	383,45	1,7461	0,6912	0,7979	145,79	45,31	
liquid	–20,00	0,1327	1358,3	173,54	173,64	0,9002	0,8551	1,2930	713,8	–0,2428
vapour		6,784	366,99	386,55	1,7413	0,7046	0,8158	146,28	42,26	
liquid	–15,00	0,1639	1342,8	180,02	180,14	0,9256	0,8609	1,3040	690,7	–0,2270
vapour		8,287	369,85	389,63	1,7371	0,7183	0,8346	146,65	39,54	

5.10 R143a — 1,1,1–trifluoroethane

5.10.1 Range of validity

The coefficients are valid within the following ranges:

T_{min} = 161,34 K, T_{max} = 650 K; p_{max} = 100 MPa; ρ_{max} = 15,85 mol/l (1 332 kg/m^3)

Table 26 — Coefficients and exponents of the ideal-gas part [Equations (3) to (5)]

k	c_k	t_k	a_k	b_k
1	1,057 8	0,33	—	—
2	—	—	4,440 2	1 791
3	—	—	3,751 5	823

Table 27 — Coefficients and exponents of the real-gas part [Equation (2)]

k	N_k	t_k	d_k	l_k	α_k
1	7,773 644 3	0,67	1	0	0
2	– 8,701 85	0,833	1	0	0
3	– 0,277 797 99	1,7	1	0	0
4	0,146 092 2	1,82	2	0	0
5	0,008 958 161 6	0,35	5	0	0
6	– 0,205 521 16	3,9	1	1	1
7	0,106 532 58	0,95	3	1	1
8	0,023 270 816	0	5	1	1
9	– 0,013 247 542	1,19	7	1	1
10	– 0,042 793 87	7,2	1	2	1
11	0,362 216 85	5,9	2	2	1
12	– 0,256 718 99	7,65	2	2	1
13	– 0,092 326 113	7,5	3	2	1
14	0,083 774 837	7,45	4	2	1
15	0,017 128 445	15,5	2	3	1
16	– 0,017 256 11	22	3	3	1
17	0,004 908 049 2	19	5	3	1

5.10.2 Reducing parameters, molar mass, and gas constant

T^* = 345,857 K, ρ^* = 5,128 45 mol/L, M = 84,041 g/mol, R = 8,314 472 J/(mol·K)

5.10.3 Reference state parameters

T_{ref} = 273,15 K, p_{ref} = 1,0 kPa, h_{ref} = 33 936,397 J/mol, s_{ref} = 198,961 3 J/(mol·K), f_1 = –1,577 780 74, f_2 = 2 527,263 78

Table 28 — R143a property values along the liquid-vapour saturation boundary

	Temp. coefficient K/MPa	Pressure °C	Density MPa	Internal energy kg/m³	Enthalpy kJ/kg	Entropy kJ/kg	C_v kJ/(kg·K)	C_p kJ/(kg·K)	Sound speed kJ/(kg·K)	J-T m/s
liquid	–111,81[a]	0,00107	1330,5	52,52	52,52	0,3142	0,8138	1,2112	1058,1	–0,4394
vapour			0,0675	303,67	319,59	1,9695	0,5283	0,6299	137,57	385,09
liquid	–110,00	0,00129	1326,2	54,71	54,71	0,3277	0,8128	1,2119	1049,4	–0,4375
vapour			0,0805	304,59	320,68	1,9579	0,5331	0,6350	138,22	354,60
liquid	–105,00	0,00211	1314,1	60,78	60,78	0,3643	0,8114	1,2151	1025,5	–0,4316
vapour			0,1274	307,17	323,73	1,9281	0,5467	0,6495	139,98	284,35
liquid	–100,00	0,00333	1301,9	66,87	66,87	0,4000	0,8115	1,2199	1001,7	–0,4247
vapour			0,1956	309,78	326,81	1,9012	0,5604	0,6642	141,68	230,56
liquid	–95,00	0,00510	1289,6	72,98	72,98	0,4348	0,8131	1,2260	977,9	–0,4171
vapour			0,2917	312,43	329,92	1,8770	0,5742	0,6792	143,32	189,21
liquid	–90,00	0,00761	1277,2	79,13	79,13	0,4688	0,8157	1,2333	954,2	–0,4086
vapour			0,4238	315,11	333,06	1,8553	0,5881	0,6944	144,89	157,26
liquid	–85,00	0,0111	1264,8	85,31	85,32	0,5021	0,8194	1,2415	930,4	–0,3994
vapour			0,601	317,83	336,22	1,8357	0,6021	0,7100	146,39	132,44
liquid	–80,00	0,0157	1252,2	91,54	91,55	0,5348	0,8238	1,2504	906,6	–0,3895
vapour			0,835	320,58	339,40	1,8180	0,6162	0,7258	147,81	113,01
liquid	–75,00	0,0219	1239,5	97,81	97,83	0,5669	0,8288	1,2601	882,8	–0,3789
vapour			1,138	323,36	342,60	1,8021	0,6304	0,7421	149,13	97,68
liquid	–70,00	0,0299	1226,7	104,14	104,16	0,5984	0,8344	1,2704	859,1	–0,3674
vapour			1,523	326,16	345,80	1,7879	0,6448	0,7589	150,37	85,45
liquid	–65,00	0,0402	1213,7	110,51	110,54	0,6294	0,8405	1,2813	835,3	–0,3551
vapour			2,005	328,98	349,01	1,7750	0,6593	0,7763	151,50	75,60
liquid	–60,00	0,0531	1200,6	116,94	116,99	0,6599	0,8470	1,2928	811,5	–0,3419
vapour			2,601	331,81	352,21	1,7635	0,6741	0,7944	152,51	67,57
liquid	–55,00	0,0691	1187,3	123,43	123,49	0,6900	0,8538	1,3049	787,7	–0,3277
vapour			3,329	334,66	355,41	1,7531	0,6892	0,8133	153,41	60,93
liquid	–50,00	0,0887	1173,9	129,97	130,05	0,7197	0,8608	1,3175	763,9	–0,3123
vapour			4,210	337,51	358,58	1,7438	0,7046	0,8331	154,19	55,38
liquid	–47,24[b]	0,1013	1166,4	133,61	133,70	0,7359	0,8648	1,3248	750,8	–0,3032
vapour			4,769	339,08	360,33	1,7391	0,7132	0,8444	154,55	52,70
liquid	–45,00	0,1125	1160,3	136,58	136,68	0,7490	0,8681	1,3309	740,1	–0,2956
vapour			5,264	340,36	361,74	1,7354	0,7203	0,8539	154,82	50,69
liquid	–40,00	0,1411	1146,4	143,26	143,38	0,7779	0,8756	1,3448	716,3	–0,2774
vapour			6,514	343,20	364,86	1,7279	0,7363	0,8758	155,31	46,68
liquid	–35,00	0,1750	1132,3	150,00	150,15	0,8065	0,8833	1,3596	692,5	–0,2576
vapour			7,988	346,04	367,95	1,7211	0,7526	0,8989	155,65	43,21
liquid	–30,00	0,2149	1117,9	156,81	157,00	0,8348	0,8911	1,3752	668,6	–0,2358
vapour			9,711	348,86	370,99	1,7149	0,7693	0,9233	155,84	40,20
liquid	–25,00	0,2614	1103,3	163,70	163,93	0,8629	0,8991	1,3918	644,7	–0,2118
vapour			11,716	351,67	373,98	1,7093	0,7863	0,9492	155,85	37,55
liquid	–20,00	0,3154	1088,3	170,66	170,95	0,8907	0,9072	1,4094	620,8	–0,1852
vapour			14,036	354,44	376,91	1,7043	0,8035	0,9767	155,68	35,22
liquid	–15,00	0,3774	1072,9	177,71	178,06	0,9183	0,9154	1,4283	596,8	–0,1555
vapour			16,709	357,18	379,76	1,6996	0,8211	1,0061	155,33	33,16

Table 28 (*continued*)

	Temp. coefficient K/MPa	Pressure °C	Density MPa	Internal energy kg/m³	Enthalpy kJ/kg	Entropy kJ/kg	C_v kJ/(kg·K)	C_p kJ/(kg·K)	Sound speed kJ/(kg·K)	J-T m/s
liquid	–10,00	0,4482	1057,2	184,84	185,27	0,9457	0,9237	1,4487	572,8	–0,1223
vapour			19,778	359,88	382,54	1,6953	0,8390	1,0377	154,78	31,33
liquid	–5,00	0,5287	1041,0	192,07	192,58	0,9729	0,9322	1,4709	548,6	–0,0847
vapour			23,292	362,53	385,23	1,6913	0,8571	1,0717	154,03	29,69
liquid	0,00	0,6197	1024,3	199,40	200,00	1,0000	0,9408	1,4951	524,3	–0,0420
vapour			27,306	365,11	387,81	1,6876	0,8756	1,1087	153,06	28,24
liquid	5,00	0,7219	1007,0	206,83	207,54	1,0270	0,9495	1,5219	499,8	0,0069
vapour			31,885	367,63	390,27	1,6839	0,8944	1,1492	151,87	26,94
liquid	10,00	0,8363	989,1	214,37	215,22	1,0539	0,9585	1,5517	475,1	0,0635
vapour			37,107	370,06	392,60	1,6804	0,9135	1,1942	150,43	25,79
liquid	15,00	0,9637	970,4	222,05	223,04	1,0809	0,9678	1,5854	450,2	0,1295
vapour			43,062	372,39	394,77	1,6768	0,9331	1,2447	148,74	24,76
liquid	20,00	1,1052	950,8	229,86	231,02	1,1078	0,9773	1,6239	425,0	0,2075
vapour			49,864	374,60	396,76	1,6732	0,9531	1,3024	146,77	23,84
liquid	25,00	1,2616	930,2	237,83	239,19	1,1349	0,9873	1,6687	399,5	0,3007
vapour			57,653	376,66	398,54	1,6693	0,9737	1,3695	144,51	23,04
liquid	30,00	1,4340	908,4	245,98	247,56	1,1621	0,9978	1,7218	373,5	0,4140
vapour			66,605	378,54	400,07	1,6652	0,9951	1,4494	141,93	22,33
liquid	35,00	1,6236	885,2	254,33	256,16	1,1895	1,0091	1,7863	347,0	0,5543
vapour			76,954	380,21	401,31	1,6606	1,0173	1,5472	139,02	21,71
liquid	40,00	1,8314	860,3	262,91	265,04	1,2174	1,0213	1,8670	319,8	0,7319
vapour			89,018	381,61	402,19	1,6553	1,0408	1,6715	135,73	21,17
liquid	45,00	2,0589	833,1	271,79	274,26	1,2457	1,0350	1,9725	291,8	0,9636
vapour			103,245	382,66	402,61	1,6491	1,0659	1,8366	132,04	20,69
liquid	50,00	2,3073	803,0	281,02	283,90	1,2748	1,0509	2,1181	262,7	1,2777
vapour			120,307	383,25	402,43	1,6416	1,0932	2,0700	127,89	20,26
liquid	55,00	2,5785	768,9	290,74	294,09	1,3051	1,0702	2,3369	232,2	1,7273
vapour			141,302	383,20	401,44	1,6322	1,1237	2,4302	123,22	19,84
liquid	60,00	2,8744	728,9	301,15	305,09	1,3371	1,0951	2,7143	199,5	2,4237
vapour			168,236	382,16	399,24	1,6197	1,1595	3,0685	117,93	19,37
liquid	65,00	3,1977	678,3	312,73	317,45	1,3726	1,1312	3,5635	163,8	3,6529
vapour			205,645	379,39	394,94	1,6018	1,2044	4,5323	111,84	18,67
liquid	70,00	3,5527	600,8	327,28	333,19	1,4172	1,1984	7,7197	122,4	6,4733
vapour			270,096	372,27	385,42	1,5694	1,2720	11,5008	104,25	17,07
critical	72,71	3,7610	431,0	350,18	358,91	1,4906	c	c	c	12,3969

a Triple point.

b Normal boiling point.

c The values of C_v, C_p, and w at the critical point are not included as part of this International Standard.

Table 28 (*continued*)

	Temp. coefficient K/MPa	Pressure °C	Density MPa	Internal energy kg/m³	Enthalpy kJ/kg	Entropy kJ/kg	C_v kJ/(kg·K)	C_p kJ/(kg·K)	Sound speed kJ/(kg·K)	J-T m/s
liquid	–10,00	0,4482	1057,2	184,84	185,27	0,9457	0,9237	1,4487	572,8	–0,1223
vapour			19,778	359,88	382,54	1,6953	0,8390	1,0377	154,78	31,33
liquid	–5,00	0,5287	1041,0	192,07	192,58	0,9729	0,9322	1,4709	548,6	–0,0847
vapour			23,292	362,53	385,23	1,6913	0,8571	1,0717	154,03	29,69
liquid	0,00	0,6197	1024,3	199,40	200,00	1,0000	0,9408	1,4951	524,3	–0,0420
vapour			27,306	365,11	387,81	1,6876	0,8756	1,1087	153,06	28,24
liquid	5,00	0,7219	1007,0	206,83	207,54	1,0270	0,9495	1,5219	499,8	0,0069
vapour			31,885	367,63	390,27	1,6839	0,8944	1,1492	151,87	26,94
liquid	10,00	0,8363	989,1	214,37	215,22	1,0539	0,9585	1,5517	475,1	0,0635
vapour			37,107	370,06	392,60	1,6804	0,9135	1,1942	150,43	25,79
liquid	15,00	0,9637	970,4	222,05	223,04	1,0809	0,9678	1,5854	450,2	0,1295
vapour			43,062	372,39	394,77	1,6768	0,9331	1,2447	148,74	24,76
liquid	20,00	1,1052	950,8	229,86	231,02	1,1078	0,9773	1,6239	425,0	0,2075
vapour			49,864	374,60	396,76	1,6732	0,9531	1,3024	146,77	23,84
liquid	25,00	1,2616	930,2	237,83	239,19	1,1349	0,9873	1,6687	399,5	0,3007
vapour			57,653	376,66	398,54	1,6693	0,9737	1,3695	144,51	23,04
liquid	30,00	1,4340	908,4	245,98	247,56	1,1621	0,9978	1,7218	373,5	0,4140
vapour			66,605	378,54	400,07	1,6652	0,9951	1,4494	141,93	22,33
liquid	35,00	1,6236	885,2	254,33	256,16	1,1895	1,0091	1,7863	347,0	0,5543
vapour			76,954	380,21	401,31	1,6606	1,0173	1,5472	139,02	21,71
liquid	40,00	1,8314	860,3	262,91	265,04	1,2174	1,0213	1,8670	319,8	0,7319
vapour			89,018	381,61	402,19	1,6553	1,0408	1,6715	135,73	21,17
liquid	45,00	2,0589	833,1	271,79	274,26	1,2457	1,0350	1,9725	291,8	0,9636
vapour			103,245	382,66	402,61	1,6491	1,0659	1,8366	132,04	20,69
liquid	50,00	2,3073	803,0	281,02	283,90	1,2748	1,0509	2,1181	262,7	1,2777
vapour			120,307	383,25	402,43	1,6416	1,0932	2,0700	127,89	20,26
liquid	55,00	2,5785	768,9	290,74	294,09	1,3051	1,0702	2,3369	232,2	1,7273
vapour			141,302	383,20	401,44	1,6322	1,1237	2,4302	123,22	19,84
liquid	60,00	2,8744	728,9	301,15	305,09	1,3371	1,0951	2,7143	199,5	2,4237
vapour			168,236	382,16	399,24	1,6197	1,1595	3,0685	117,93	19,37
liquid	65,00	3,1977	678,3	312,73	317,45	1,3726	1,1312	3,5635	163,8	3,6529
vapour			205,645	379,39	394,94	1,6018	1,2044	4,5323	111,84	18,67
liquid	70,00	3,5527	600,8	327,28	333,19	1,4172	1,1984	7,7197	122,4	6,4733
vapour			270,096	372,27	385,42	1,5694	1,2720	11,5008	104,25	17,07
critical	72,71	3,7610	431,0	350,18	358,91	1,4906	c	c	c	12,3969

a Triple point.

b Normal boiling point.

c The values of C_v, C_p, and w at the critical point are not included as part of this International Standard.

Table 30 (*continued*)

k	N_k	t_k	d_k	l_k	α_k
21	$0{,}216\,879\,133\,161 \times 10^{-2}$	3	7	0	0
22	$-0{,}233\,597\,690\,478 \times 10^{-3}$	3	8	0	0
23	$0{,}354\,657\,949\,982 \times 10^{1}$	3	0	2	1
24	0,364 631 280 620	4	0	2	1
25	$-0{,}333\,233\,335\,558 \times 10^{-1}$	5	0	2	1
26	$0{,}276\,133\,830\,254 \times 10^{1}$	3	2	2	1
27	$-0{,}691\,185\,711\,880 \times 10^{-1}$	4	2	2	1
28	$-0{,}333\,233\,335\,558 \times 10^{-1}$	5	2	2	1
29	0,782 761 327 717	3	4	2	1
30	$-0{,}345\,592\,855\,940 \times 10^{-1}$	4	4	2	1
31	0,137 813 531 906	5	4	2	1
32	0,186 173 126 153	3	6	2	1
33	$-0{,}341\,119\,393\,297 \times 10^{-1}$	4	6	2	1
34	$0{,}459\,378\,439\,687 \times 10^{-1}$	5	6	2	1
35	$0{,}216\,470\,012\,607 \times 10^{-1}$	3	8	2	1
36	$-0{,}852\,798\,483\,242 \times 10^{-2}$	4	8	2	1
37	$0{,}620\,394\,038\,634 \times 10^{-2}$	5	8	2	1
38	$0{,}185\,210\,290\,813 \times 10^{-2}$	3	10	2	1
39	$0{,}101\,674\,662\,734 \times 10^{-2}$	4	10	2	1
40	$0{,}124\,078\,807\,727 \times 10^{-2}$	5	10	2	1

5.11.2 Reducing parameters, molar mass, and gas constant

$T^* = 386{,}411$ K, $\rho^* = 5{,}571\,45$ mol/, $M = 66{,}051$ g/mol, $R = 8{,}314\,471$ J/(mol·K)

5.11.3 Reference state parameters

$T_{ref} = 273{,}15$ K, $p_{ref} = 1{,}0$ kPa, $h_{ref} = 34\,189{,}811$ J/mol, $s_{ref} = 188{,}564\,6$ J/(mol·K), $f_1 = 4{,}360\,056$, $f_2 = 2\,654{,}673\,62$

Table 31 (*continued*)

