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Refrigerant properties

Propriétés des fluides frigorigènes

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Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 86, *Refrigeration and air-conditioning*, Subcommittee SC 8, *Refrigerants and refrigeration lubricants*.

This second edition cancels and replaces the first edition (ISO 17584:2005), which has been technically revised.

The main changes are as follows:

— Addition of new refrigerants (R290, R600a, R1233zd(E), R1336mzz(Z), R1234yf, R1234ze(E));

— Update of Ammonia.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document is consistent with and is intended to complement ISO 817. The purpose of this document 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 document represent those for which sufficient high-quality data were available.

This document 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).

Tolerances in this document do not necessarily represent the uncertainty of the original experimental data or of the equation of state in fitting the data.

The tolerances are relative (i.e. plus or minus a percentage) for some properties and absolute for others (e.g. plus or minus a constant enthalpy value). Properties such as enthalpy and entropy, which can be negative, demand an absolute tolerance; any allowable percentage variation would be too strict at values near zero. The allowable tolerances for enthalpy and entropy are scaled by the enthalpy and entropy of vapourisation for each fluid. By scaling the tolerance to the vapourisation values, a greater tolerance is allowed for fluids, such as ammonia, with high heats of vapourisation.

The tolerances apply to individual thermodynamic states. In cycle and equipment analyses, it is the differences in enthalpy and/or entropy between two different states that are important. However, it is not possible to specify, in a simple way, allowable tolerances based on pairs of states because of the large number of possible pairs of interest.

The values of C_v and C_p approach infinity at the critical point, but the actual values returned by the equation of state are large numbers that vary from computer to computer due to round-off errors in the calculations. According to critical-region theory, the speed of sound is zero at the critical point; all traditional equations of state (including the ones in this document), however, do not reproduce this behaviour. Rather than list values that are inconsistent with either the theory or the specified equations of state, these points are not included as part of this document.

The values of the gas constant, R, vary from fluid to fluid. Similarly, the number of significant values given for the molecular mass, M, vary. The various values of R differ by less than 5×10^{-6} (equal to parts per million, a deprecated unit) from the currently accepted value of 8,314 462 618 J/(mol·K) and result in similarly small differences in the properties. The compositions of the refrigerant blends (R400- and R500-series) are defined on a mass basis, but the equations of state are given on a molar basis. The mass compositions have been converted to the equivalent molar basis and listed in Clause 5; a large number of significant values are given for consistency with the tables of "verification values" given in Annex D.

Refrigerant properties

1 Scope

This document specifies the thermophysical properties of several commonly used refrigerants and refrigerant blends.

This document is applicable to refrigerants R12, R22, R32, R123, R125, R134a, R143a, R152a, R290, R600a, R717 (ammonia), R744 (carbon dioxide), R1233zd(E), R1336mzz(Z), R1234yf and R1234ze(E) 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.

NOTE 1 R12, R22, R123 are controlled substances under the Montreal Protocol, Annex A (R12) or Annex C Group I (R22, R123).

NOTE 2 R32, R125, R134a, R143a, R152a, R404A, R407C, R410A, and R507A are controlled substances under the Montreal Protocol, Annex F or blend thereof.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
algorithm
procedure for the computation of refrigerant properties

Note 1 to entry: 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 1 to entry: 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 1 to entry: 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 1 to entry: 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 1 to entry: 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
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 document specifies properties for the refrigerants listed in Clause 1. These properties are derived from experimental measurements.

The properties enumerated in this document are calculated from specified equations of state, although alternative algorithms are allowed. The properties themselves constitute this document. The equations of state serve as a convenient means to represent and reproduce the properties. The properties enumerated in the tables in this document thus represent only a subset of the properties specified by this document; 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, T, and density. The equation of state is composed of separate terms arising from ideal-gas behaviour (subscript "id") and a "residual" or "real-fluid" (subscript "r") contribution as given in Formula (1):

$$\phi = \frac{A}{RT} = \phi_{\mathrm{id}} + \phi_{\mathrm{r}} \tag{1}$$

where R is the gas constant.