	Temp. coefficient K/MPa	Pressure °C	Density MPa	Internal energy kg/m³	Enthalpy kJ/kg	Entropy kJ/kg	C_v kJ/(kg·K)	C_p kJ/(kg·K)	Sound speed kJ/(kg·K)	J-T m/s
liquid	5,00	0,3148	947,7	208,22	208,55	1,0308	1,1069	1,7151	747,4	–0,1938
vapour			9,896	478,68	510,49	2,1164	0,9157	1,1218	187,37	37,31
liquid	10,00	0,3728	936,1	216,79	217,19	1,0614	1,1144	1,7342	722,7	–0,1706
vapour			11,651	481,79	513,78	2,1089	0,9339	1,1517	187,21	35,23
liquid	15,00	0,4386	924,2	225,45	225,93	1,0917	1,1220	1,7546	697,9	–0,1449
vapour			13,647	484,85	516,99	2,1018	0,9525	1,1834	186,87	33,35
liquid	20,00	0,5129	912,0	234,21	234,77	1,1219	1,1299	1,7765	673,0	–0,1165
vapour			15,910	487,85	520,09	2,0952	0,9714	1,2173	186,36	31,64
liquid	25,00	0,5964	899,5	243,07	243,73	1,1519	1,1379	1,8001	647,9	–0,0849
vapour			18,469	490,79	523,09	2,0888	0,9906	1,2536	185,65	30,09
liquid	30,00	0,6898	886,6	252,03	252,80	1,1817	1,1462	1,8258	622,7	–0,0495
vapour			21,357	493,66	525,96	2,0828	1,0101	1,2926	184,74	28,69
liquid	35,00	0,7939	873,4	261,10	262,01	1,2114	1,1548	1,8539	597,3	–0,0096
vapour			24,613	496,44	528,70	2,0769	1,0300	1,3349	183,63	27,41
liquid	40,00	0,9093	859,7	270,29	271,35	1,2411	1,1636	1,8847	571,7	0,0357
vapour			28,280	499,13	531,28	2,0711	1,0502	1,3811	182,30	26,25
liquid	45,00	1,0368	845,5	279,62	280,84	1,2707	1,1728	1,9190	545,9	0,0873
vapour			32,408	501,71	533,70	2,0655	1,0707	1,4320	180,74	25,20
liquid	50,00	1,1774	830,8	289,08	290,50	1,3003	1,1823	1,9574	519,9	0,1468
vapour			37,058	504,16	535,93	2,0598	1,0917	1,4887	178,94	24,24
liquid	55,00	1,3317	815,4	298,70	300,34	1,3299	1,1922	2,0009	493,5	0,2159
vapour			42,300	506,47	537,95	2,0540	1,1131	1,5526	176,89	23,38
liquid	60,00	1,5007	799,4	308,50	310,38	1,3596	1,2026	2,0510	466,9	0,2970
vapour			48,222	508,60	539,72	2,0480	1,1350	1,6257	174,57	22,60
liquid	65,00	1,6853	782,5	318,49	320,64	1,3895	1,2135	2,1094	440,0	0,3934
vapour			54,933	510,53	541,21	2,0418	1,1575	1,7109	171,96	21,90
liquid	70,00	1,8864	764,6	328,70	331,16	1,4196	1,2251	2,1789	412,6	0,5096
vapour			62,569	512,22	542,37	2,0351	1,1806	1,8122	169,04	21,27
liquid	75,00	2,1051	745,6	339,16	341,98	1,4501	1,2375	2,2637	384,8	0,6522
vapour			71,312	513,62	543,14	2,0279	1,2045	1,9360	165,79	20,71
liquid	80,00	2,3424	725,2	349,92	353,15	1,4810	1,2509	2,3703	356,4	0,8309
vapour			81,403	514,66	543,43	2,0198	1,2294	2,0924	162,17	20,20
liquid	85,00	2,5996	703,0	361,04	364,74	1,5126	1,2655	2,5099	327,4	1,0609
vapour			93,185	515,23	543,13	2,0107	1,2555	2,2985	158,15	19,74
liquid	90,00	2,8780	678,5	372,63	376,87	1,5451	1,2818	2,7034	297,4	1,3675
vapour			107,172	515,21	542,06	2,0000	1,2832	2,5863	153,69	19,32
liquid	95,00	3,1791	650,9	384,82	389,71	1,5790	1,3004	2,9947	266,3	1,7961
vapour			124,192	514,35	539,95	1,9871	1,3130	3,0228	148,70	18,90
liquid	100,00	3,5050	618,5	397,93	403,59	1,6151	1,3223	3,4951	233,5	2,4378
vapour			145,754	512,23	536,28	1,9707	1,3459	3,7759	143,11	18,43
liquid	105,00	3,8583	578,1	412,57	419,25	1,6552	1,3502	4,5947	198,0	3,5082
vapour			175,224	507,95	529,97	1,9479	1,3838	5,4245	136,73	17,78
liquid	110,00	4,2432	517,4	431,02	439,22	1,7058	1,3921	9,2614	157,9	5,7104
vapour			224,256	498,39	517,31	1,9096	1,4317	12,2150	129,14	16,42
critical	113,26	4,5168	368,0	465,28	477,55	1,8037	c	c	c	11,2920

a Triple point.

b Normal boiling point.

c The values of C_v, C_p, and w at the critical point are not included as part of this International Standard.

5.12 R404A — R125/143a/134a (44/52/4)

5.12.1 Composition of R404A

Table 32 — Composition of R404A

i	Component	Mass fraction	Mole fraction
1	R125	0,44	0,357 816 78
2	R143a	0,52	0,603 919 22
3	R134a	0,04	0,038 264 00
M = 97,604 0 g/mol			

5.12.2 Range of validity

The coefficients are valid within the following ranges:

T_{min} = 172,52 K, T_{max} = 455 K; p_{max} = 60 MPa; ρ_{max} = 15,04 mol/l (1 468 kg/m^3)

5.12.3 Interaction parameters (Equations 19 and 20)

ξ_{12} = 5,551; ξ_{12} = – 0,000 445 2; ξ_{13} = – 0,432 6; ξ_{13} = – 0,000 345 3; ξ_{23} = 2 ,324; ξ_{23} = 0,000 618 2

5.12.4 Coefficients and exponents of the excess functions (Equation 21)

Table 33 — Coefficients and exponents of the excess functions,
i = 1; j = 2 (R125/143a binary pair)

R125/134a binary pair[a] and R143a/134a binary pair[b]				
k	N_k	t_k	d_k	l_k
1	– 0,013 073	7,4	1	1
2	0,018 259	0,35	3	1
3	0,000 008 129 9	10,0	11	2
4	0,007 849 6	5,3	2	3
F_{12} = 1,169 7				
a i = 1; j = 3: F_{13} = 1,00; the $\varphi_{ij,excess}$ function for the R125/134a pair is identical to that for the R125/143a pair.				
b For i = 2; j = 3: F_{23} = 0,555 7; the $\varphi_{ij,excess}$ function for the R143a/134a pair is identical to that for the R125/143a pair.				

5.12.5 Reference state parameters

f_3 = 0,753 387 285, f_4 = 17,495 997 7

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3	0,000 008 129 9	10,0	11	2
4	0,007 849 6	5,3	2	3
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5.12.5 Reference state parameters

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ξ_{12} = 5,551; ξ_{12} = – 0,000 445 2; ξ_{13} = – 0,432 6; ξ_{13} = – 0,000 345 3; ξ_{23} = 2 ,324; ξ_{23} = 0,000 618 2

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4	0,007 849 6	5,3	2	3
F_{12} = 1,169 7				
a i = 1; j = 3: F_{13} = 1,00; the $\varphi_{ij,excess}$ function for the R125/134a pair is identical to that for the R125/143a pair.				
b For i = 2; j = 3: F_{23} = 0,555 7; the $\varphi_{ij,excess}$ function for the R143a/134a pair is identical to that for the R125/143a pair.				

5.12.5 Reference state parameters

f_3 = 0,753 387 285, f_4 = 17,495 997 7

5.13.3 Reference state parameters

$f_3 = 1{,}043\,708\,79$, $f_4 = -8{,}741\,068\,03$

Table 37 — R407C property values of liquid on the bubble line and vapour on the dew line

	Pressure MPa	Temp. °C	Density kg/m³	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/(kg·K)	C_v kJ/(kg·K)	C_p kJ/(kg·K)	Sound speed m/s	J-T coefficient K/MPa
bubble dew	0,0100	–82,45 –74,81	1495,5 0,527	90,48 347,81	90,48 366,78	0,5259 1,9471	0,8200 0,5654	1,2815 0,6681	1008,4 149,08	–0,3299 115,10
bubble dew	0,0150	–76,77 –69,22	1479,1 0,771	97,75 350,74	97,76 370,19	0,5634 1,9253	0,8219 0,5781	1,2820 0,6826	976,2 150,70	–0,3246 100,56
bubble dew	0,0200	–72,50 –65,02	1466,7 1,010	103,23 352,95	103,24 372,75	0,5910 1,9104	0,8235 0,5879	1,2835 0,6941	952,7 151,85	–0,3198 91,36
bubble dew	0,0250	–69,03 –61,61	1456,6 1,245	107,68 354,75	107,70 374,83	0,6130 1,8991	0,8250 0,5960	1,2853 0,7038	934,1 152,74	–0,3154 84,79
bubble dew	0,0300	–66,09 –58,72	1448,0 1,477	111,46 356,27	111,48 376,59	0,6314 1,8900	0,8263 0,6031	1,2872 0,7123	918,5 153,46	–0,3113 79,75
bubble dew	0,0400	–61,25 –53,95	1433,7 1,934	117,70 358,79	117,72 379,47	0,6612 1,8761	0,8287 0,6149	1,2912 0,7269	893,3 154,58	–0,3039 72,38
bubble dew	0,0500	–57,31 –50,08	1422,0 2,384	122,79 360,83	122,82 381,80	0,6850 1,8656	0,8308 0,6248	1,2950 0,7393	873,1 155,43	–0,2972 67,09
bubble dew	0,0600	–53,96 –46,79	1412,0 2,829	127,13 362,56	127,17 383,77	0,7050 1,8573	0,8327 0,6334	1,2987 0,7502	856,1 156,10	–0,2911 63,04
bubble dew	0,0800	–48,42 –41,34	1395,3 3,707	134,33 365,41	134,39 386,99	0,7374 1,8445	0,8361 0,6479	1,3056 0,7692	828,3 157,10	–0,2799 57,08
bubble dew	0,1000	–43,90 –36,90	1381,5 4,574	140,24 367,73	140,31 389,59	0,7635 1,8349	0,8391 0,6601	1,3121 0,7855	805,8 157,81	–0,2698 52,81
bubble dew	0,1013[a]	–43,63 –36,63	1380,7 4,631	140,60 367,87	140,67 389,75	0,7650 1,8343	0,8393 0,6609	1,3125 0,7865	804,5 157,85	–0,2691 52,57
bubble dew	0,1200	–40,05 –33,11	1369,7 5,432	145,30 369,69	145,39 391,78	0,7854 1,8273	0,8418 0,6707	1,3181 0,8001	786,8 158,34	–0,2604 49,54
bubble dew	0,1400	–36,67 –29,79	1359,1 6,283	149,75 371,40	149,86 393,68	0,8043 1,8210	0,8443 0,6802	1,3238 0,8133	770,2 158,74	–0,2515 46,91
bubble dew	0,1600	–33,65 –26,83	1349,7 7,130	153,75 372,92	153,86 395,36	0,8211 1,8156	0,8466 0,6887	1,3292 0,8255	755,4 159,05	–0,2431 44,74
bubble dew	0,1800	–30,92 –24,15	1341,0 7,973	157,38 374,29	157,51 396,86	0,8362 1,8110	0,8488 0,6965	1,3344 0,8369	742,1 159,29	–0,2350 42,90
bubble dew	0,2000	–28,41 –21,69	1333,0 8,813	160,72 375,53	160,87 398,22	0,8499 1,8069	0,8508 0,7038	1,3394 0,8476	729,9 159,47	–0,2272 41,32
bubble dew	0,2500	–22,90 –16,28	1315,1 10,904	168,11 378,24	168,30 401,17	0,8798 1,7984	0,8555 0,7200	1,3513 0,8722	703,1 159,74	–0,2084 38,14
bubble dew	0,3000	–18,19 –11,66	1299,5 12,989	174,48 380,52	174,71 403,62	0,9050 1,7917	0,8598 0,7340	1,3624 0,8945	680,1 159,82	–0,1906 35,72
bubble dew	0,3500	–14,04 –7,61	1285,5 15,071	180,12 382,49	180,39 405,72	0,9269 1,7861	0,8637 0,7465	1,3731 0,9151	660,0 159,79	–0,1733 33,80
bubble dew	0,4000	–10,33 –3,97	1272,8 17,154	185,20 384,24	185,52 407,55	0,9465 1,7814	0,8673 0,7578	1,3834 0,9345	641,9 159,66	–0,1564 32,22
bubble dew	0,4500	–6,95 –0,67	1261,1 19,241	189,86 385,79	190,21 409,18	0,9641 1,7772	0,8707 0,7682	1,3934 0,9528	625,5 159,46	–0,1398 30,89
bubble dew	0,5000	–3,85 2,36	1250,1 21,334	194,16 387,20	194,56 410,64	0,9801 1,7735	0,8740 0,7779	1,4032 0,9704	610,4 159,20	–0,1233 29,76
bubble dew	0,5500	–0,98 5,17	1239,8 23,435	198,17 388,48	198,61 411,95	0,9950 1,7702	0,8771 0,7868	1,4129 0,9875	596,3 158,91	–0,1069 28,77
bubble dew	0,6000	1,70 7,79	1230,0 25,545	201,93 389,66	202,42 413,15	1,0087 1,7672	0,8801 0,7953	1,4224 1,0040	583,2 158,58	–0,0905 27,91

Table 37 (*continued*)

	Pressure MPa	Temp. °C	Density kg/m³	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/(kg·K)	C_v kJ/(kg·K)	C_p kJ/(kg·K)	Sound speed m/s	J-T coefficient K/MPa
bubble dew	0,6500	4,22 10,24	1220,7 27,665	205,49 390,75	206,02 414,25	1,0216 1,7644	0,8830 0,8032	1,4319 1,0201	570,8 158,22	–0,0741 27,14
bubble dew	0,7000	6,60 12,56	1211,7 29,796	208,87 391,76	209,44 415,25	1,0338 1,7618	0,8857 0,8108	1,4413 1,0360	559,1 157,83	–0,0576 26,46
bubble dew	0,7500	8,85 14,76	1203,1 31,940	212,08 392,70	212,71 416,18	1,0452 1,7594	0,8884 0,8179	1,4507 1,0516	548,0 157,42	–0,0410 25,84
bubble dew	0,8000	11,00 16,85	1194,9 34,098	215,16 393,57	215,83 417,03	1,0561 1,7571	0,8911 0,8248	1,4600 1,0670	537,4 157,00	–0,0242 25,29
bubble dew	0,9000	15,00 20,74	1179,1 38,456	220,95 395,16	221,71 418,57	1,0764 1,7529	0,8961 0,8378	1,4789 1,0976	517,6 156,11	0,0098 24,32
bubble dew	1,0000	18,69 24,32	1164,1 42,877	226,33 396,57	227,19 419,89	1,0950 1,7491	0,9010 0,8499	1,4979 1,1282	499,2 155,16	0,0447 23,50
bubble dew	1,2000	25,30 30,73	1136,2 51,932	236,14 398,92	237,20 422,03	1,1283 1,7421	0,9102 0,8721	1,5370 1,1902	466,0 153,16	0,1180 22,18
bubble dew	1,4000	31,14 36,37	1110,2 61,306	244,98 400,79	246,24 423,63	1,1577 1,7358	0,9190 0,8926	1,5780 1,2549	436,4 151,05	0,1968 21,17
bubble dew	1,6000	36,39 41,43	1085,5 71,047	253,09 402,28	254,57 424,80	1,1843 1,7298	0,9274 0,9120	1,6219 1,3242	409,4 148,85	0,2826 20,36
bubble dew	1,8000	41,18 46,03	1061,7 81,203	260,64 403,44	262,33 425,61	1,2086 1,7241	0,9358 0,9305	1,6695 1,3996	384,5 146,57	0,3769 19,69
bubble dew	2,0000	45,59 50,25	1038,5 91,831	267,74 404,32	269,66 426,10	1,2311 1,7184	0,9441 0,9484	1,7218 1,4831	361,3 144,24	0,4815 19,13
bubble dew	2,2000	49,68 54,15	1015,7 103,00	274,47 404,93	276,64 426,29	1,2522 1,7126	0,9526 0,9660	1,7804 1,5770	339,3 141,84	0,5987 18,64
bubble dew	2,4000	53,51 57,79	993,1 114,78	280,92 405,29	283,34 426,20	1,2723 1,7068	0,9613 0,9834	1,8470 1,6845	318,4 139,40	0,7315 18,22
bubble dew	2,6000	57,11 61,19	970,5 127,27	287,14 405,42	289,82 425,85	1,2914 1,7007	0,9705 1,0008	1,9244 1,8096	298,2 136,90	0,8838 17,84
bubble dew	2,8000	60,51 64,38	947,5 140,60	293,17 405,30	296,12 425,21	1,3097 1,6944	0,9802 1,0183	2,0161 1,9582	278,6 134,35	1,0607 17,48
bubble dew	3,0000	63,73 67,40	924,1 154,93	299,07 404,93	302,31 424,29	1,3276 1,6877	0,9909 1,0360	2,1279 2,1390	259,4 131,75	1,2695 17,15
bubble dew	3,2000	66,80 70,25	899,9 170,45	304,88 404,28	308,43 423,06	1,3450 1,6805	1,0028 1,0543	2,2682 2,3648	240,4 129,09	1,5201 16,83
bubble dew	3,4000	69,73 72,94	874,6 187,47	310,65 403,33	314,54 421,46	1,3622 1,6726	1,0164 1,0734	2,4511 2,6567	221,6 126,38	1,8268 16,49
bubble dew	3,6000	72,53 75,50	847,6 206,40	316,46 402,01	320,71 419,45	1,3795 1,6639	1,0322 1,0937	2,7011 3,0504	202,7 123,59	2,2107 16,14
bubble dew	3,8000	75,22 77,92	818,1 227,89	322,38 400,24	327,02 416,91	1,3970 1,6540	1,0512 1,1156	3,0653 3,6132	183,8 120,73	2,7043 15,74
bubble dew	4,0000	77,82 80,21	785,1 253,04	328,54 397,85	333,64 413,66	1,4152 1,6424	1,0747 1,1401	3,6469 4,4863	164,8 117,75	3,3604 15,26
bubble dew	4,2000	80,32 82,37	746,0 284,01	335,20 394,55	340,83 409,34	1,4348 1,6281	1,1050 1,1687	4,7261 6,0289	145,6 114,58	4,2742 14,63
critical	4,6298	86,03	484,2	368,92	378,48	1,5384	[b]	[b]	[b]	10,3922

[a] Bubble point and dew point at one standard atmosphere.

[b] The values of C_v, C_p, and w at the critical point are not included as part of this International Standard.

Table 37 (*continued*)

	Pressure MPa	Temp. °C	Density kg/m³	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/(kg·K)	C_v kJ/(kg·K)	C_p kJ/(kg·K)	Sound speed m/s	J-T coefficient K/MPa
bubble dew	0,6500	4,22 10,24	1220,7 27,665	205,49 390,75	206,02 414,25	1,0216 1,7644	0,8830 0,8032	1,4319 1,0201	570,8 158,22	–0,0741 27,14
bubble dew	0,7000	6,60 12,56	1211,7 29,796	208,87 391,76	209,44 415,25	1,0338 1,7618	0,8857 0,8108	1,4413 1,0360	559,1 157,83	–0,0576 26,46
bubble dew	0,7500	8,85 14,76	1203,1 31,940	212,08 392,70	212,71 416,18	1,0452 1,7594	0,8884 0,8179	1,4507 1,0516	548,0 157,42	–0,0410 25,84
bubble dew	0,8000	11,00 16,85	1194,9 34,098	215,16 393,57	215,83 417,03	1,0561 1,7571	0,8911 0,8248	1,4600 1,0670	537,4 157,00	–0,0242 25,29
bubble dew	0,9000	15,00 20,74	1179,1 38,456	220,95 395,16	221,71 418,57	1,0764 1,7529	0,8961 0,8378	1,4789 1,0976	517,6 156,11	0,0098 24,32
bubble dew	1,0000	18,69 24,32	1164,1 42,877	226,33 396,57	227,19 419,89	1,0950 1,7491	0,9010 0,8499	1,4979 1,1282	499,2 155,16	0,0447 23,50
bubble dew	1,2000	25,30 30,73	1136,2 51,932	236,14 398,92	237,20 422,03	1,1283 1,7421	0,9102 0,8721	1,5370 1,1902	466,0 153,16	0,1180 22,18
bubble dew	1,4000	31,14 36,37	1110,2 61,306	244,98 400,79	246,24 423,63	1,1577 1,7358	0,9190 0,8926	1,5780 1,2549	436,4 151,05	0,1968 21,17
bubble dew	1,6000	36,39 41,43	1085,5 71,047	253,09 402,28	254,57 424,80	1,1843 1,7298	0,9274 0,9120	1,6219 1,3242	409,4 148,85	0,2826 20,36
bubble dew	1,8000	41,18 46,03	1061,7 81,203	260,64 403,44	262,33 425,61	1,2086 1,7241	0,9358 0,9305	1,6695 1,3996	384,5 146,57	0,3769 19,69
bubble dew	2,0000	45,59 50,25	1038,5 91,831	267,74 404,32	269,66 426,10	1,2311 1,7184	0,9441 0,9484	1,7218 1,4831	361,3 144,24	0,4815 19,13
bubble dew	2,2000	49,68 54,15	1015,7 103,00	274,47 404,93	276,64 426,29	1,2522 1,7126	0,9526 0,9660	1,7804 1,5770	339,3 141,84	0,5987 18,64
bubble dew	2,4000	53,51 57,79	993,1 114,78	280,92 405,29	283,34 426,20	1,2723 1,7068	0,9613 0,9834	1,8470 1,6845	318,4 139,40	0,7315 18,22
bubble dew	2,6000	57,11 61,19	970,5 127,27	287,14 405,42	289,82 425,85	1,2914 1,7007	0,9705 1,0008	1,9244 1,8096	298,2 136,90	0,8838 17,84
bubble dew	2,8000	60,51 64,38	947,5 140,60	293,17 405,30	296,12 425,21	1,3097 1,6944	0,9802 1,0183	2,0161 1,9582	278,6 134,35	1,0607 17,48
bubble dew	3,0000	63,73 67,40	924,1 154,93	299,07 404,93	302,31 424,29	1,3276 1,6877	0,9909 1,0360	2,1279 2,1390	259,4 131,75	1,2695 17,15
bubble dew	3,2000	66,80 70,25	899,9 170,45	304,88 404,28	308,43 423,06	1,3450 1,6805	1,0028 1,0543	2,2682 2,3648	240,4 129,09	1,5201 16,83
bubble dew	3,4000	69,73 72,94	874,6 187,47	310,65 403,33	314,54 421,46	1,3622 1,6726	1,0164 1,0734	2,4511 2,6567	221,6 126,38	1,8268 16,49
bubble dew	3,6000	72,53 75,50	847,6 206,40	316,46 402,01	320,71 419,45	1,3795 1,6639	1,0322 1,0937	2,7011 3,0504	202,7 123,59	2,2107 16,14
bubble dew	3,8000	75,22 77,92	818,1 227,89	322,38 400,24	327,02 416,91	1,3970 1,6540	1,0512 1,1156	3,0653 3,6132	183,8 120,73	2,7043 15,74
bubble dew	4,0000	77,82 80,21	785,1 253,04	328,54 397,85	333,64 413,66	1,4152 1,6424	1,0747 1,1401	3,6469 4,4863	164,8 117,75	3,3604 15,26
bubble dew	4,2000	80,32 82,37	746,0 284,01	335,20 394,55	340,83 409,34	1,4348 1,6281	1,1050 1,1687	4,7261 6,0289	145,6 114,58	4,2742 14,63
critical	4,6298	86,03	484,2	368,92	378,48	1,5384	[b]	[b]	[b]	10,3922

[a] Bubble point and dew point at one standard atmosphere.

[b] The values of C_v, C_p, and w at the critical point are not included as part of this International Standard.

Table 40 — R410A property values of liquid on the bubble line and vapour on the dew line

	Pressure MPa	Temp. °C	Density kg/m³	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/(kg·K)	C_v kJ/(kg·K)	C_p kJ/(kg·K)	Sound speed m/s	J-T coefficient K/MPa
bubble dew	0,0100	–88,23 –88,14	1460,6 0,476	76,55 357,77	76,56 378,76	0,4588 2,0927	0,8662 0,5442	1,3441 0,6680	1004,0 159,71	–0,3215 156,70
bubble dew	0,0150	–82,84 –82,75	1444,9 0,697	83,79 360,37	83,80 381,90	0,4974 2,0635	0,8620 0,5569	1,3444 0,6836	977,6 161,51	–0,3156 137,58
bubble dew	0,0200	–78,79 –78,70	1432,9 0,912	89,24 362,31	89,26 384,25	0,5258 2,0432	0,8596 0,5670	1,3455 0,6964	957,8 162,79	–0,3105 125,06
bubble dew	0,0250	–75,50 –75,41	1423,1 1,124	93,67 363,88	93,69 386,13	0,5484 2,0276	0,8580 0,5757	1,3468 0,7074	941,8 163,78	–0,3060 115,92
bubble dew	0,0300	–72,71 –72,63	1414,8 1,333	97,42 365,21	97,44 387,71	0,5672 2,0151	0,8569 0,5833	1,3483 0,7172	928,2 164,59	–0,3018 108,80
bubble dew	0,0400	–68,12 –68,04	1401,1 1,745	103,61 367,37	103,64 390,29	0,5978 1,9956	0,8555 0,5964	1,3515 0,7344	905,8 165,84	–0,2944 98,17
bubble dew	0,0500	–64,39 –64,31	1389,7 2,151	108,66 369,11	108,70 392,36	0,6222 1,9807	0,8548 0,6075	1,3546 0,7492	887,6 166,78	–0,2878 90,44
bubble dew	0,0600	–61,22 –61,14	1380,0 2,551	112,96 370,58	113,00 394,10	0,6426 1,9687	0,8544 0,6172	1,3577 0,7624	872,1 167,53	–0,2818 84,44
bubble dew	0,0800	–55,98 –55,90	1363,9 3,342	120,08 372,99	120,14 396,92	0,6758 1,9500	0,8543 0,6338	1,3636 0,7855	846,5 168,66	–0,2708 75,56
bubble dew	0,1000	–51,70 –51,62	1350,5 4,123	125,92 374,92	125,99 399,17	0,7024 1,9358	0,8546 0,6477	1,3693 0,8054	825,6 169,47	–0,2609 69,16
bubble dew	0,1013[a]	–51,44 –51,36	1349,7 4,174	126,27 375,03	126,34 399,31	0,7040 1,9350	0,8547 0,6486	1,3697 0,8066	824,3 169,52	–0,2602 68,80
bubble dew	0,1200	–48,06 –47,98	1339,0 4,895	130,90 376,54	130,99 401,05	0,7247 1,9243	0,8552 0,6599	1,3747 0,8231	807,7 170,08	–0,2516 64,24
bubble dew	0,1400	–44,87 –44,79	1328,8 5,662	135,29 377,95	135,39 402,67	0,7441 1,9147	0,8559 0,6706	1,3799 0,8391	792,0 170,56	–0,2430 60,30
bubble dew	0,1600	–42,02 –41,94	1319,6 6,425	139,22 379,19	139,34 404,09	0,7612 1,9065	0,8567 0,6804	1,3850 0,8539	777,9 170,93	–0,2347 57,05
bubble dew	0,1800	–39,44 –39,36	1311,2 7,183	142,79 380,30	142,93 405,36	0,7766 1,8993	0,8576 0,6892	1,3899 0,8677	765,2 171,22	–0,2267 54,30
bubble dew	0,2000	–37,07 –36,99	1303,4 7,940	146,07 381,31	146,23 406,50	0,7905 1,8928	0,8585 0,6974	1,3946 0,8806	753,4 171,45	–0,2190 51,94
bubble dew	0,2500	–31,88 –31,79	1286,1 9,822	153,32 383,48	153,51 408,93	0,8209 1,8794	0,8608 0,7155	1,4061 0,9100	727,5 171,83	–0,2006 47,24
bubble dew	0,3000	–27,44 –27,35	1271,1 11,697	159,56 385,29	159,80 410,94	0,8466 1,8685	0,8631 0,7310	1,4172 0,9365	705,3 172,01	–0,1830 43,70
bubble dew	0,3500	–23,54 –23,45	1257,6 13,569	165,08 386,84	165,36 412,64	0,8689 1,8593	0,8655 0,7447	1,4279 0,9608	685,6 172,06	–0,1660 40,90
bubble dew	0,4000	–20,04 –19,95	1245,3 15,442	170,05 388,20	170,38 414,10	0,8887 1,8514	0,8678 0,7570	1,4384 0,9834	667,8 172,00	–0,1493 38,62
bubble dew	0,4500	–16,87 –16,78	1233,9 17,318	174,60 389,40	174,96 415,39	0,9065 1,8445	0,8702 0,7682	1,4487 1,0049	651,6 171,87	–0,1329 36,72
bubble dew	0,5000	–13,96 –13,86	1223,3 19,198	178,80 390,48	179,21 416,53	0,9228 1,8383	0,8725 0,7786	1,4589 1,0253	636,7 171,68	–0,1166 35,10
bubble dew	0,5500	–11,26 –11,16	1213,4 21,085	182,72 391,46	183,17 417,54	0,9379 1,8326	0,8747 0,7881	1,4690 1,0450	622,7 171,44	–0,1004 33,70
bubble dew	0,6000	–8,74 –8,64	1203,9 22,979	186,39 392,34	186,89 418,46	0,9518 1,8275	0,8770 0,7970	1,4791 1,0641	609,6 171,16	–0,0843 32,48

Table 40 — R410A property values of liquid on the bubble line and vapour on the dew line

	Pressure MPa	Temp. °C	Density kg/m³	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/(kg·K)	C_v kJ/(kg·K)	C_p kJ/(kg·K)	Sound speed m/s	J-T coefficient K/MPa
bubble dew	0,0100	–88,23 –88,14	1460,6 0,476	76,55 357,77	76,56 378,76	0,4588 2,0927	0,8662 0,5442	1,3441 0,6680	1004,0 159,71	–0,3215 156,70
bubble dew	0,0150	–82,84 –82,75	1444,9 0,697	83,79 360,37	83,80 381,90	0,4974 2,0635	0,8620 0,5569	1,3444 0,6836	977,6 161,51	–0,3156 137,58
bubble dew	0,0200	–78,79 –78,70	1432,9 0,912	89,24 362,31	89,26 384,25	0,5258 2,0432	0,8596 0,5670	1,3455 0,6964	957,8 162,79	–0,3105 125,06
bubble dew	0,0250	–75,50 –75,41	1423,1 1,124	93,67 363,88	93,69 386,13	0,5484 2,0276	0,8580 0,5757	1,3468 0,7074	941,8 163,78	–0,3060 115,92
bubble dew	0,0300	–72,71 –72,63	1414,8 1,333	97,42 365,21	97,44 387,71	0,5672 2,0151	0,8569 0,5833	1,3483 0,7172	928,2 164,59	–0,3018 108,80
bubble dew	0,0400	–68,12 –68,04	1401,1 1,745	103,61 367,37	103,64 390,29	0,5978 1,9956	0,8555 0,5964	1,3515 0,7344	905,8 165,84	–0,2944 98,17
bubble dew	0,0500	–64,39 –64,31	1389,7 2,151	108,66 369,11	108,70 392,36	0,6222 1,9807	0,8548 0,6075	1,3546 0,7492	887,6 166,78	–0,2878 90,44
bubble dew	0,0600	–61,22 –61,14	1380,0 2,551	112,96 370,58	113,00 394,10	0,6426 1,9687	0,8544 0,6172	1,3577 0,7624	872,1 167,53	–0,2818 84,44
bubble dew	0,0800	–55,98 –55,90	1363,9 3,342	120,08 372,99	120,14 396,92	0,6758 1,9500	0,8543 0,6338	1,3636 0,7855	846,5 168,66	–0,2708 75,56
bubble dew	0,1000	–51,70 –51,62	1350,5 4,123	125,92 374,92	125,99 399,17	0,7024 1,9358	0,8546 0,6477	1,3693 0,8054	825,6 169,47	–0,2609 69,16
bubble dew	0,1013[a]	–51,44 –51,36	1349,7 4,174	126,27 375,03	126,34 399,31	0,7040 1,9350	0,8547 0,6486	1,3697 0,8066	824,3 169,52	–0,2602 68,80
bubble dew	0,1200	–48,06 –47,98	1339,0 4,895	130,90 376,54	130,99 401,05	0,7247 1,9243	0,8552 0,6599	1,3747 0,8231	807,7 170,08	–0,2516 64,24
bubble dew	0,1400	–44,87 –44,79	1328,8 5,662	135,29 377,95	135,39 402,67	0,7441 1,9147	0,8559 0,6706	1,3799 0,8391	792,0 170,56	–0,2430 60,30
bubble dew	0,1600	–42,02 –41,94	1319,6 6,425	139,22 379,19	139,34 404,09	0,7612 1,9065	0,8567 0,6804	1,3850 0,8539	777,9 170,93	–0,2347 57,05
bubble dew	0,1800	–39,44 –39,36	1311,2 7,183	142,79 380,30	142,93 405,36	0,7766 1,8993	0,8576 0,6892	1,3899 0,8677	765,2 171,22	–0,2267 54,30
bubble dew	0,2000	–37,07 –36,99	1303,4 7,940	146,07 381,31	146,23 406,50	0,7905 1,8928	0,8585 0,6974	1,3946 0,8806	753,4 171,45	–0,2190 51,94
bubble dew	0,2500	–31,88 –31,79	1286,1 9,822	153,32 383,48	153,51 408,93	0,8209 1,8794	0,8608 0,7155	1,4061 0,9100	727,5 171,83	–0,2006 47,24
bubble dew	0,3000	–27,44 –27,35	1271,1 11,697	159,56 385,29	159,80 410,94	0,8466 1,8685	0,8631 0,7310	1,4172 0,9365	705,3 172,01	–0,1830 43,70
bubble dew	0,3500	–23,54 –23,45	1257,6 13,569	165,08 386,84	165,36 412,64	0,8689 1,8593	0,8655 0,7447	1,4279 0,9608	685,6 172,06	–0,1660 40,90
bubble dew	0,4000	–20,04 –19,95	1245,3 15,442	170,05 388,20	170,38 414,10	0,8887 1,8514	0,8678 0,7570	1,4384 0,9834	667,8 172,00	–0,1493 38,62
bubble dew	0,4500	–16,87 –16,78	1233,9 17,318	174,60 389,40	174,96 415,39	0,9065 1,8445	0,8702 0,7682	1,4487 1,0049	651,6 171,87	–0,1329 36,72
bubble dew	0,5000	–13,96 –13,86	1223,3 19,198	178,80 390,48	179,21 416,53	0,9228 1,8383	0,8725 0,7786	1,4589 1,0253	636,7 171,68	–0,1166 35,10
bubble dew	0,5500	–11,26 –11,16	1213,4 21,085	182,72 391,46	183,17 417,54	0,9379 1,8326	0,8747 0,7881	1,4690 1,0450	622,7 171,44	–0,1004 33,70
bubble dew	0,6000	–8,74 –8,64	1203,9 22,979	186,39 392,34	186,89 418,46	0,9518 1,8275	0,8770 0,7970	1,4791 1,0641	609,6 171,16	–0,0843 32,48

Table 40 — R410A property values of liquid on the bubble line and vapour on the dew line