Formulae of this form may be written on either a molar basis or a mass basis. For a consistent representation in this document, 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 Formula (2):

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

where

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

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

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

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

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 Formula (3):

$$\phi_{\mathrm{id}} = \frac{h_{\mathrm{ref}}}{\mathrm{R}T} - \frac{s_{\mathrm{ref}}}{\mathrm{R}} - 1 + \ln\left(\frac{RT\rho}{p_{\mathrm{ref}}}\right) + \frac{1}{RT}\int_{T_{\mathrm{ref}}}^{T} C_{p,\mathrm{id}}\,\mathrm{d}T - \frac{1}{R}\int_{T_{\mathrm{ref}}}^{T} \frac{C_{p,\mathrm{id}}}{T}\,\mathrm{d}T \tag{3}$$

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 document, 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 Formula (4):

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

where

$$u_k = \frac{b_k}{T}; \tag{5}$$

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 Formula (6):

$$\phi_{\mathrm{id}} = d_1 + d_2\tau + \ln\delta + d_3 \ln\tau + \sum_k d_k \tau^{t_k} + \sum_k a_k \ln[1-\exp(-\tau\lambda_k)] \tag{6}$$

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.

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

$$\frac{C_{p,\mathrm{id}}}{R} = d_3 + 1 - \sum_k d_k t_k (t_k - 1)\left(\frac{T^*}{T}\right)^{t_k} + \sum_k a_k \frac{u_k^2 \exp(u_k)}{[\exp(u_k)-1]^2} \tag{7}$$

where

$$u_k = \frac{\lambda_k T^*}{T} \tag{8}$$

The equations of state for certain fluids may also include special terms to represent the behaviour very close to the critical point. These are of the form of Formula (9):

$$\phi_{\mathrm{crit}} = \sum_k N_k \delta \Delta^{b_k} \Psi \tag{9}$$

where

$$\Delta = \theta^2 + B_k\left[(\delta-1)^2\right]^{a_k} \tag{10}$$

$$\theta = (1-\tau) + A_k\left[(\delta-1)^2\right]^{1/(2\beta_k)} \tag{11}$$

$$\Psi = \exp\left[-C_k(\delta-1)^2 - D_k(\tau-1)^2\right] \tag{12}$$

where N_k, A_k, B_k, C_k, D_k, α_k and β_k are adjustable parameters fitted to data.

Formula (9) is added to the normal terms in Formula (1). Among the fluids in this document, 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 Formula (13):

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

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 formula is combined with an expression for the ideal-gas heat capacity, such as Formula (4) or (5).

In this document, pressure-explicit equations of state [such as Formula (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 Formula (14):

$$p = -\left(\frac{\partial A}{\partial V}\right)_T \tag{14}$$

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

$$\frac{A_r(T,\rho)}{RT} = \phi_r = -\int_V^\infty \left(\frac{p}{RT} - \rho\right) \mathrm{d}V \tag{15}$$

Formula (15) is then combined with an ideal-gas contribution given by Formulae (3) to (5) to yield a complete description of the thermodynamic properties. Among the fluids in this document, 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 Formulae (1) through (15) encompass all those specified in this document.

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

4.3 Mixture equation of state

Thermodynamic properties of mixtures are calculated by applying mixing rules to the Helmholtz energy of the mixture components together with a separate mixture function. The reduced Helmholtz energy of the mixture is a sum of ideal-gas and residual contributions as given by Formula (16):

$$\phi_{\text{mix}} = \frac{A}{RT} = \phi_{\text{mix,id}} + \phi_{\text{mix,r}} \tag{16}$$

The ideal gas part is given by Formula (17):

$$\phi_{\text{mix,id}} = \sum_{i=1}^{n}\left[x_i \phi_{i,\text{id}} + x_i \ln x_i\right] + f_3 + f_4/T \tag{17}$$

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 Formula (18):

$$\phi_{\text{mix,r}} = \sum_{i=1}^{n} x_i \phi_{i,\text{r}} + \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} x_i x_j \phi_{ij,\text{excess}} \tag{18}$$

The first summation in this formula 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 $\phi_{i,\text{r}}$ and $\phi_{ij,\text{excess}}$ functions in Formula (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 Formulae (19) and (20):

$$\tau = \frac{T^*}{T_{\text{mix}}} \tag{19}$$

where

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

and

$$\delta = \frac{\rho_{\text{mix}}}{\rho^*} \tag{20}$$

where

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

where

ζ_{ij} and ξ_{ij} are "interaction parameters";

T_i^* and ρ_i^* are the reducing parameters of the pure fluids.