	Pressure MPa	Temp. °C	Density kg/m³	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/(kg·K)	C_v kJ/(kg·K)	C_p kJ/(kg·K)	Sound speed m/s	J-T coefficient K/MPa
bubble dew	0,0100	–88,23 –88,14	1460,6 0,476	76,55 357,77	76,56 378,76	0,4588 2,0927	0,8662 0,5442	1,3441 0,6680	1004,0 159,71	–0,3215 156,70
bubble dew	0,0150	–82,84 –82,75	1444,9 0,697	83,79 360,37	83,80 381,90	0,4974 2,0635	0,8620 0,5569	1,3444 0,6836	977,6 161,51	–0,3156 137,58
bubble dew	0,0200	–78,79 –78,70	1432,9 0,912	89,24 362,31	89,26 384,25	0,5258 2,0432	0,8596 0,5670	1,3455 0,6964	957,8 162,79	–0,3105 125,06
bubble dew	0,0250	–75,50 –75,41	1423,1 1,124	93,67 363,88	93,69 386,13	0,5484 2,0276	0,8580 0,5757	1,3468 0,7074	941,8 163,78	–0,3060 115,92
bubble dew	0,0300	–72,71 –72,63	1414,8 1,333	97,42 365,21	97,44 387,71	0,5672 2,0151	0,8569 0,5833	1,3483 0,7172	928,2 164,59	–0,3018 108,80
bubble dew	0,0400	–68,12 –68,04	1401,1 1,745	103,61 367,37	103,64 390,29	0,5978 1,9956	0,8555 0,5964	1,3515 0,7344	905,8 165,84	–0,2944 98,17
bubble dew	0,0500	–64,39 –64,31	1389,7 2,151	108,66 369,11	108,70 392,36	0,6222 1,9807	0,8548 0,6075	1,3546 0,7492	887,6 166,78	–0,2878 90,44
bubble dew	0,0600	–61,22 –61,14	1380,0 2,551	112,96 370,58	113,00 394,10	0,6426 1,9687	0,8544 0,6172	1,3577 0,7624	872,1 167,53	–0,2818 84,44
bubble dew	0,0800	–55,98 –55,90	1363,9 3,342	120,08 372,99	120,14 396,92	0,6758 1,9500	0,8543 0,6338	1,3636 0,7855	846,5 168,66	–0,2708 75,56
bubble dew	0,1000	–51,70 –51,62	1350,5 4,123	125,92 374,92	125,99 399,17	0,7024 1,9358	0,8546 0,6477	1,3693 0,8054	825,6 169,47	–0,2609 69,16
bubble dew	0,1013[a]	–51,44 –51,36	1349,7 4,174	126,27 375,03	126,34 399,31	0,7040 1,9350	0,8547 0,6486	1,3697 0,8066	824,3 169,52	–0,2602 68,80
bubble dew	0,1200	–48,06 –47,98	1339,0 4,895	130,90 376,54	130,99 401,05	0,7247 1,9243	0,8552 0,6599	1,3747 0,8231	807,7 170,08	–0,2516 64,24
bubble dew	0,1400	–44,87 –44,79	1328,8 5,662	135,29 377,95	135,39 402,67	0,7441 1,9147	0,8559 0,6706	1,3799 0,8391	792,0 170,56	–0,2430 60,30
bubble dew	0,1600	–42,02 –41,94	1319,6 6,425	139,22 379,19	139,34 404,09	0,7612 1,9065	0,8567 0,6804	1,3850 0,8539	777,9 170,93	–0,2347 57,05
bubble dew	0,1800	–39,44 –39,36	1311,2 7,183	142,79 380,30	142,93 405,36	0,7766 1,8993	0,8576 0,6892	1,3899 0,8677	765,2 171,22	–0,2267 54,30
bubble dew	0,2000	–37,07 –36,99	1303,4 7,940	146,07 381,31	146,23 406,50	0,7905 1,8928	0,8585 0,6974	1,3946 0,8806	753,4 171,45	–0,2190 51,94
bubble dew	0,2500	–31,88 –31,79	1286,1 9,822	153,32 383,48	153,51 408,93	0,8209 1,8794	0,8608 0,7155	1,4061 0,9100	727,5 171,83	–0,2006 47,24
bubble dew	0,3000	–27,44 –27,35	1271,1 11,697	159,56 385,29	159,80 410,94	0,8466 1,8685	0,8631 0,7310	1,4172 0,9365	705,3 172,01	–0,1830 43,70
bubble dew	0,3500	–23,54 –23,45	1257,6 13,569	165,08 386,84	165,36 412,64	0,8689 1,8593	0,8655 0,7447	1,4279 0,9608	685,6 172,06	–0,1660 40,90
bubble dew	0,4000	–20,04 –19,95	1245,3 15,442	170,05 388,20	170,38 414,10	0,8887 1,8514	0,8678 0,7570	1,4384 0,9834	667,8 172,00	–0,1493 38,62
bubble dew	0,4500	–16,87 –16,78	1233,9 17,318	174,60 389,40	174,96 415,39	0,9065 1,8445	0,8702 0,7682	1,4487 1,0049	651,6 171,87	–0,1329 36,72
bubble dew	0,5000	–13,96 –13,86	1223,3 19,198	178,80 390,48	179,21 416,53	0,9228 1,8383	0,8725 0,7786	1,4589 1,0253	636,7 171,68	–0,1166 35,10
bubble dew	0,5500	–11,26 –11,16	1213,4 21,085	182,72 391,46	183,17 417,54	0,9379 1,8326	0,8747 0,7881	1,4690 1,0450	622,7 171,44	–0,1004 33,70
bubble dew	0,6000	–8,74 –8,64	1203,9 22,979	186,39 392,34	186,89 418,46	0,9518 1,8275	0,8770 0,7970	1,4791 1,0641	609,6 171,16	–0,0843 32,48

Table 43 — R507A property values of liquid on the bubble line and vapour on the dew line

	Pressure	Temp.	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	MPa	°C	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
bubble	0,0100	–85,26	1432,7	92,21	92,21	0,5310	0,7633	1,2026	926,5	–0,3545
dew		–85,24	0,639	297,04	312,68	1,7044	0,5669	0,6573	133,98	112,99
bubble	0,0150	–79,66	1416,1	98,94	98,95	0,5663	0,7720	1,2028	889,9	–0,3494
dew		–79,65	0,934	300,00	316,06	1,6884	0,5809	0,6730	135,47	96,12
bubble	0,0200	–75,44	1403,6	104,02	104,04	0,5923	0,7780	1,2044	864,2	–0,3442
dew		–75,43	1,223	302,26	318,61	1,6776	0,5916	0,6851	136,53	85,83
bubble	0,0250	–72,01	1393,4	108,16	108,17	0,6130	0,7826	1,2067	844,3	–0,3393
dew		–72,00	1,506	304,10	320,70	1,6696	0,6003	0,6951	137,34	78,70
bubble	0,0300	–69,10	1384,7	111,67	111,69	0,6304	0,7865	1,2091	827,9	–0,3346
dew		–69,09	1,786	305,67	322,47	1,6633	0,6077	0,7039	137,99	73,37
bubble	0,0400	–64,29	1370,4	117,49	117,52	0,6586	0,7926	1,2141	801,8	–0,3258
dew		–64,29	2,337	308,28	325,39	1,6538	0,6201	0,7186	139,00	65,80
bubble	0,0500	–60,37	1358,6	122,25	122,29	0,6812	0,7976	1,2191	781,2	–0,3176
dew		–60,37	2,880	310,41	327,77	1,6469	0,6304	0,7310	139,75	60,55
bubble	0,0600	–57,04	1348,5	126,32	126,36	0,7001	0,8017	1,2238	764,1	–0,3100
dew		–57,04	3,416	312,23	329,79	1,6415	0,6392	0,7418	140,33	56,62
bubble	0,0800	–51,53	1331,6	133,08	133,14	0,7310	0,8085	1,2326	736,3	–0,2960
dew		–51,53	4,474	315,25	333,13	1,6334	0,6540	0,7605	141,18	51,02
bubble	0,1000	–47,01	1317,6	138,65	138,73	0,7559	0,8141	1,2408	714,0	–0,2832
dew		–47,01	5,517	317,72	335,85	1,6276	0,6662	0,7764	141,76	47,13
bubble	0,1013[a]	–46,74	1316,8	138,99	139,07	0,7574	0,8145	1,2413	712,7	–0,2824
dew		–46,74	5,586	317,87	336,01	1,6273	0,6670	0,7774	141,79	46,91
bubble	0,1200	–43,16	1305,6	143,44	143,53	0,7769	0,8190	1,2483	695,2	–0,2712
dew		–43,16	6,551	319,83	338,15	1,6231	0,6769	0,7905	142,17	44,21
bubble	0,1400	–39,79	1294,9	147,65	147,76	0,7951	0,8232	1,2555	678,9	–0,2598
dew		–39,79	7,578	321,68	340,15	1,6195	0,6863	0,8033	142,47	41,91
bubble	0,1600	–36,77	1285,2	151,44	151,57	0,8113	0,8271	1,2622	664,3	–0,2488
dew		–36,77	8,599	323,33	341,93	1,6166	0,6948	0,8152	142,67	40,03
bubble	0,1800	–34,03	1276,4	154,90	155,04	0,8258	0,8306	1,2686	651,2	–0,2383
dew		–34,03	9,616	324,82	343,54	1,6141	0,7026	0,8262	142,82	38,45
bubble	0,2000	–31,52	1268,2	158,08	158,24	0,8390	0,8339	1,2748	639,2	–0,2280
dew		–31,51	10,631	326,19	345,00	1,6119	0,7098	0,8367	142,90	37,11
bubble	0,2500	–25,99	1249,8	165,14	165,34	0,8679	0,8411	1,2893	612,9	–0,2034
dew		–25,99	13,159	329,18	348,18	1,6077	0,7259	0,8607	142,96	34,44
bubble	0,3000	–21,26	1233,7	171,24	171,48	0,8924	0,8475	1,3029	590,5	–0,1797
dew		–21,25	15,682	331,72	350,85	1,6044	0,7399	0,8825	142,84	32,43
bubble	0,3500	–17,10	1219,3	176,66	176,95	0,9137	0,8532	1,3158	570,7	–0,1565
dew		–17,08	18,208	333,93	353,15	1,6019	0,7524	0,9028	142,60	30,85
bubble	0,4000	–13,36	1206,1	181,56	181,89	0,9327	0,8584	1,3282	553,0	–0,1337
dew		–13,35	20,741	335,90	355,18	1,5998	0,7637	0,9219	142,28	29,57
bubble	0,4500	–9,97	1193,8	186,05	186,43	0,9499	0,8633	1,3403	536,9	–0,1111
dew		–9,95	23,284	337,67	356,99	1,5980	0,7741	0,9401	141,89	28,49
bubble	0,5000	–6,85	1182,3	190,21	190,63	0,9657	0,8678	1,3520	522,0	–0,0884
dew		–6,83	25,841	339,28	358,63	1,5965	0,7836	0,9577	141,45	27,59
bubble	0,5500	–3,96	1171,5	194,10	194,57	0,9802	0,8720	1,3636	508,3	–0,0657
dew		–3,94	28,413	340,75	360,11	1,5951	0,7924	0,9747	140,98	26,81
bubble	0,6000	–1,26	1161,2	197,75	198,27	0,9937	0,8760	1,3751	495,3	–0,0427
dew		–1,24	31,003	342,11	361,47	1,5939	0,8007	0,9913	140,47	26,14

Table 43 — R507A property values of liquid on the bubble line and vapour on the dew line

	Pressure	Temp.	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	MPa	°C	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
bubble	0,0100	–85,26	1432,7	92,21	92,21	0,5310	0,7633	1,2026	926,5	–0,3545
dew		–85,24	0,639	297,04	312,68	1,7044	0,5669	0,6573	133,98	112,99
bubble	0,0150	–79,66	1416,1	98,94	98,95	0,5663	0,7720	1,2028	889,9	–0,3494
dew		–79,65	0,934	300,00	316,06	1,6884	0,5809	0,6730	135,47	96,12
bubble	0,0200	–75,44	1403,6	104,02	104,04	0,5923	0,7780	1,2044	864,2	–0,3442
dew		–75,43	1,223	302,26	318,61	1,6776	0,5916	0,6851	136,53	85,83
bubble	0,0250	–72,01	1393,4	108,16	108,17	0,6130	0,7826	1,2067	844,3	–0,3393
dew		–72,00	1,506	304,10	320,70	1,6696	0,6003	0,6951	137,34	78,70
bubble	0,0300	–69,10	1384,7	111,67	111,69	0,6304	0,7865	1,2091	827,9	–0,3346
dew		–69,09	1,786	305,67	322,47	1,6633	0,6077	0,7039	137,99	73,37
bubble	0,0400	–64,29	1370,4	117,49	117,52	0,6586	0,7926	1,2141	801,8	–0,3258
dew		–64,29	2,337	308,28	325,39	1,6538	0,6201	0,7186	139,00	65,80
bubble	0,0500	–60,37	1358,6	122,25	122,29	0,6812	0,7976	1,2191	781,2	–0,3176
dew		–60,37	2,880	310,41	327,77	1,6469	0,6304	0,7310	139,75	60,55
bubble	0,0600	–57,04	1348,5	126,32	126,36	0,7001	0,8017	1,2238	764,1	–0,3100
dew		–57,04	3,416	312,23	329,79	1,6415	0,6392	0,7418	140,33	56,62
bubble	0,0800	–51,53	1331,6	133,08	133,14	0,7310	0,8085	1,2326	736,3	–0,2960
dew		–51,53	4,474	315,25	333,13	1,6334	0,6540	0,7605	141,18	51,02
bubble	0,1000	–47,01	1317,6	138,65	138,73	0,7559	0,8141	1,2408	714,0	–0,2832
dew		–47,01	5,517	317,72	335,85	1,6276	0,6662	0,7764	141,76	47,13
bubble	0,1013[a]	–46,74	1316,8	138,99	139,07	0,7574	0,8145	1,2413	712,7	–0,2824
dew		–46,74	5,586	317,87	336,01	1,6273	0,6670	0,7774	141,79	46,91
bubble	0,1200	–43,16	1305,6	143,44	143,53	0,7769	0,8190	1,2483	695,2	–0,2712
dew		–43,16	6,551	319,83	338,15	1,6231	0,6769	0,7905	142,17	44,21
bubble	0,1400	–39,79	1294,9	147,65	147,76	0,7951	0,8232	1,2555	678,9	–0,2598
dew		–39,79	7,578	321,68	340,15	1,6195	0,6863	0,8033	142,47	41,91
bubble	0,1600	–36,77	1285,2	151,44	151,57	0,8113	0,8271	1,2622	664,3	–0,2488
dew		–36,77	8,599	323,33	341,93	1,6166	0,6948	0,8152	142,67	40,03
bubble	0,1800	–34,03	1276,4	154,90	155,04	0,8258	0,8306	1,2686	651,2	–0,2383
dew		–34,03	9,616	324,82	343,54	1,6141	0,7026	0,8262	142,82	38,45
bubble	0,2000	–31,52	1268,2	158,08	158,24	0,8390	0,8339	1,2748	639,2	–0,2280
dew		–31,51	10,631	326,19	345,00	1,6119	0,7098	0,8367	142,90	37,11
bubble	0,2500	–25,99	1249,8	165,14	165,34	0,8679	0,8411	1,2893	612,9	–0,2034
dew		–25,99	13,159	329,18	348,18	1,6077	0,7259	0,8607	142,96	34,44
bubble	0,3000	–21,26	1233,7	171,24	171,48	0,8924	0,8475	1,3029	590,5	–0,1797
dew		–21,25	15,682	331,72	350,85	1,6044	0,7399	0,8825	142,84	32,43
bubble	0,3500	–17,10	1219,3	176,66	176,95	0,9137	0,8532	1,3158	570,7	–0,1565
dew		–17,08	18,208	333,93	353,15	1,6019	0,7524	0,9028	142,60	30,85
bubble	0,4000	–13,36	1206,1	181,56	181,89	0,9327	0,8584	1,3282	553,0	–0,1337
dew		–13,35	20,741	335,90	355,18	1,5998	0,7637	0,9219	142,28	29,57
bubble	0,4500	–9,97	1193,8	186,05	186,43	0,9499	0,8633	1,3403	536,9	–0,1111
dew		–9,95	23,284	337,67	356,99	1,5980	0,7741	0,9401	141,89	28,49
bubble	0,5000	–6,85	1182,3	190,21	190,63	0,9657	0,8678	1,3520	522,0	–0,0884
dew		–6,83	25,841	339,28	358,63	1,5965	0,7836	0,9577	141,45	27,59
bubble	0,5500	–3,96	1171,5	194,10	194,57	0,9802	0,8720	1,3636	508,3	–0,0657
dew		–3,94	28,413	340,75	360,11	1,5951	0,7924	0,9747	140,98	26,81
bubble	0,6000	–1,26	1161,2	197,75	198,27	0,9937	0,8760	1,3751	495,3	–0,0427
dew		–1,24	31,003	342,11	361,47	1,5939	0,8007	0,9913	140,47	26,14

Annex A
(normative)

Requirements for implementations claiming conformance with this International Standard

Any computer program or other implementation of this International Standard shall satisfy the requirements specified in this annex before it can claim conformance to this International Standard. These requirements are to be carried out by the developer of the particular implementation.

A.1 Implementation of the specified equations of state

An algorithm conforms to this International Standard if it directly implements (for every refrigerant for which conformance is claimed) the equation of state specified in Clause 5 together with the methods of calculating the thermodynamic properties given in Annex B and is also demonstrated to reproduce the “verification values” for that(those) refrigerant(s) given in Annex D.

Since the properties enumerated in this International Standard have been computed using the equations of state specified in Clause 5, any other implementation of these equations should also yield the same values. The requirement for reproducing the “verification values” serves as a check on the implementation. These “verification values” span a wide range of temperature, pressure, and density and thus thoroughly test the implementation. The number of significant figures listed for these verification values far exceeds that warranted by the uncertainty of the experimental data and equation of state. The large number of significant figures serves to reveal any possible error in the implementation; if an implementation successfully reproduces the verification values (within ± 1 of the last digit listed), it is probably correct for all conditions.

A.2 Requirements of alternative implementations of the properties

An algorithm is conforming to this International Standard if, by any method, it reproduces the values of the thermodynamic properties specified in this International Standard for the fluids implemented. An algorithm claiming conformance under this section can be applicable to the full range of temperature, pressure, and density and to the full set of properties or to any subrange of conditions and/or subset of properties. Any algorithm shall state the fluid(s) for which it is applicable and its applicable property(ies) and range(s). The allowable variations between the property values specified in this International Standard and those of an alternative implementation vary from property to property and are the following:

– vapour pressure: ± 0,2 %;

– density: ± 0,2 %;

– internal energy: ± a constant value equal to 0,2 % of the internal energy of vapourisation at the normal boiling point temperature; see Note;

– enthalpy: ± a constant value equal to 0,2 % of the enthalpy of vapourisation at the normal boiling point temperature; see Note;

– entropy: ± a constant value equal to 0,2 % of the entropy of vapourisation at the normal boiling point temperature; see Note;

– C_v, C_p, speed of sound: ± 1,0 %;

– Joule–Thomson coefficient: ± 1,0 %.

NOTE The triple point temperature is used to determine the tolerances for R744 (carbon dioxide). The allowable tolerances for internal energy, enthalpy, and entropy are given in Table A.1.

An alternative implementation shall demonstrate that it meets the above tolerances over the full range of conditions for which it claims conformance. Properties are to be compared at a temperature interval of not less than 5 °C.

Table A.1 — Allowable tolerances for internal energy, enthalpy, and entropy for the fluids in this International Standard

	Allowable tolerances		
Fluid	**Internal Energy** kJ/kg	**Enthalpy** kJ/kg	**Entropy** kJ/(kg·K)
R744	± 0,63	± 0,70	± 0,003 2
R717	± 2,51	± 2,74	± 0,011 4
R12	± 0,30	± 0,33	± 0,001 4
R22	± 0,42	± 0,47	± 0,002 0
R32	± 0,70	± 0,76	± 0,003 4
R123	± 0,31	± 0,34	± 0,001 1
R125	± 0,30	± 0,33	± 0,001 5
R134a	± 0,40	± 0,43	± 0,001 8
R143a	± 0,41	± 0,45	± 0,002 0
R152a	± 0,60	± 0,66	± 0,002 6
R404A	± 0,37	± 0,40	± 0,001 8
R407C	± 0,45	± 0,50	± 0,002 1
R410A	± 0,50	± 0,55	± 0,002 5
R507A	± 0,36	± 0,39	± 0,001 7

Annex B
(informative)

Calculation of pure-fluid thermodynamic properties from an equation of state

Starting with an equation of state explicit in reduced Helmholtz energy, e.g. Equations (1) to (5), the thermodynamic properties are given by the following:

$$p = RT\rho\left(1 + \delta\left(\frac{\partial\varphi^{r}}{\partial\delta}\right)_{\tau}\right) \tag{B.1}$$

$$u = RT\left(\tau\left(\frac{\partial\varphi^{id}}{\partial\tau} + \frac{\partial\varphi^{r}}{\partial\tau}\right)_{\delta}\right) \tag{B.2}$$

$$h = RT\left(1 + \tau\left(\frac{\partial\varphi^{id}}{\partial\tau} + \frac{\partial\varphi^{r}}{\partial\tau}\right)_{\delta} + \delta\left(\frac{\partial\varphi^{r}}{\partial\delta}\right)_{\tau}\right) \tag{B.3}$$

$$s = R\left(\tau\left(\frac{\partial\varphi^{id}}{\partial\tau} + \frac{\partial\varphi^{r}}{\partial\tau}\right) - \varphi^{id} - \varphi^{r}\right) \tag{B.4}$$

$$g = RT\left(1 + \varphi^{r} + \delta\left(\frac{\partial\varphi^{r}}{\partial\delta}\right)_{\tau}\right) \tag{B.5}$$

$$C_v = R\left(-\tau^2\left(\frac{\partial^2\varphi^{id}}{\partial\tau^2}\right)_{\delta} - \tau^2\left(\frac{\partial^2\varphi^{r}}{\partial\tau^2}\right)_{\delta}\right) \tag{B.6}$$

Annex B
(informative)

Calculation of pure-fluid thermodynamic properties from an equation of state

Starting with an equation of state explicit in reduced Helmholtz energy, e.g. Equations (1) to (5), the thermodynamic properties are given by the following:

$$p = RT\rho\left(1 + \delta\left(\frac{\partial\varphi^{r}}{\partial\delta}\right)_{\tau}\right) \tag{B.1}$$

$$u = RT\left(\tau\left(\frac{\partial\varphi^{id}}{\partial\tau} + \frac{\partial\varphi^{r}}{\partial\tau}\right)_{\delta}\right) \tag{B.2}$$

$$h = RT\left(1 + \tau\left(\frac{\partial\varphi^{id}}{\partial\tau} + \frac{\partial\varphi^{r}}{\partial\tau}\right)_{\delta} + \delta\left(\frac{\partial\varphi^{r}}{\partial\delta}\right)_{\tau}\right) \tag{B.3}$$

$$s = R\left(\tau\left(\frac{\partial\varphi^{id}}{\partial\tau} + \frac{\partial\varphi^{r}}{\partial\tau}\right) - \varphi^{id} - \varphi^{r}\right) \tag{B.4}$$

$$g = RT\left(1 + \varphi^{r} + \delta\left(\frac{\partial\varphi^{r}}{\partial\delta}\right)_{\tau}\right) \tag{B.5}$$

$$C_v = R\left(-\tau^2\left(\frac{\partial^2\varphi^{id}}{\partial\tau^2}\right)_{\delta} - \tau^2\left(\frac{\partial^2\varphi^{r}}{\partial\tau^2}\right)_{\delta}\right) \tag{B.6}$$

The Joule-Thomson coefficient μ is given by

$$\mu = -\frac{1}{\left(\frac{\partial \varphi_r}{\partial \delta}\right)_\tau \left(\frac{\partial^2 \varphi_r}{\partial \delta^2}\right)_\tau - \left(\frac{\partial^2 \varphi_r}{\partial \delta \partial \tau}\right)^2} \times \frac{R\rho}{\left[1+\delta\left(\frac{\partial \varphi_r}{\partial \delta}\right)_\tau - \delta\tau\left(\frac{\partial^2 \varphi_r}{\partial \delta \partial \tau}\right)\right] + \left[-\tau^2\left(\frac{\partial^2 \varphi^{id}}{\partial \tau^2}\right) - \tau^2\left(\frac{\partial^2 \varphi_r}{\partial \tau^2}\right)\right]\left[1+2\delta\left(\frac{\partial \varphi_r}{\partial \delta}\right)_\tau + \delta^2\left(\frac{\partial^2 \varphi_r}{\partial \delta^2}\right)_\tau\right]} \tag{B.9}$$

The calculation of saturation properties for a pure fluid at a given reduced temperature, τ, involves an iteration to find the reduced liquid and vapour densities at saturation, δ_{liq} and δ_{vap}, which satisfy the Maxwell criteria:

$$p(\tau, \delta_{liq}) = p(\tau, \delta_{vap}) \tag{B.10}$$

and

$$g(\tau, \delta_{liq}) = g(\tau, \delta_{vap}) \quad . \tag{B.11}$$

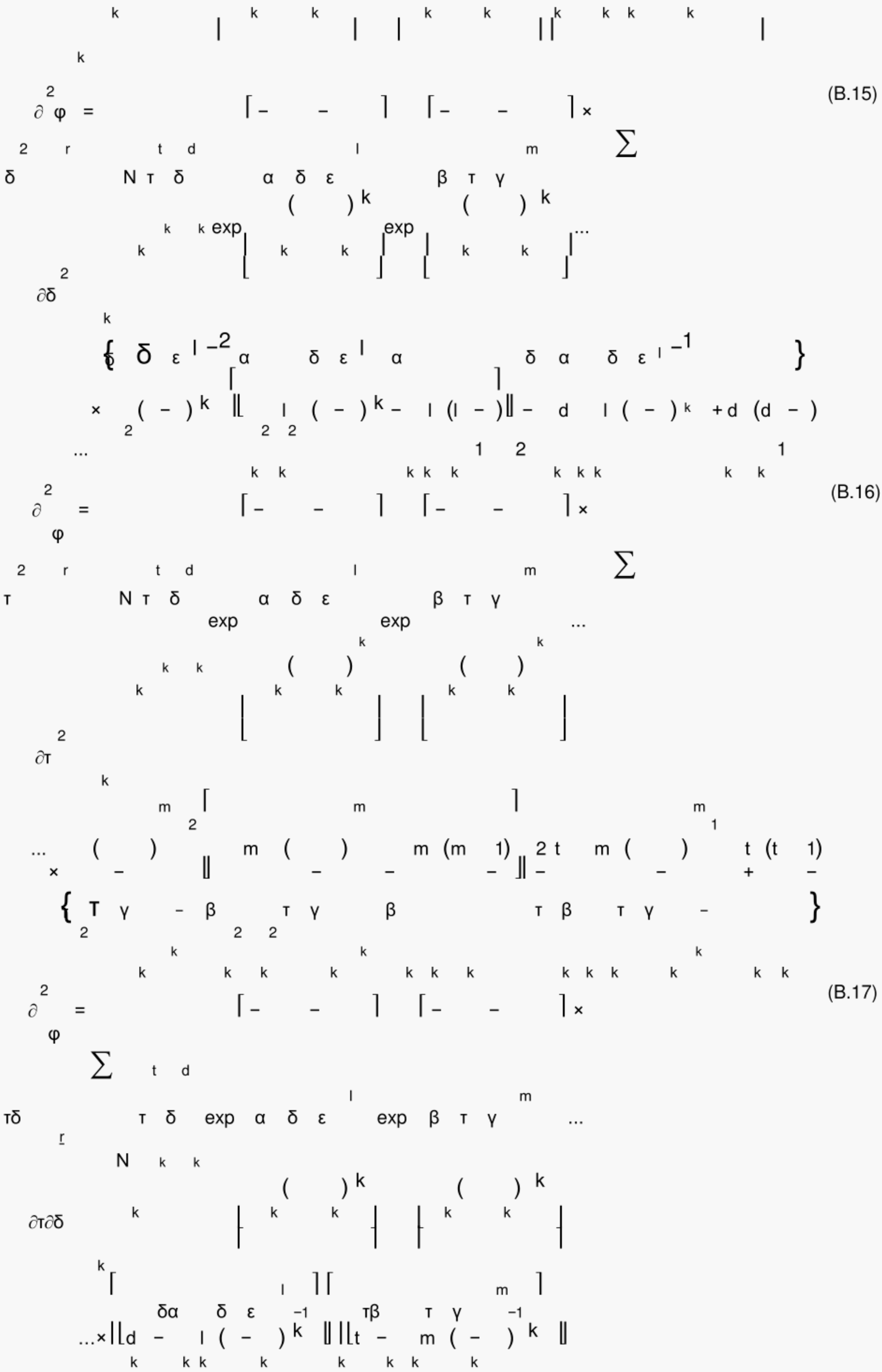
The pressure satisfying Equation (B.10) is the vapour pressure. The other thermodynamic properties are found using Equations (B.1) to (B.9) with inputs of τ, δ_{liq} and δ_{vap}.

The derivatives of the residual part of the reduced Helmholtz energy used in Equations (B.1) to (B.9) are given in terms of the coefficients and exponents of the equation of state by the following:

$$\varphi_r = \sum_{k}^{N} N_k \tau^{t_k} \delta^{d_k} \exp\left[-\alpha_k (\delta - \varepsilon_k)^{l_k}\right] \exp\left[-\beta_k (\tau - \gamma_k)^{m_k}\right] , \tag{B.12}$$

$$\left(\frac{\partial \varphi_r}{\partial \delta}\right)_\tau = \sum_{k}^{N} N_k \tau^{t_k} \delta^{d_k} \exp\left[-\alpha_k (\delta - \varepsilon_k)^{l_k}\right] \exp\left[-\beta_k (\tau - \gamma_k)^{m_k}\right] \left[d_k \delta^{d_k - 1} - \alpha_k l_k (\delta - \varepsilon_k)^{l_k - 1}\right] \tag{B.13}$$

$$\left(\frac{\partial \varphi_r}{\partial \tau}\right)_\delta = \sum_{k}^{N} N_k \tau^{t_k} \delta^{d_k} \exp\left[-\alpha_k (\delta - \varepsilon_k)^{l_k}\right] \exp\left[-\beta_k (\tau - \gamma_k)^{m_k}\right] \left[t_k \tau^{t_k - 1} - \beta_k m_k (\tau - \gamma_k)^{m_k - 1}\right] \tag{B.14}$$

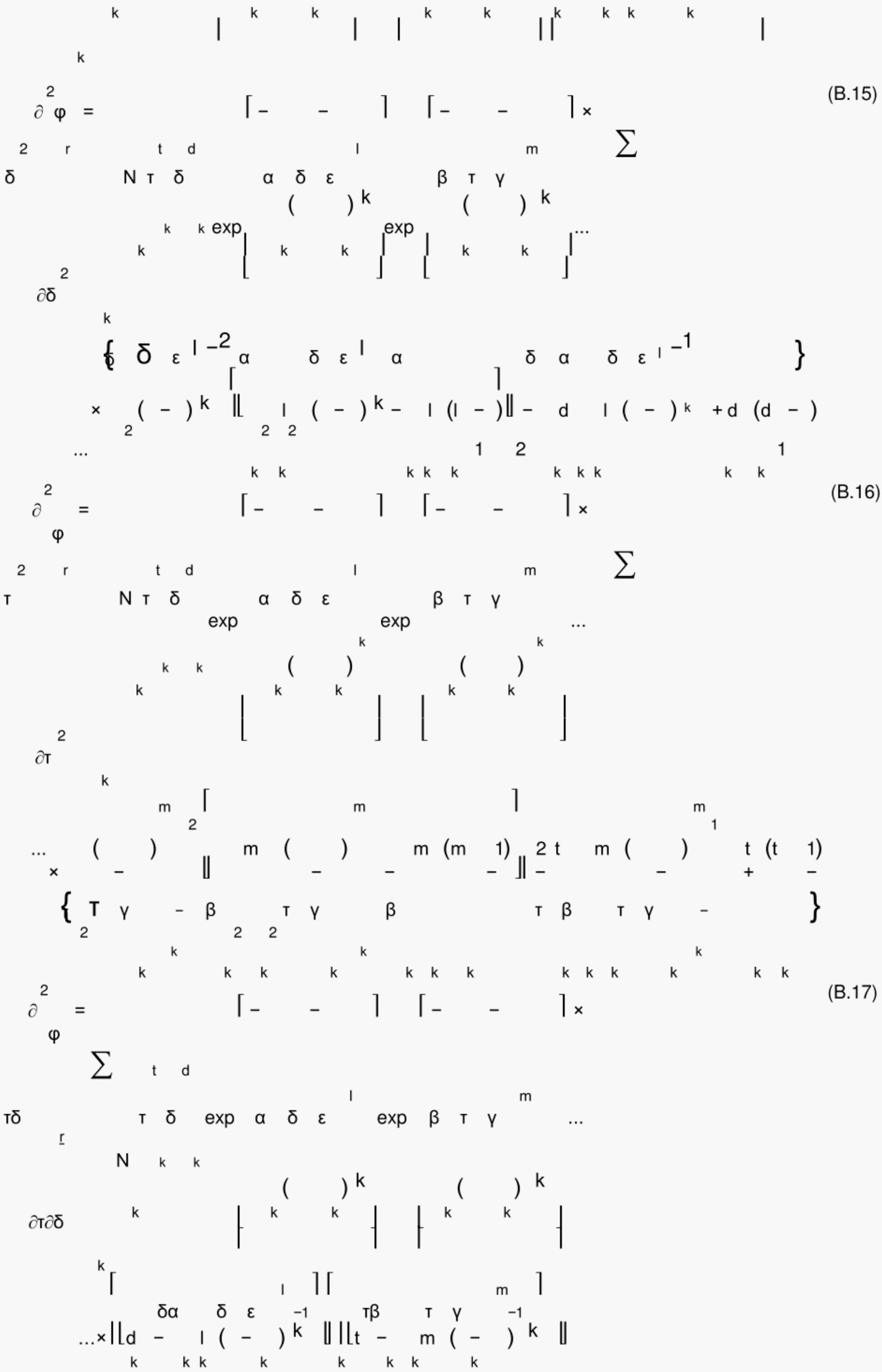


(B.15)

(B.16)

(B.17)

For the derivatives of the critical region terms [Equations (9) to (12)], see Table 32 in Span and Wagner[9].



(B.15)

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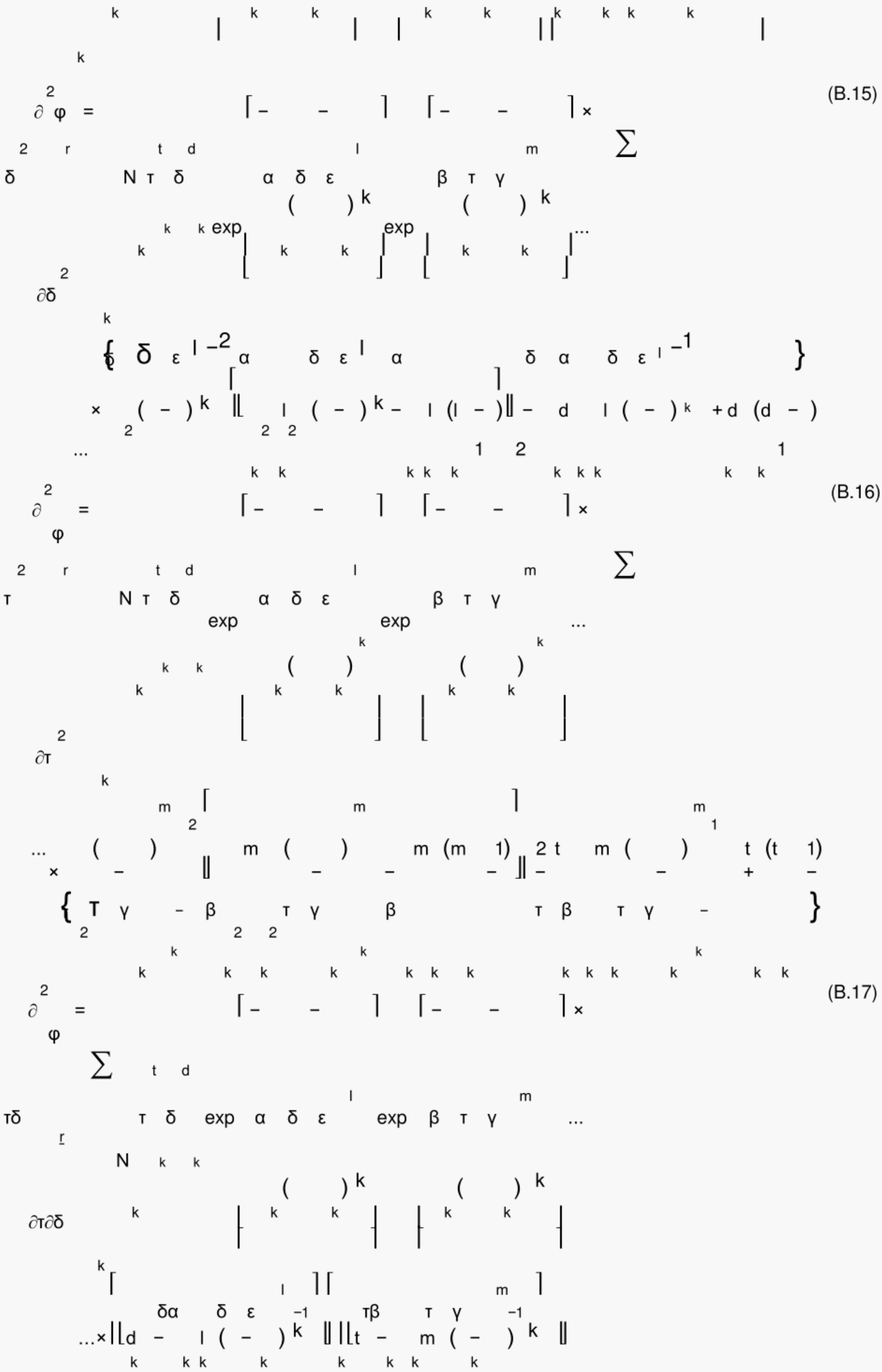
For the derivatives of the critical region terms [Equations (9) to (12)], see Table 32 in Span and Wagner[9].



(B.15)

(B.16)

(B.17)

For the derivatives of the critical region terms [Equations (9) to (12)], see Table 32 in Span and Wagner[9].