The $\phi_{ij,\text{excess}}$ function is of the general form of Formula (21):

$$\phi_{ij,\text{excess}} = F_{ij} \sum_k N_k \delta^{d_k} \tau^{t_k} \exp\left(-\delta^{l_k}\right) \tag{21}$$

The $\phi_{ij,\text{excess}}$ function will, in general, vary from mixture to mixture (see Annex E), and the coefficients and exponents are tabulated in Clause 5 for the refrigerant blends included in this document. In all cases, the pure-component contributions are those defined in Clause 5 of this document.

Methods for computing thermodynamic properties from a mixture equation of state are given in Annex C.

4.4 Implementation

An algorithm shall directly implement one or more of the equations of state specified in Clause 5 together with the methods of calculating the thermodynamic properties given in Annex B and is also demonstrate to reproduce, for the fluids implemented, the "verification values" given in Annex D.

4.5 Alternative implementation

An algorithm shall, by any method, reproduce the values of thermodynamic properties specified in this document for the fluids implemented. Such an algorithm is considered to 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 fluids for which it is applicable and the applicable property(ies) and range(s). The allowable variations (tolerances) between the property values specified in this document and those of an alternative implementation vary from property to property and are defined in Annex A.

4.6 Testing implementations against requirements

Any computer program or other implementation of this document shall satisfy the requirements specified in Annex A before it can claim compliance with this document. These requirements shall be carried out by the developer of the particular implementation.

5 Specifications for individual refrigerants

5.1 General

The following subclauses specify the equations of state used to calculate the properties of each of the refrigerants covered by this document and also tabulate the properties along the liquid-vapour saturation boundary. In the tabulations of coefficients and exponents, any terms not listed are zero.

5.2 R744 — Carbon dioxide

5.2.1 Range of validity

The coefficients are valid within the following ranges:

T_{min} = 216,592 K, T_{max} = 1 100 K; p_{max} = 800 MPa; ρ_{max} = 37,24 mol/l (1 639 kg/m^3)

Coefficients and exponents of the ideal-gas part are listed in Table 1. Coefficients and exponents of the real-gas part are listed in Table 2. Coefficients and exponents of the critical region terms are listed in Table 3.

Table 1 — Coefficients and exponents of the ideal-gas part [Formulae (3) to (5)]

k	a_k	b_k	c_k
0	—	—	3,5
1	1,994 270 42	958,499 56	—
2	0,621 052 475	1 858,801 15	—
3	0,411 952 928	2 061,101 14	—
4	1,040 289 22	3 443,899 08	—
5	0,083 276 775 3	8 238,200 35	—

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

k	N_k	t_k	d_k	l_k	α_k	m_k	β_k	γ_k	ε_k
1	0,388 568 232 032	0	1	0	0	—	—	—	—
2	0,293 854 759 427 × 10^{1}	0,75	1	0	0	—	—	—	—
3	−0,558 671 885 349 × 10^{1}	1	1	0	0	—	—	—	—
4	−0,767 531 995 925	2	1	0	0	—	—	—	—
5	0,317 290 055 804	0,75	2	0	0	—	—	—	—
6	0,548 033 158 978	2	2	0	0	—	—	—	—
7	0,122 794 112 203	0,75	3	0	0	—	—	—	—
8	0,216 589 615 432 × 10^{1}	1,5	1	1	1	—	—	—	—
9	0,158 417 351 097 × 10^{1}	1,5	2	1	1	—	—	—	—
10	−0,231 327 054 055	2,5	4	1	1	—	—	—	—
11	0,581 169 164 314 × 10^{-1}	0	5	1	1	—	—	—	—
12	−0,553 691 372 054	1,5	5	1	1	—	—	—	—
13	0,489 466 159 094	2	5	1	1	—	—	—	—
14	−0,242 757 398 435 × 10^{-1}	0	6	1	1	—	—	—	—
15	0,624 947 905 017 × 10^{-1}	1	6	1	1	—	—	—	—
16	−0,121 758 602 252	2	6	1	1	—	—	—	—
17	−0,370 556 852 701	3	1	2	1	—	—	—	—
18	−0,167 758 797 004 × 10^{-1}	6	1	2	1	—	—	—	—
19	−0,119 607 366 380	3	4	2	1	—	—	—	—
20	−0,456 193 625 088 × 10^{-1}	6	4	2	1	—	—	—	—
21	0,356 127 892 703 × 10^{-1}	8	4	2	1	—	—	—	—
22	−0,744 277 271 321 × 10^{-2}	6	7	2	1	—	—	—	—
23	−0,173 957 049 024 × 10^{-2}	8	8	2	1	—	—	—	—
24	−0,218 101 212 895 × 10^{-1}	7	2	3	1	—	—	—	—
25	0,243 321 665 592 × 10^{-1}	12	3	3	1	—	—	—	—
26	−0,374 401 334 235 × 10^{-1}	16	3	3	1	—	—	—	—
27	0,143 387 157 569	22	5	4	1	—	—	—	—
28	−0,134 919 690 833	24	5	4	1	—	—	—	—
29	−0,231 512 250 535 × 10^{-1}	16	6	4	1	—	—	—	—
30	0,123 631 254 929 × 10^{-1}	24	7	4	1	—	—	—	—
31	0,210 583 219 729 × 10^{-2}	8	8	4	1	—	—	—	—
32	−0,339 585 190 264 × 10^{-3}	2	10	4	1	—	—	—	—
33	0,559 936 517 716 × 10^{-2}	28	4	5	1	—	—	—	—
34	−0,303 351 180 556 × 10^{-3}	14	8	6	1	—	—	—	—
35	−0,213 654 886 883 × 10^{3}	1	2	2	25	2	325	1,16	1
36	0,266 415 691 493 × 10^{5}	0	2	2	25	2	300	1,19	1
37	−0,240 272 122 046 × 10^{5}	1	2	2	25	2	300	1,19	1
38	−0,283 416 034 240 × 10^{3}	3	3	2	15	2	275	1,25	1
39	0,212 472 844 002 × 10^{3}	3	3	2	20	2	275	1,22	1

Table 3 — Coefficients and exponents of the critical region terms [Formulae (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

Table 3 *(continued)*

k	N_k	a_k	b_k	β_k	A_k	B_k	C_k	D_k
41	0,726 086 323 499	3,5	0,925	0,3	0,7	0,3	10	275
42	$0{,}550\,686\,686\,128 \times 10^{-1}$	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

R744 property values along the liquid-vapour saturation boundary are listed in Table 4.

Table 4 — R744 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	MPa	kg/m³	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
liquid	−56,56[a]	0,518 0	1 178,5	79,60	80,04	0,521 3	0,974 7	1,953 2	975,8	−0,144 3
vapour			13,761	392,78	430,42	2,139 0	0,629 2	0,908 7	222,78	26,17
liquid	−55,00	0,554 0	1 172,9	82,62	83,09	0,535 2	0,972 4	1,956 9	964,6	−0,138 7
vapour			14,673	393,23	430,99	2,130 0	0,633 6	0,918 4	222,96	25,67
liquid	−50,00	0,682 3	1 154,6	92,35	92,94	0,579 4	0,965 5	1,971 2	928,5	−0,119 1
vapour			17,925	394,61	432,68	2,101 8	0,648 3	0,951 9	223,39	24,14
liquid	−45,00	0,831 8	1 135,8	102,14	102,87	0,622 8	0,959 0	1,989 2	892,4	−0,096 3
vapour			21,717	395,83	434,13	2,074 7	0,664 0	0,990 0	223,57	22,77
liquid	−40,00	1,004 5	1 116,4	112,00	112,90	0,665 6	0,952 9	2,011 7	856,3	−0,069 9
vapour			26,121	396,87	435,32	2,048 5	0,680 7	1,033 3	223,50	21,51
liquid	−35,00	1,202 4	1 096,4	121,95	123,05	0,707 9	0,947 3	2,039 3	819,9	−0,039 1
vapour			31,216	397,71	436,23	2,023 0	0,698 5	1,083 0	223,15	20,37
liquid	−30,00	1,427 8	1 075,7	132,01	133,34	0,749 8	0,942 2	2,073 1	783,2	−0,003 1
vapour			37,098	398,33	436,82	1,998 0	0,717 4	1,140 6	222,54	19,32
liquid	−25,00	1,682 7	1 054,2	142,20	143,79	0,791 4	0,937 9	2,114 5	745,8	0,039 4
vapour			43,880	398,71	437,06	1,973 2	0,737 9	1,208 3	221,63	18,35
liquid	−20,00	1,969 6	1 031,7	152,54	154,45	0,832 8	0,934 4	2,165 3	707,5	0,090 0
vapour			51,700	398,79	436,89	1,948 5	0,760 2	1,289 3	220,41	17,44
liquid	−15,00	2,290 8	1 008,0	163,07	165,34	0,874 2	0,932 4	2,228 3	667,8	0,150 9
vapour			60,728	398,55	436,27	1,923 7	0,784 7	1,387 7	218,85	16,58
liquid	−10,00	2,648 7	982,9	173,83	176,52	0,915 7	0,933 0	2,307 2	626,1	0,225 1
vapour			71,185	397,93	435,14	1,898 5	0,811 3	1,509 1	216,94	15,77
liquid	−5,00	3,045 9	956,2	184,86	188,05	0,957 6	0,937 1	2,408 5	582,2	0,316 8
vapour			83,359	396,84	433,38	1,872 5	0,840 3	1,662 8	214,68	14,99