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Annex C
(informative)

Calculation of mixture thermodynamic properties from an equation of state

Starting with the mixture equation of state explicit in reduced Helmholtz energy, Equations (16) to (21), the thermodynamic properties of mixtures are given by the same expressions as for pure fluids [Equations (B.1) to (B.20)], except that the derivatives of the residual part are composed of contributions from the pure components and the excess function.

$$\varphi = \varphi^{\mathrm{mix,r}} + \varphi^{\mathrm{excess}} \qquad \text{(C.1)}$$

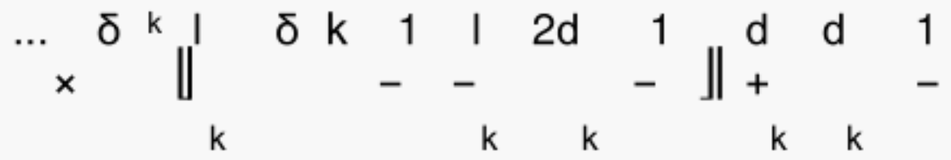
$$\varphi^{\mathrm{mix,r}} = \sum_{i=1}^{n} x_i \varphi_{i,r}$$

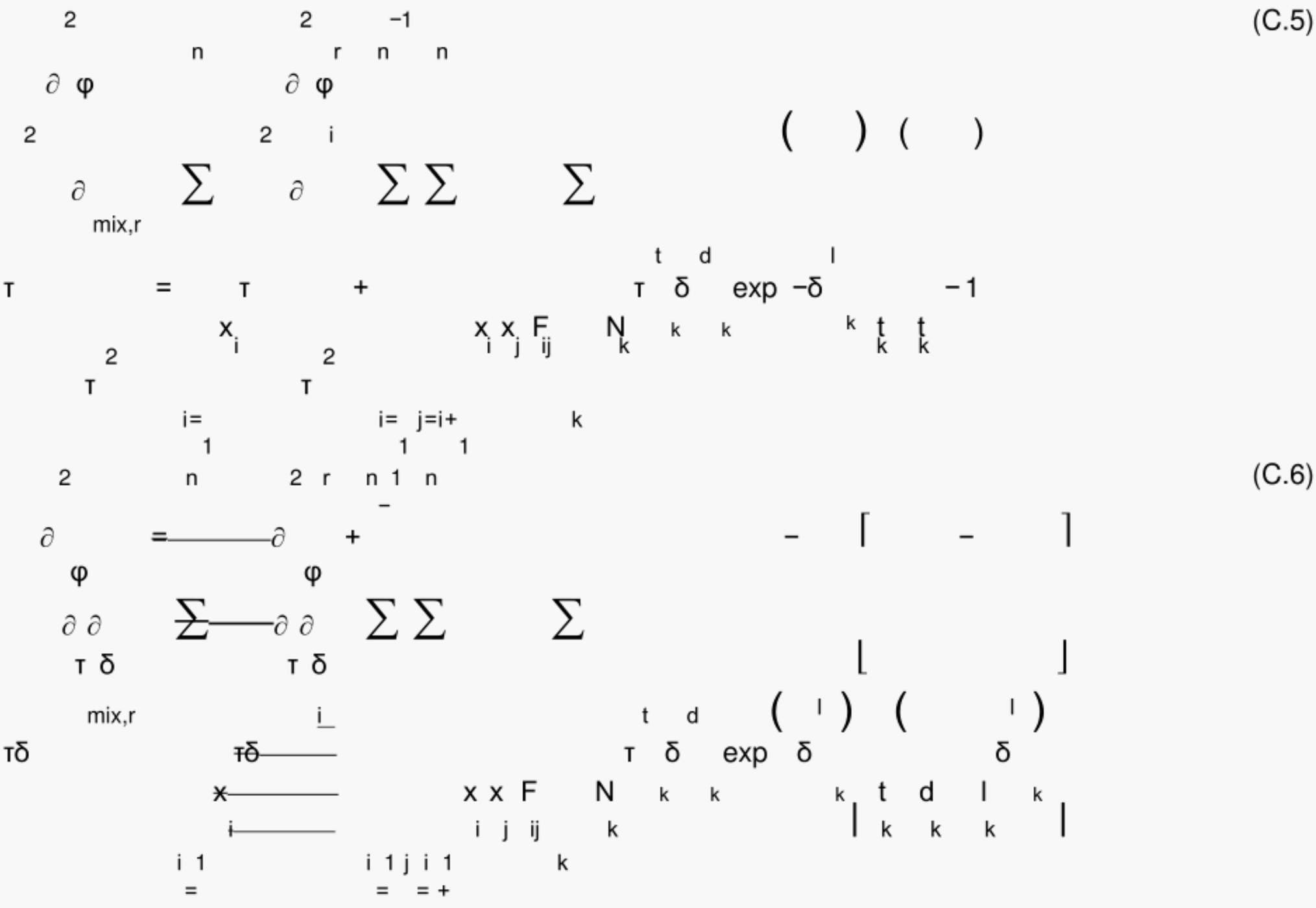
$$\varphi^{\mathrm{excess}} = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} x_i x_j F_{ij} \varphi_{ij}^{\mathrm{excess}}$$

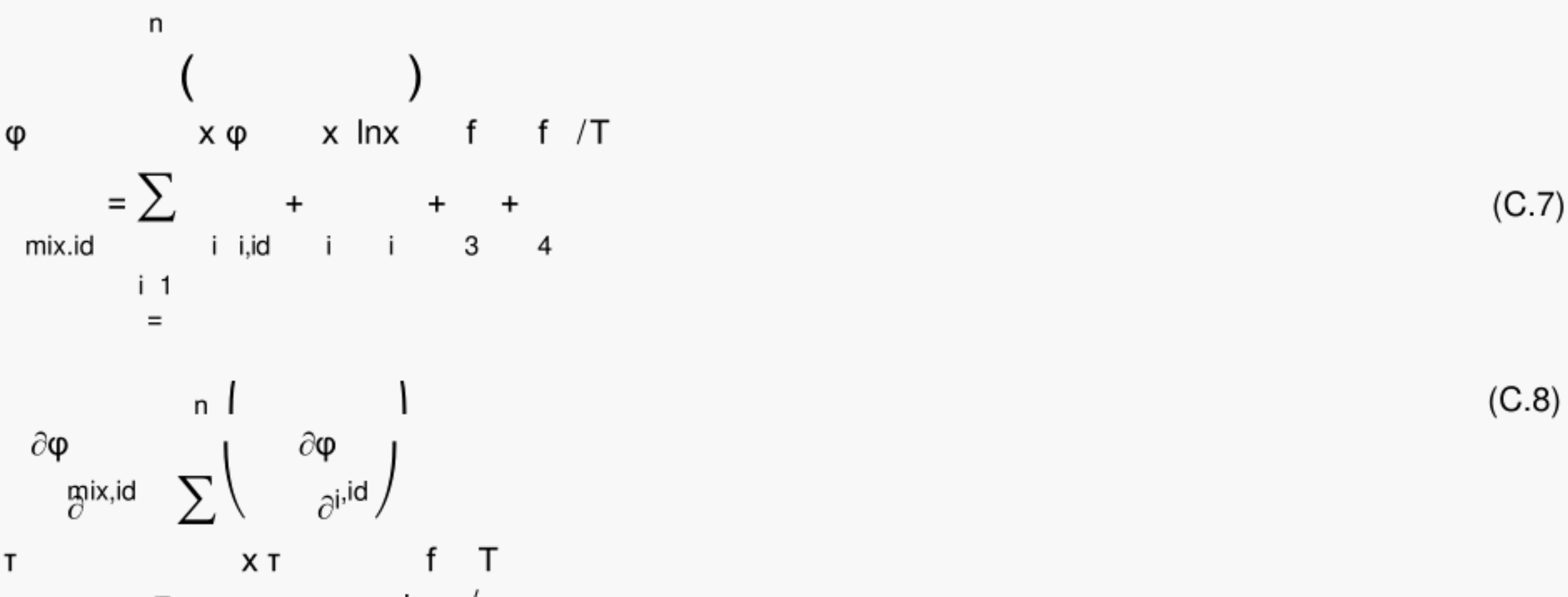
$$\frac{\partial \varphi^{\mathrm{mix,r}}}{\partial \delta} = \sum_{i=1}^{n} x_i \frac{\partial \varphi_{i,r}}{\partial \delta} + \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} x_i x_j F_{ij} \frac{\partial \varphi_{ij}^{\mathrm{excess}}}{\partial \delta} \qquad \text{(C.2)}$$

$$\frac{\partial \varphi^{\mathrm{mix,r}}}{\partial \tau} = \sum_{i=1}^{n} x_i \frac{\partial \varphi_{i,r}}{\partial \tau} + \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} x_i x_j F_{ij} \frac{\partial \varphi_{ij}^{\mathrm{excess}}}{\partial \tau} \qquad \text{(C.3)}$$

$$\frac{\partial^2 \varphi^{\mathrm{mix,r}}}{\partial \delta^2} = \sum_{i=1}^{n} x_i \frac{\partial^2 \varphi_{i,r}}{\partial \delta^2} + \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} x_i x_j F_{ij} \frac{\partial^2 \varphi_{ij}^{\mathrm{excess}}}{\partial \delta^2} \qquad \text{(C.4)}$$







The derivatives of the ideal-gas part of the reduced Helmholtz energy in Equations (B.1) to (B.9) as applied to mixtures are simply summations of the pure component ideal-gas derivatives.

(C.7)

(C.8)

(C.9)

i 1

The calculation of properties at liquid-vapour equilibrium involves an iteration to find the reduced liquid and vapour densities δ_{liq} and δ_{vap}, and liquid and vapour compositions $x_{liq,i}$ and $x_{vap,i}$ which satisfy the following system of equations:

$$p(\tau, \delta_{liq}) = p(\tau, \delta_{vap}) \tag{C.10}$$

and

$$f_{liq,i}(x_{liq,i}, \tau, \delta_{liq}) = f_{vap,i}(x_{vap,i}, \tau, \delta_{vap}), \quad \text{for } i = 1 \text{"} n \tag{C.11}$$

The fugacity, f, for component i is given by

$$f_i = x_i \rho RT \exp\left[\left(\frac{\partial (n\varphi_{mix,r})}{\partial n_i}\right)_{T,V,n_j}\right] \tag{C.12}$$

where n_i is the number of molecules of component i in the blend, and the derivative is taken holding constant the temperature, total volume (not molar volume), and the number of molecules of the other components.

In solving Equations (C.10) and (C.11) either the liquid compositions or vapour compositions are known, corresponding to the bubble or dew point, respectively. The pressure satisfying Equation (C.10) is then the bubble point or dew point pressure. The other thermodynamic properties are found using Equations (B.1) to (B.9) with inputs of τ, $x_{liq,i}$, $x_{vap,i}$, δ_{liq}, and δ_{vap}.

Equations of state for mixtures of R–32, R–125, R–134a, R–143a, and R–152a are provided in Lemmon and Jacobsen[2].

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Annex D
(informative)

Literature citations for equations of state and verification values

D.1 General

The equations of state specified in Clause 5 of this International Standard are drawn from the scientific literature. Literature citations for these equations are given here. Also given are “verification values” spanning a wide range of temperature, pressure, and density which may be used to test an implementation of any of these equations. The number of significant figures listed for these verification values far exceeds that warranted by the uncertainty of the experimental data and equation of state. The large number of significant figures serves to reveal any possible error in the implementation; if an implementation successfully reproduces the verification values (within ± 1 of the last digit listed), it will probably be correct for all conditions.

D.2 R744 — Carbon dioxide

Values for the equation of state given for R744 in Table D.1 are taken from Span and Wagner [9].

Table D.1 — R744 property values in the single-phase region to serve as verification values for the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
240,000 0	0,000 100 0	$0{,}199\,544\,2 \times 10^{-3}$	20 223,66	164,594 9	26,028 3	34,343 6	244,590 9
240,000 0	28,400 000 0	$0{,}931\,599\,9 \times 10^{2}$	6 984,40	23,429 4	44,030 8	74,474 3	1 243,448 2
304,128 2	1,000 000 0	$0{,}224\,327\,6 \times 10^{1}$	21 562,39	93,261 7	31,641 2	45,813 9	254,563 5
304,128 2	25,400 000 0	$0{,}980\,899\,4 \times 10^{2}$	11 733,78	40,308 2	41,459 9	71,077 9	1 039,393 7
500,000 0	0,000 100 0	$0{,}415\,724\,2 \times 10^{-3}$	30 611,70	187,354 3	36,317 7	44,632 4	340,716 6
500,000 0	17,400 000 0	$0{,}982\,411\,0 \times 10^{2}$	250 16,27	74,135 2	41,249 1	64,713 5	698,279 9

D.3 R717 — Ammonia

Values for the equation of state given for R717 in Table D.2 are taken from Tillner-Roth *et al.* [11].

Table D.2 — R717 property values in the single-phase region to serve as verification values for the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
220,000 0	0,000 100 0	$0{,}182\,905\,5 \times 10^{-3}$	23 716,39	154,617 7	26,007 3	34,326 3	376,489 4
220,000 0	43,400 000 0	$0{,}956\,616\,5 \times 10^{2}$	902,15	− 2,603 9	51,353 5	69,616 3	2 121,501 6
405,400 0	1,000 000 0	$0{,}301\,572\,0 \times 10^{1}$	29 117,16	93,477 5	34,570 9	48,925 6	471,553 5
405,400 0	32,600 000 0	$0{,}964\,576\,4 \times 10^{2}$	14 385,54	41,679 6	46,491 0	73,980 9	1 342,495 0
500,000 0	0,000 100 0	$0{,}415\,720\,9 \times 10^{-3}$	34 249,99	178,237 3	33,851 0	42,165 8	551,420 8
500,000 0	27,000 000 0	$0{,}991\,883\,4 \times 10^{2}$	21 471,86	57,182 1	45,985 3	75,616 5	1 077,241 8

D.4 R12 — Dichlorodifluoromethane

Values for the equation of state given for R12 in Table D.3 are taken from Marx *et al.* [6].

Table D.3 — R12 property values in the single-phase region to serve as verification values for the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
180,000 0	0,000 100 0	$0{,}149\,638\,2 \times 10^{-3}$	37 392,20	227,478 3	47,116 8	55,437 7	120,661 1
180,000 0	14,600 000 0	$0{,}895\,352\,6 \times 10^{2}$	19 212,75	69,146 9	67,463 7	96,414 2	1 252,438 9
385,120 0	1,000 000 0	$0{,}243\,271\,2 \times 10^{1}$	49 176,11	193,993 0	78,027 3	104,700 0	138,816 8
385,120 0	11,800 000 0	$0{,}977\,220\,6 \times 10^{2}$	40 641,90	145,718 7	81,564 6	108,273 8	832,271 1
500,000 0	0,000 100 0	$0{,}415\,717\,7 \times 10^{-3}$	61 666,26	293,496 3	81,414 0	89,729 1	194,660 1
500,000 0	10,400 000 0	$0{,}943\,040\,9 \times 10^{2}$	53 169,03	174,861 4	87,743 4	112,258 7	689,532 0

D.5 R22 — Chlorodifluoromethane

Values for the equation of state given for R22 in Table D.4 are taken from Kamei *et al.* [1].

Table D.4 — R22 property values in the single-phase region to serve as verification values for the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
180,000 0	0,000 100 0	$0{,}149\,641\,9 \times 10^{-3}$	31 345,16	200,950 5	35,259 6	43,580 0	146,243 1
180,000 0	18,600 000 0	$0{,}484\,127\,4 \times 10^{2}$	10 391,89	43,195 4	59,630 7	89,533 5	1 232,788 5
369,295 0	1,000 000 0	$0{,}246\,504\,9 \times 10^{1}$	39 359,61	153,643 1	60,038 8	82,135 7	173,670 3
369,295 0	14,000 000 0	$0{,}541\,600\,9 \times 10^{2}$	27 889,80	107,976 8	65,027 7	96,605v8	696,174 8
500,000 0	0,000 100 0	$0{,}415\,721\,5 \times 10^{-3}$	50 457,59	250,843 5	65,237 9	73,552 8	232,820 6
500,000 0	11,200 000 0	$0{,}574\,566\,1 \times 10^{2}$	40 884,41	137,468 9	72,690 5	100,321 9	519,184 8

D.6 R32 — Difluoromethane

Values for the equation of state given for R32 in Table D.5 are taken from Tillner-Roth and Yokozeki [13].

Table D.5 — R32 property values in the single-phase region to serve as verification values for the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
180,000 0	0,000 100 0	$0{,}149\,637\,2 \times 10^{-3}$	24 642,56	171,613 4	27,520 4	35,845 3	193,540 8
180,000 0	26,600 000 0	$0{,}678\,660\,9 \times 10^{2}$	4 407,98	12,952 9	52,025 2	78,243 0	1 411,750 0
351,255 0	1,000 000 0	$0{,}240\,080\,6 \times 10^{1}$	29 728,57	113,970 5	45,166 1	65,591 7	232,189 3
351,255 0	20,000 000 0	$0{,}657\,835\,9 \times 10^{2}$	17 751,81	65,274 6	52,263 8	81,082 4	824,899 9
420,000 0	0,000 100 0	$0{,}349\,203\,5 \times 10^{-3}$	35 093,81	200,438 5	44,711 9	53,026 9	282,144 4
420,000 0	17,600 000 0	$0{,}682\,732\,6 \times 10^{2}$	23 463,30	79,773 2	56,027 4	84,070 4	690,619 9

D.7 R123 — 2,2–dichloro–1,1,1–trifluoroethane

Values for the equation of state given for R123 in Table D.6 are taken from Younglove and McLinden [14]. This equation has been transformed from the MBWR form of the original reference to a Helmholtz energy form by the application of Equation (15).

Table D.6 — R123 property values in the single-phase region to serve as verification values for the implementation of the equation of state

Temperature K	Density mol/l	Pressure MPa	Enthalpy J/mol	Entropy J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	Sound speed m/s
200,000 0	0,000 100 0	$0{,}166\,236\,1 \times 10^{-3}$	51 932,59	271,015 4	72,941 1	81,272 2	110,034 5
200,000 0	11,200 000 0	$0{,}159\,802\,9 \times 10^{2}$	20 989,93	105,753 9	99,537 8	140,695 5	1 125,084 1
456,831 0	1,000 000 0	$0{,}260\,763\,8 \times 10^{1}$	74 932,17	268,877 9	128,403 8	172,820 8	118,162 1
456,831 0	8,200 000 0	$0{,}392\,310\,8 \times 10^{2}$	61 611,27	227,466 5	127,039 2	163,828 4	556,202 0
500,000 0	0,000 100 0	$0{,}415\,713\,8 \times 10^{-3}$	84 983,25	360,763 3	124,235 6	132,551 4	170,299 1
500,000 0	7,600 000 0	$0{,}370\,207\,1 \times 10^{2}$	68 699,97	242,875 3	130,455 4	167,894 8	484,679 8

D.8 R125 — Pentafluoroethane

Values for the equation of state given for R125 in Table D.7 are taken from Lemmon and Jacobsen [3].

Table D.7 — R125 property values in the single-phase region to serve as verification values for the implementation of the equation of state

Temperature K	Density mol/l	Pressure MPa	Enthalpy J/mol	Entropy J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	Sound speed m/s
200,000 0	0,000 100 0	$0{,}166\,272\,1 \times 10^{-3}$	35 264,67	225,586 9	65,917 0	74,236 2	124,901 3
200,000 0	14,000 000 0	$0{,}423\,025\,2 \times 10^{2}$	15 906,32	71,935 4	85,816 3	123,536 4	968,671 9
339,173 0	1,000 000 0	$0{,}213\,324\,3 \times 10^{1}$	45 066,59	187,464 2	101,757 7	131,702 5	127,877 5
339,173 0	11,400 000 0	$0{,}549\,441\,7 \times 10^{2}$	34 771,90	139,417 8	105,116 8	139,137 3	635,452 7
500,000 0	0,000 100 0	$0{,}415\,719\,7 \times 10^{-3}$	66 051,40	308,359 7	117,595 0	125,910 0	192,577 1
500,000 0	8,800 000 0	$0{,}576\,070\,8 \times 10^{2}$	58 381,94	195,593 0	124,570 9	152,147 8	460,407 1

D.9 R134a — 1,1,1,2–tetrafluoroethane

Values for the equation of state given for R134a in Table D.8 are taken from Tillner-Roth and Baehr [10].

Table D.8 — R134a property values in the single-phase region to serve as verification values for the implementation of the equation of state

Temperature K	Density mol/l	Pressure MPa	Enthalpy J/mol	Entropy J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	Sound speed m/s
200,000 0	0,000 100 0	$0{,}166\,262\,5 \times 10^{-3}$	36 070,67	217,719 5	57,594 2	65,918 6	136,555 3
200,000 0	15,500 000 0	$0{,}554\,122\,4 \times 10^{2}$	13 479,24	56,317 0	83,680 6	119,279 6	1 162,988 5
374,210 0	1,000 00 0	$0{,}234\,989\,9 \times 10^{1}$	47 594,85	183,166 9	98,683 0	129,206 5	146,495 0
374,210 0	12,200 000 0	$0{,}631\,710\,1 \times 10^{2}$	35 940,48	134,577 7	102,190 3	135,280 3	711,790 0
440,000 0	0,000 100 0	$0{,}365\,830\,3 \times 10^{-3}$	57 297,93	278,689 3	100,598 0	108,913 2	197,021 5
440,000 0	11,200 000 0	$0{,}685\,725\,9 \times 10^{2}$	45 217,73	156,266 6	110,055 3	141,253 6	634,823 3

D.10 R143a — 1,1,1–trifluoroethane

Values for the equation of state given for R143a in Table D.9 are taken from Lemmon and Jacobsen [4].

Table D.9 — R143a property values in the single-phase region to serve as verification values for the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
200,000 0	0,000 100 0	$0{,}166\,266\,2 \times 10^{-3}$	29 045,32	193,149 5	51,532 1	59,855 6	151,579 2
200,000 0	15,800 000 0	$0{,}648\,278\,0 \times 10^{2}$	11 245,14	41,576 0	71,010 3	101,123 0	1 142,182 1
345,857 0	1,000 000 0	$0{,}215\,875\,6 \times 10^{1}$	37 147,53	148,319 0	85,392 2	114,327 8	156,365 6
345,857 0	13,400 000 0	$0{,}901\,458\,6 \times 10^{2}$	28 271,15	98,620 6	90,157 5	116,496 8	879,874 8
500,000 0	0,000 100 0	$0{,}415\,719\,3 \times 10^{-3}$	54 741,98	260,681 0	99,013 5	107,328 6	231,559 5
500,000 0	11,400 000 0	$0{,}987\,330\,5 \times 10^{2}$	47 616,64	143,077 0	108,177 9	129,232 3	717,998 8

D.11 R152a — 1,1–difluoroethane

Values for the equation of state given for R152a in Table D.10 are taken from Outcalt and McLinden [8].

NOTE This equation has been transformed from the MBWR form of the original reference to a Helmholtz energy form.

Table D.10 — R152a property values in the single-phase region to serve as verification values for the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
180,000 0	0,000 100 0	$0{,}149\,627\,0 \times 10^{-3}$	28 915,19	180,944 2	41,424 2	49,750 4	164,925 6
180,000 0	18,000 000 0	$0{,}524\,530\,1 \times 10^{2}$	5 642,67	18,301 2	69,808 3	98,156 5	1 419,016 1
386,411 0	1,000 000 0	$0{,}245\,931\,5 \times 10^{1}$	39 592,51	143,147 8	80,071 0	107,439 1	191,098 5
386,411 0	13,400 000 0	$0{,}542\,090\,6 \times 10^{2}$	27 384,42	97,523 8	84,898 9	114,566 1	768,672 1
500,000 0	0,000 100 0	$0{,}415\,718\,1 \times 10^{-3}$	52 482,90	243,606 9	88,282 7	96,597 9	262,423 5
500,000 0	11,200 000 0	$0{,}578\,693\,2 \times 10^{2}$	41 011,44	127,717 0	95,800 3	123,574 6	602,256 5

D.12 R404A — R125/143a/134a (44/52/4)

Values for the equation of state given for R404A in Table D.11 are taken from Lemmon and Jacobsen [2].

Table D.11 — R404A property values in the single-phase region to serve as verification values for the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
200,000 0	0,000 100 0	$0{,}166\,267\,3 \times 10^{-3}$	31 684,93	206,060 1	56,912 8	65,235 3	139,726 2
200,000 0	15,000 000 0	$0{,}478\,096\,4 \times 10^{2}$	12 470,14	53,110 6	80,737 7	115,335 2	1 048,161 2
345,000 0	1,000 000 0	$0{,}215\,478\,7 \times 10^{1}$	40 558,17	164,163 3	92,158 0	121,829 8	143,863 8
345,000 0	5,800 000 0	$0{,}371\,587\,1 \times 10^{1}$	32 697,30	138,571 8	116,954 3	5 684,144 8	90,288 0
345,000 0	12,200 000 0	$0{,}589\,688\,7 \times 10^{2}$	30 313,09	116,835 7	96,128 2	126,538 8	698,246 4
440,000 0	0,000 100 0	$0{,}365\,313 \times 10^{-3}$	52 653,79	266,237 5	98,412 5	106,727 6	201,612 4
440,000 0	10,400 000 0	$0{,}570\,197\,1 \times 10^{2}$	42 711,70	148,976 5	107,399 7	135,438 2	546,926 9

D.13 R407C — R32/125/134a (23/25/52)

Values for the equation of state given for R407C in Table D.12 are taken from Lemmon and Jacobsen [2].

Table D.12 — R407C property values in the single-phase region to serve as verification values or the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
200,000 0	0,000 100 0	$0{,}166\,267\,5 \times 10^{-3}$	31 774,36	202,629 9	47,967 2	56,289 6	150,436 8
200,000 0	17,900 000 0	$0{,}553\,926\,9 \times 10^{2}$	10 927,61	45,265 7	73,513 9	107,094 6	1 152,133 7
355,000 0	1,000 000 0	$0{,}229\,640\,0 \times 10^{1}$	39 788,21	156,305 1	78,767 3	105,478 7	162,875 9
355,000 0	8,400 000 0	$0{,}435\,213\,7 \times 10^{1}$	29 746,16	124,669 9	96,528 3	468,523 2	137,917 1
355,000 0	14,000 000 0	$0{,}557\,344\,0 \times 10^{2}$	28 020,22	108,209 6	83,118 0	115,842 8	696,432 9
420,000 0	0,000 100 0	$0{,}349\,202\,3 \times 10^{-3}$	47 657,20	248,603 3	79,036 1	87,351 3	211,589 6
420,000 0	12,600 000 0	$0{,}594\,362\,1 \times 10^{2}$	35 796,97	127,595 2	89,326 4	120,705 6	598,869 6

D.14 R410A — R32/125 (50/50)

Values for the equation of state given for R410A in Table D.13 are taken from Lemmon and Jacobsen [2].

Table D.13 — R410A property values in the single-phase region to serve as verification values for the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
200,000 0	0,000 100 0	$0{,}166\,271\,3 \times 10^{-3}$	28 272,46	189,950 0	39,755 4	48,076 4	166,428 6
200,000 0	20,600 000 0	$0{,}560\,445\,5 \times 10^{2}$	8 824,58	35,989 8	63,515 5	93,716 8	1 137,248 4
340,000 0	1,000 000 0	$0{,}225\,047\,7 \times 10^{1}$	33 876,54	135,158 5	62,914 7	86,967 5	181,537 7
340,000 0	10,000 000 0	$0{,}450\,682\,3 \times 10^{1}$	23 770,26	101,635 1	81,639 8	397,059 8	156,705 1
340,000 0	16,200 000 0	$0{,}550\,240\,0 \times 10^{2}$	22 189,48	86,707 0	68,183 8	99,824 3	714,199 4
420,000 0	0,000 100 0	$0{,}349\,203\,3 \times 10^{-3}$	41 445,78	227,114 4	63,514 0	71,829 1	233,252 9
420,000 0	14,000 000 0	$0{,}592\,175\,4 \times 10^{2}$	30 450,19	107,776 3	74,125 2	104,685 5	584,444 2

D.15 R507A [R125/143a (50/50)]

Values for the equation of state given for R507A in Table D.14 are taken from Lemmon and Jacobsen [2].

Table D.14 — R507A property values in the single-phase region to serve as verification values for the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
200,000 0	0,000 100 0	$0{,}166\,267\,7 \times 10^{-3}$	31 767,48	206,895 2	57,458 0	65,780 3	138,752 2
200,000 0	14,900 000 0	$0{,}460\,896\,0 \times 10^{2}$	12 596,27	54,278 6	80,934 3	115,808 8	1035,313 1
340,000 0	1,000 000 0	$0{,}210\,473\,4 \times 10^{1}$	40 236,28	164,010 0	92,395 7	123,280 7	140,846 5
340,000 0	7,200 000 0	$0{,}343\,922\,5 \times 10^{1}$	31 045,65	134,438 7	106,760 9	474,594 0	124,120 2
340,000 0	12,200 000 0	$0{,}579\,585\,8 \times 10^{2}$	29 927,83	116,390 8	96,028 5	126,730 6	697,265 1
500,000 0	0,000 100 0	$0{,}415\,719\,4 \times 10^{-3}$	59 560,49	280,703 9	106,666 1	114,981 1	212,906 8
500,000 0	9,400 000 0	$0{,}577\,036\,1 \times 10^{2}$	51 358,49	167,937 2	114,301 5	140,078 1	493,140 6

D.13 R407C — R32/125/134a (23/25/52)

Values for the equation of state given for R407C in Table D.12 are taken from Lemmon and Jacobsen [2].

Table D.12 — R407C property values in the single-phase region to serve as verification values or the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
200,000 0	0,000 100 0	$0{,}166\,267\,5 \times 10^{-3}$	31 774,36	202,629 9	47,967 2	56,289 6	150,436 8
200,000 0	17,900 000 0	$0{,}553\,926\,9 \times 10^{2}$	10 927,61	45,265 7	73,513 9	107,094 6	1 152,133 7
355,000 0	1,000 000 0	$0{,}229\,640\,0 \times 10^{1}$	39 788,21	156,305 1	78,767 3	105,478 7	162,875 9
355,000 0	8,400 000 0	$0{,}435\,213\,7 \times 10^{1}$	29 746,16	124,669 9	96,528 3	468,523 2	137,917 1
355,000 0	14,000 000 0	$0{,}557\,344\,0 \times 10^{2}$	28 020,22	108,209 6	83,118 0	115,842 8	696,432 9
420,000 0	0,000 100 0	$0{,}349\,202\,3 \times 10^{-3}$	47 657,20	248,603 3	79,036 1	87,351 3	211,589 6
420,000 0	12,600 000 0	$0{,}594\,362\,1 \times 10^{2}$	35 796,97	127,595 2	89,326 4	120,705 6	598,869 6

D.14 R410A — R32/125 (50/50)

Values for the equation of state given for R410A in Table D.13 are taken from Lemmon and Jacobsen [2].

Table D.13 — R410A property values in the single-phase region to serve as verification values for the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
200,000 0	0,000 100 0	$0{,}166\,271\,3 \times 10^{-3}$	28 272,46	189,950 0	39,755 4	48,076 4	166,428 6
200,000 0	20,600 000 0	$0{,}560\,445\,5 \times 10^{2}$	8 824,58	35,989 8	63,515 5	93,716 8	1 137,248 4
340,000 0	1,000 000 0	$0{,}225\,047\,7 \times 10^{1}$	33 876,54	135,158 5	62,914 7	86,967 5	181,537 7
340,000 0	10,000 000 0	$0{,}450\,682\,3 \times 10^{1}$	23 770,26	101,635 1	81,639 8	397,059 8	156,705 1
340,000 0	16,200 000 0	$0{,}550\,240\,0 \times 10^{2}$	22 189,48	86,707 0	68,183 8	99,824 3	714,199 4
420,000 0	0,000 100 0	$0{,}349\,203\,3 \times 10^{-3}$	41 445,78	227,114 4	63,514 0	71,829 1	233,252 9
420,000 0	14,000 000 0	$0{,}592\,175\,4 \times 10^{2}$	30 450,19	107,776 3	74,125 2	104,685 5	584,444 2

D.15 R507A [R125/143a (50/50)]

Values for the equation of state given for R507A in Table D.14 are taken from Lemmon and Jacobsen [2].

Table D.14 — R507A property values in the single-phase region to serve as verification values for the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
200,000 0	0,000 100 0	$0{,}166\,267\,7 \times 10^{-3}$	31 767,48	206,895 2	57,458 0	65,780 3	138,752 2
200,000 0	14,900 000 0	$0{,}460\,896\,0 \times 10^{2}$	12 596,27	54,278 6	80,934 3	115,808 8	1035,313 1
340,000 0	1,000 000 0	$0{,}210\,473\,4 \times 10^{1}$	40 236,28	164,010 0	92,395 7	123,280 7	140,846 5
340,000 0	7,200 000 0	$0{,}343\,922\,5 \times 10^{1}$	31 045,65	134,438 7	106,760 9	474,594 0	124,120 2
340,000 0	12,200 000 0	$0{,}579\,585\,8 \times 10^{2}$	29 927,83	116,390 8	96,028 5	126,730 6	697,265 1
500,000 0	0,000 100 0	$0{,}415\,719\,4 \times 10^{-3}$	59 560,49	280,703 9	106,666 1	114,981 1	212,906 8
500,000 0	9,400 000 0	$0{,}577\,036\,1 \times 10^{2}$	51 358,49	167,937 2	114,301 5	140,078 1	493,140 6

D.13 R407C — R32/125/134a (23/25/52)

Values for the equation of state given for R407C in Table D.12 are taken from Lemmon and Jacobsen [2].

Table D.12 — R407C property values in the single-phase region to serve as verification values or the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
200,000 0	0,000 100 0	$0{,}166\,267\,5 \times 10^{-3}$	31 774,36	202,629 9	47,967 2	56,289 6	150,436 8
200,000 0	17,900 000 0	$0{,}553\,926\,9 \times 10^{2}$	10 927,61	45,265 7	73,513 9	107,094 6	1 152,133 7
355,000 0	1,000 000 0	$0{,}229\,640\,0 \times 10^{1}$	39 788,21	156,305 1	78,767 3	105,478 7	162,875 9
355,000 0	8,400 000 0	$0{,}435\,213\,7 \times 10^{1}$	29 746,16	124,669 9	96,528 3	468,523 2	137,917 1
355,000 0	14,000 000 0	$0{,}557\,344\,0 \times 10^{2}$	28 020,22	108,209 6	83,118 0	115,842 8	696,432 9
420,000 0	0,000 100 0	$0{,}349\,202\,3 \times 10^{-3}$	47 657,20	248,603 3	79,036 1	87,351 3	211,589 6
420,000 0	12,600 000 0	$0{,}594\,362\,1 \times 10^{2}$	35 796,97	127,595 2	89,326 4	120,705 6	598,869 6

D.14 R410A — R32/125 (50/50)

Values for the equation of state given for R410A in Table D.13 are taken from Lemmon and Jacobsen [2].

Table D.13 — R410A property values in the single-phase region to serve as verification values for the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
200,000 0	0,000 100 0	$0{,}166\,271\,3 \times 10^{-3}$	28 272,46	189,950 0	39,755 4	48,076 4	166,428 6
200,000 0	20,600 000 0	$0{,}560\,445\,5 \times 10^{2}$	8 824,58	35,989 8	63,515 5	93,716 8	1 137,248 4
340,000 0	1,000 000 0	$0{,}225\,047\,7 \times 10^{1}$	33 876,54	135,158 5	62,914 7	86,967 5	181,537 7
340,000 0	10,000 000 0	$0{,}450\,682\,3 \times 10^{1}$	23 770,26	101,635 1	81,639 8	397,059 8	156,705 1
340,000 0	16,200 000 0	$0{,}550\,240\,0 \times 10^{2}$	22 189,48	86,707 0	68,183 8	99,824 3	714,199 4
420,000 0	0,000 100 0	$0{,}349\,203\,3 \times 10^{-3}$	41 445,78	227,114 4	63,514 0	71,829 1	233,252 9
420,000 0	14,000 000 0	$0{,}592\,175\,4 \times 10^{2}$	30 450,19	107,776 3	74,125 2	104,685 5	584,444 2

D.15 R507A [R125/143a (50/50)]

Values for the equation of state given for R507A in Table D.14 are taken from Lemmon and Jacobsen [2].

Table D.14 — R507A property values in the single-phase region to serve as verification values for the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
200,000 0	0,000 100 0	$0{,}166\,267\,7 \times 10^{-3}$	31 767,48	206,895 2	57,458 0	65,780 3	138,752 2
200,000 0	14,900 000 0	$0{,}460\,896\,0 \times 10^{2}$	12 596,27	54,278 6	80,934 3	115,808 8	1035,313 1
340,000 0	1,000 000 0	$0{,}210\,473\,4 \times 10^{1}$	40 236,28	164,010 0	92,395 7	123,280 7	140,846 5
340,000 0	7,200 000 0	$0{,}343\,922\,5 \times 10^{1}$	31 045,65	134,438 7	106,760 9	474,594 0	124,120 2
340,000 0	12,200 000 0	$0{,}579\,585\,8 \times 10^{2}$	29 927,83	116,390 8	96,028 5	126,730 6	697,265 1
500,000 0	0,000 100 0	$0{,}415\,719\,4 \times 10^{-3}$	59 560,49	280,703 9	106,666 1	114,981 1	212,906 8
500,000 0	9,400 000 0	$0{,}577\,036\,1 \times 10^{2}$	51 358,49	167,937 2	114,301 5	140,078 1	493,140 6

D.13 R407C — R32/125/134a (23/25/52)

Values for the equation of state given for R407C in Table D.12 are taken from Lemmon and Jacobsen [2].

Table D.12 — R407C property values in the single-phase region to serve as verification values or the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
200,000 0	0,000 100 0	$0{,}166\,267\,5 \times 10^{-3}$	31 774,36	202,629 9	47,967 2	56,289 6	150,436 8
200,000 0	17,900 000 0	$0{,}553\,926\,9 \times 10^{2}$	10 927,61	45,265 7	73,513 9	107,094 6	1 152,133 7
355,000 0	1,000 000 0	$0{,}229\,640\,0 \times 10^{1}$	39 788,21	156,305 1	78,767 3	105,478 7	162,875 9
355,000 0	8,400 000 0	$0{,}435\,213\,7 \times 10^{1}$	29 746,16	124,669 9	96,528 3	468,523 2	137,917 1
355,000 0	14,000 000 0	$0{,}557\,344\,0 \times 10^{2}$	28 020,22	108,209 6	83,118 0	115,842 8	696,432 9
420,000 0	0,000 100 0	$0{,}349\,202\,3 \times 10^{-3}$	47 657,20	248,603 3	79,036 1	87,351 3	211,589 6
420,000 0	12,600 000 0	$0{,}594\,362\,1 \times 10^{2}$	35 796,97	127,595 2	89,326 4	120,705 6	598,869 6

D.14 R410A — R32/125 (50/50)

Values for the equation of state given for R410A in Table D.13 are taken from Lemmon and Jacobsen [2].

Table D.13 — R410A property values in the single-phase region to serve as verification values for the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
200,000 0	0,000 100 0	$0{,}166\,271\,3 \times 10^{-3}$	28 272,46	189,950 0	39,755 4	48,076 4	166,428 6
200,000 0	20,600 000 0	$0{,}560\,445\,5 \times 10^{2}$	8 824,58	35,989 8	63,515 5	93,716 8	1 137,248 4
340,000 0	1,000 000 0	$0{,}225\,047\,7 \times 10^{1}$	33 876,54	135,158 5	62,914 7	86,967 5	181,537 7
340,000 0	10,000 000 0	$0{,}450\,682\,3 \times 10^{1}$	23 770,26	101,635 1	81,639 8	397,059 8	156,705 1
340,000 0	16,200 000 0	$0{,}550\,240\,0 \times 10^{2}$	22 189,48	86,707 0	68,183 8	99,824 3	714,199 4
420,000 0	0,000 100 0	$0{,}349\,203\,3 \times 10^{-3}$	41 445,78	227,114 4	63,514 0	71,829 1	233,252 9
420,000 0	14,000 000 0	$0{,}592\,175\,4 \times 10^{2}$	30 450,19	107,776 3	74,125 2	104,685 5	584,444 2

D.15 R507A [R125/143a (50/50)]

Values for the equation of state given for R507A in Table D.14 are taken from Lemmon and Jacobsen [2].

Table D.14 — R507A property values in the single-phase region to serve as verification values for the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
200,000 0	0,000 100 0	$0{,}166\,267\,7 \times 10^{-3}$	31 767,48	206,895 2	57,458 0	65,780 3	138,752 2
200,000 0	14,900 000 0	$0{,}460\,896\,0 \times 10^{2}$	12 596,27	54,278 6	80,934 3	115,808 8	1035,313 1
340,000 0	1,000 000 0	$0{,}210\,473\,4 \times 10^{1}$	40 236,28	164,010 0	92,395 7	123,280 7	140,846 5
340,000 0	7,200 000 0	$0{,}343\,922\,5 \times 10^{1}$	31 045,65	134,438 7	106,760 9	474,594 0	124,120 2
340,000 0	12,200 000 0	$0{,}579\,585\,8 \times 10^{2}$	29 927,83	116,390 8	96,028 5	126,730 6	697,265 1
500,000 0	0,000 100 0	$0{,}415\,719\,4 \times 10^{-3}$	59 560,49	280,703 9	106,666 1	114,981 1	212,906 8
500,000 0	9,400 000 0	$0{,}577\,036\,1 \times 10^{2}$	51 358,49	167,937 2	114,301 5	140,078 1	493,140 6

D.13 R407C — R32/125/134a (23/25/52)

Values for the equation of state given for R407C in Table D.12 are taken from Lemmon and Jacobsen [2].

Table D.12 — R407C property values in the single-phase region to serve as verification values or the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
200,000 0	0,000 100 0	$0{,}166\,267\,5 \times 10^{-3}$	31 774,36	202,629 9	47,967 2	56,289 6	150,436 8
200,000 0	17,900 000 0	$0{,}553\,926\,9 \times 10^{2}$	10 927,61	45,265 7	73,513 9	107,094 6	1 152,133 7
355,000 0	1,000 000 0	$0{,}229\,640\,0 \times 10^{1}$	39 788,21	156,305 1	78,767 3	105,478 7	162,875 9
355,000 0	8,400 000 0	$0{,}435\,213\,7 \times 10^{1}$	29 746,16	124,669 9	96,528 3	468,523 2	137,917 1
355,000 0	14,000 000 0	$0{,}557\,344\,0 \times 10^{2}$	28 020,22	108,209 6	83,118 0	115,842 8	696,432 9
420,000 0	0,000 100 0	$0{,}349\,202\,3 \times 10^{-3}$	47 657,20	248,603 3	79,036 1	87,351 3	211,589 6
420,000 0	12,600 000 0	$0{,}594\,362\,1 \times 10^{2}$	35 796,97	127,595 2	89,326 4	120,705 6	598,869 6

D.14 R410A — R32/125 (50/50)

Values for the equation of state given for R410A in Table D.13 are taken from Lemmon and Jacobsen [2].

Table D.13 — R410A property values in the single-phase region to serve as verification values for the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
200,000 0	0,000 100 0	$0{,}166\,271\,3 \times 10^{-3}$	28 272,46	189,950 0	39,755 4	48,076 4	166,428 6
200,000 0	20,600 000 0	$0{,}560\,445\,5 \times 10^{2}$	8 824,58	35,989 8	63,515 5	93,716 8	1 137,248 4
340,000 0	1,000 000 0	$0{,}225\,047\,7 \times 10^{1}$	33 876,54	135,158 5	62,914 7	86,967 5	181,537 7
340,000 0	10,000 000 0	$0{,}450\,682\,3 \times 10^{1}$	23 770,26	101,635 1	81,639 8	397,059 8	156,705 1
340,000 0	16,200 000 0	$0{,}550\,240\,0 \times 10^{2}$	22 189,48	86,707 0	68,183 8	99,824 3	714,199 4
420,000 0	0,000 100 0	$0{,}349\,203\,3 \times 10^{-3}$	41 445,78	227,114 4	63,514 0	71,829 1	233,252 9
420,000 0	14,000 000 0	$0{,}592\,175\,4 \times 10^{2}$	30 450,19	107,776 3	74,125 2	104,685 5	584,444 2

D.15 R507A [R125/143a (50/50)]

Values for the equation of state given for R507A in Table D.14 are taken from Lemmon and Jacobsen [2].

Table D.14 — R507A property values in the single-phase region to serve as verification values for the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
200,000 0	0,000 100 0	$0{,}166\,267\,7 \times 10^{-3}$	31 767,48	206,895 2	57,458 0	65,780 3	138,752 2
200,000 0	14,900 000 0	$0{,}460\,896\,0 \times 10^{2}$	12 596,27	54,278 6	80,934 3	115,808 8	1035,313 1
340,000 0	1,000 000 0	$0{,}210\,473\,4 \times 10^{1}$	40 236,28	164,010 0	92,395 7	123,280 7	140,846 5
340,000 0	7,200 000 0	$0{,}343\,922\,5 \times 10^{1}$	31 045,65	134,438 7	106,760 9	474,594 0	124,120 2
340,000 0	12,200 000 0	$0{,}579\,585\,8 \times 10^{2}$	29 927,83	116,390 8	96,028 5	126,730 6	697,265 1
500,000 0	0,000 100 0	$0{,}415\,719\,4 \times 10^{-3}$	59 560,49	280,703 9	106,666 1	114,981 1	212,906 8
500,000 0	9,400 000 0	$0{,}577\,036\,1 \times 10^{2}$	51 358,49	167,937 2	114,301 5	140,078 1	493,140 6

D.13 R407C — R32/125/134a (23/25/52)

Values for the equation of state given for R407C in Table D.12 are taken from Lemmon and Jacobsen [2].

Table D.12 — R407C property values in the single-phase region to serve as verification values or the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
200,000 0	0,000 100 0	$0{,}166\,267\,5 \times 10^{-3}$	31 774,36	202,629 9	47,967 2	56,289 6	150,436 8
200,000 0	17,900 000 0	$0{,}553\,926\,9 \times 10^{2}$	10 927,61	45,265 7	73,513 9	107,094 6	1 152,133 7
355,000 0	1,000 000 0	$0{,}229\,640\,0 \times 10^{1}$	39 788,21	156,305 1	78,767 3	105,478 7	162,875 9
355,000 0	8,400 000 0	$0{,}435\,213\,7 \times 10^{1}$	29 746,16	124,669 9	96,528 3	468,523 2	137,917 1
355,000 0	14,000 000 0	$0{,}557\,344\,0 \times 10^{2}$	28 020,22	108,209 6	83,118 0	115,842 8	696,432 9
420,000 0	0,000 100 0	$0{,}349\,202\,3 \times 10^{-3}$	47 657,20	248,603 3	79,036 1	87,351 3	211,589 6
420,000 0	12,600 000 0	$0{,}594\,362\,1 \times 10^{2}$	35 796,97	127,595 2	89,326 4	120,705 6	598,869 6

D.14 R410A — R32/125 (50/50)

Values for the equation of state given for R410A in Table D.13 are taken from Lemmon and Jacobsen [2].

Table D.13 — R410A property values in the single-phase region to serve as verification values for the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
200,000 0	0,000 100 0	$0{,}166\,271\,3 \times 10^{-3}$	28 272,46	189,950 0	39,755 4	48,076 4	166,428 6
200,000 0	20,600 000 0	$0{,}560\,445\,5 \times 10^{2}$	8 824,58	35,989 8	63,515 5	93,716 8	1 137,248 4
340,000 0	1,000 000 0	$0{,}225\,047\,7 \times 10^{1}$	33 876,54	135,158 5	62,914 7	86,967 5	181,537 7
340,000 0	10,000 000 0	$0{,}450\,682\,3 \times 10^{1}$	23 770,26	101,635 1	81,639 8	397,059 8	156,705 1
340,000 0	16,200 000 0	$0{,}550\,240\,0 \times 10^{2}$	22 189,48	86,707 0	68,183 8	99,824 3	714,199 4
420,000 0	0,000 100 0	$0{,}349\,203\,3 \times 10^{-3}$	41 445,78	227,114 4	63,514 0	71,829 1	233,252 9
420,000 0	14,000 000 0	$0{,}592\,175\,4 \times 10^{2}$	30 450,19	107,776 3	74,125 2	104,685 5	584,444 2

D.15 R507A [R125/143a (50/50)]

Values for the equation of state given for R507A in Table D.14 are taken from Lemmon and Jacobsen [2].

Table D.14 — R507A property values in the single-phase region to serve as verification values for the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
200,000 0	0,000 100 0	$0{,}166\,267\,7 \times 10^{-3}$	31 767,48	206,895 2	57,458 0	65,780 3	138,752 2
200,000 0	14,900 000 0	$0{,}460\,896\,0 \times 10^{2}$	12 596,27	54,278 6	80,934 3	115,808 8	1035,313 1
340,000 0	1,000 000 0	$0{,}210\,473\,4 \times 10^{1}$	40 236,28	164,010 0	92,395 7	123,280 7	140,846 5
340,000 0	7,200 000 0	$0{,}343\,922\,5 \times 10^{1}$	31 045,65	134,438 7	106,760 9	474,594 0	124,120 2
340,000 0	12,200 000 0	$0{,}579\,585\,8 \times 10^{2}$	29 927,83	116,390 8	96,028 5	126,730 6	697,265 1
500,000 0	0,000 100 0	$0{,}415\,719\,4 \times 10^{-3}$	59 560,49	280,703 9	106,666 1	114,981 1	212,906 8
500,000 0	9,400 000 0	$0{,}577\,036\,1 \times 10^{2}$	51 358,49	167,937 2	114,301 5	140,078 1	493,140 6

D.13 R407C — R32/125/134a (23/25/52)

Values for the equation of state given for R407C in Table D.12 are taken from Lemmon and Jacobsen [2].

Table D.12 — R407C property values in the single-phase region to serve as verification values or the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
200,000 0	0,000 100 0	$0{,}166\,267\,5 \times 10^{-3}$	31 774,36	202,629 9	47,967 2	56,289 6	150,436 8
200,000 0	17,900 000 0	$0{,}553\,926\,9 \times 10^{2}$	10 927,61	45,265 7	73,513 9	107,094 6	1 152,133 7
355,000 0	1,000 000 0	$0{,}229\,640\,0 \times 10^{1}$	39 788,21	156,305 1	78,767 3	105,478 7	162,875 9
355,000 0	8,400 000 0	$0{,}435\,213\,7 \times 10^{1}$	29 746,16	124,669 9	96,528 3	468,523 2	137,917 1
355,000 0	14,000 000 0	$0{,}557\,344\,0 \times 10^{2}$	28 020,22	108,209 6	83,118 0	115,842 8	696,432 9
420,000 0	0,000 100 0	$0{,}349\,202\,3 \times 10^{-3}$	47 657,20	248,603 3	79,036 1	87,351 3	211,589 6
420,000 0	12,600 000 0	$0{,}594\,362\,1 \times 10^{2}$	35 796,97	127,595 2	89,326 4	120,705 6	598,869 6

D.14 R410A — R32/125 (50/50)

Values for the equation of state given for R410A in Table D.13 are taken from Lemmon and Jacobsen [2].

Table D.13 — R410A property values in the single-phase region to serve as verification values for the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
200,000 0	0,000 100 0	$0{,}166\,271\,3 \times 10^{-3}$	28 272,46	189,950 0	39,755 4	48,076 4	166,428 6
200,000 0	20,600 000 0	$0{,}560\,445\,5 \times 10^{2}$	8 824,58	35,989 8	63,515 5	93,716 8	1 137,248 4
340,000 0	1,000 000 0	$0{,}225\,047\,7 \times 10^{1}$	33 876,54	135,158 5	62,914 7	86,967 5	181,537 7
340,000 0	10,000 000 0	$0{,}450\,682\,3 \times 10^{1}$	23 770,26	101,635 1	81,639 8	397,059 8	156,705 1
340,000 0	16,200 000 0	$0{,}550\,240\,0 \times 10^{2}$	22 189,48	86,707 0	68,183 8	99,824 3	714,199 4
420,000 0	0,000 100 0	$0{,}349\,203\,3 \times 10^{-3}$	41 445,78	227,114 4	63,514 0	71,829 1	233,252 9
420,000 0	14,000 000 0	$0{,}592\,175\,4 \times 10^{2}$	30 450,19	107,776 3	74,125 2	104,685 5	584,444 2

D.15 R507A [R125/143a (50/50)]

Values for the equation of state given for R507A in Table D.14 are taken from Lemmon and Jacobsen [2].

Table D.14 — R507A property values in the single-phase region to serve as verification values for the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
200,000 0	0,000 100 0	$0{,}166\,267\,7 \times 10^{-3}$	31 767,48	206,895 2	57,458 0	65,780 3	138,752 2
200,000 0	14,900 000 0	$0{,}460\,896\,0 \times 10^{2}$	12 596,27	54,278 6	80,934 3	115,808 8	1035,313 1
340,000 0	1,000 000 0	$0{,}210\,473\,4 \times 10^{1}$	40 236,28	164,010 0	92,395 7	123,280 7	140,846 5
340,000 0	7,200 000 0	$0{,}343\,922\,5 \times 10^{1}$	31 045,65	134,438 7	106,760 9	474,594 0	124,120 2
340,000 0	12,200 000 0	$0{,}579\,585\,8 \times 10^{2}$	29 927,83	116,390 8	96,028 5	126,730 6	697,265 1
500,000 0	0,000 100 0	$0{,}415\,719\,4 \times 10^{-3}$	59 560,49	280,703 9	106,666 1	114,981 1	212,906 8
500,000 0	9,400 000 0	$0{,}577\,036\,1 \times 10^{2}$	51 358,49	167,937 2	114,301 5	140,078 1	493,140 6

D.13 R407C — R32/125/134a (23/25/52)

Values for the equation of state given for R407C in Table D.12 are taken from Lemmon and Jacobsen [2].

Table D.12 — R407C property values in the single-phase region to serve as verification values or the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
200,000 0	0,000 100 0	$0{,}166\,267\,5 \times 10^{-3}$	31 774,36	202,629 9	47,967 2	56,289 6	150,436 8
200,000 0	17,900 000 0	$0{,}553\,926\,9 \times 10^{2}$	10 927,61	45,265 7	73,513 9	107,094 6	1 152,133 7
355,000 0	1,000 000 0	$0{,}229\,640\,0 \times 10^{1}$	39 788,21	156,305 1	78,767 3	105,478 7	162,875 9
355,000 0	8,400 000 0	$0{,}435\,213\,7 \times 10^{1}$	29 746,16	124,669 9	96,528 3	468,523 2	137,917 1
355,000 0	14,000 000 0	$0{,}557\,344\,0 \times 10^{2}$	28 020,22	108,209 6	83,118 0	115,842 8	696,432 9
420,000 0	0,000 100 0	$0{,}349\,202\,3 \times 10^{-3}$	47 657,20	248,603 3	79,036 1	87,351 3	211,589 6
420,000 0	12,600 000 0	$0{,}594\,362\,1 \times 10^{2}$	35 796,97	127,595 2	89,326 4	120,705 6	598,869 6

D.14 R410A — R32/125 (50/50)

Values for the equation of state given for R410A in Table D.13 are taken from Lemmon and Jacobsen [2].

Table D.13 — R410A property values in the single-phase region to serve as verification values for the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
200,000 0	0,000 100 0	$0{,}166\,271\,3 \times 10^{-3}$	28 272,46	189,950 0	39,755 4	48,076 4	166,428 6
200,000 0	20,600 000 0	$0{,}560\,445\,5 \times 10^{2}$	8 824,58	35,989 8	63,515 5	93,716 8	1 137,248 4
340,000 0	1,000 000 0	$0{,}225\,047\,7 \times 10^{1}$	33 876,54	135,158 5	62,914 7	86,967 5	181,537 7
340,000 0	10,000 000 0	$0{,}450\,682\,3 \times 10^{1}$	23 770,26	101,635 1	81,639 8	397,059 8	156,705 1
340,000 0	16,200 000 0	$0{,}550\,240\,0 \times 10^{2}$	22 189,48	86,707 0	68,183 8	99,824 3	714,199 4
420,000 0	0,000 100 0	$0{,}349\,203\,3 \times 10^{-3}$	41 445,78	227,114 4	63,514 0	71,829 1	233,252 9
420,000 0	14,000 000 0	$0{,}592\,175\,4 \times 10^{2}$	30 450,19	107,776 3	74,125 2	104,685 5	584,444 2

D.15 R507A [R125/143a (50/50)]

Values for the equation of state given for R507A in Table D.14 are taken from Lemmon and Jacobsen [2].

Table D.14 — R507A property values in the single-phase region to serve as verification values for the implementation of the equation of state

Temperature K	**Density** mol/l	**Pressure** MPa	**Enthalpy** J/mol	**Entropy** J/(mol·K)	C_v J/(mol·K)	C_p J/(mol·K)	**Sound speed** m/s
200,000 0	0,000 100 0	$0{,}166\,267\,7 \times 10^{-3}$	31 767,48	206,895 2	57,458 0	65,780 3	138,752 2
200,000 0	14,900 000 0	$0{,}460\,896\,0 \times 10^{2}$	12 596,27	54,278 6	80,934 3	115,808 8	1035,313 1
340,000 0	1,000 000 0	$0{,}210\,473\,4 \times 10^{1}$	40 236,28	164,010 0	92,395 7	123,280 7	140,846 5
340,000 0	7,200 000 0	$0{,}343\,922\,5 \times 10^{1}$	31 045,65	134,438 7	106,760 9	474,594 0	124,120 2
340,000 0	12,200 000 0	$0{,}579\,585\,8 \times 10^{2}$	29 927,83	116,390 8	96,028 5	126,730 6	697,265 1
500,000 0	0,000 100 0	$0{,}415\,719\,4 \times 10^{-3}$	59 560,49	280,703 9	106,666 1	114,981 1	212,906 8
500,000 0	9,400 000 0	$0{,}577\,036\,1 \times 10^{2}$	51 358,49	167,937 2	114,301 5	140,078 1	493,140 6