[a] Triple point.

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

Table 4 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
liquid	0,00	3,485 1	927,4	196,24	200,00	1,000 0	0,944 9	2,542 3	536,4	0,432 5
vapour			97,647	395,20	430,89	1,845 3	0,872 2	1,864 8	212,04	14,23
liquid	5,00	3,969 5	896,0	208,07	212,50	1,043 4	0,955 8	2,726 8	489,3	0,582 4
vapour			114,621	392,85	427,48	1,816 3	0,908 4	2,144 0	208,97	13,47
liquid	10,00	4,502 2	861,1	220,50	225,73	1,088 4	0,969 1	2,997 6	441,0	0,783 6
vapour			135,156	389,57	422,88	1,784 7	0,950 7	2,557 8	205,41	12,69
liquid	15,00	5,087 1	821,2	233,79	239,99	1,135 9	0,985 9	3,436 0	391,1	1,067 0
vapour			160,730	384,99	416,64	1,748 9	1,002 9	3,237 1	201,21	11,85
liquid	20,00	5,729 1	773,4	248,46	255,87	1,187 7	1,011 4	4,263 7	337,6	1,497 3
vapour			194,202	378,36	407,87	1,706 2	1,072 5	4,559 9	196,09	10,88
liquid	25,00	6,434 2	710,5	265,73	274,78	1,248 5	1,070 4	6,467 4	274,3	2,256 5
vapour			242,732	367,92	394,43	1,649 8	1,181 9	8,212 3	189,12	9,62
liquid	30,00	7,213 7	593,3	292,40	304,55	1,343 5	1,406 3	35,338 4	177,2	4,278 9
vapour			345,102	344,23	365,13	1,543 3	1,522 8	55,821 7	171,26	7,39
critical	30,98	7,377 3	467,6	316,47	332,25	1,433 6	[b]	[b]	[b]	5,866 5

[a] Triple point.

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

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} = 725 K; p_{max} = 1 000 MPa; ρ_{max} = 52,43 mol/l (893 kg/m^3)

5.3.2 Coefficients and exponents of the ideal-gas part [Formulae (3) to (5)]

Coefficients and exponents of the ideal-gas part are listed in Table 5 and Table 6. Coefficients and exponents of the real-gas part are listed in Table 7, Table 8 and Table 9.

Table 5 — Coefficients and exponents for k =0

k	c_k
0	4,000

Table 6 — Coefficients and exponents for k = 1 up to 3

k	a_k	b_k
1	2,224	1 646
2	3,148	3 965
3	0,957 9	7 231

5.3.3 Coefficients and exponents of the real-gas part [Formula (2)]

Parameters not listed are zero.

Table 7 — Coefficients and exponents for k = 1 up to 5

k	N_k	t_k	d_k
1	0,006 132 232	1,0	4
2	1,739 586 6	0,382	1
3	−2,226 179 2	1	1
4	−0,301 275 53	1	2
5	0,089 670 23	0,677	3

Table 8 — Coefficients and exponents for k = 6 up to 18

k	N_k	t_k	d_k	l_k	α_k	m_k	β_k	γ_k	ε_k
6	−0,076 387 037	2,915	3	2	1	1	0	1	0
7	−0,840 639 63	3,51	2	2	1	1	0	1	0
8	−0,270 263 27	1,063	3	1	1	1	0	1	0
9	6,212 578	0,655	1	2	−0,427 76	2	−1,708	1,036	−0,072 6
10	−5,784 435 7	1,3	1	2	−0,642 4	2	−1,486 5	1,277 7	−0,127 4
11	2,481 754 2	3,1	1	2	−0,817 5	2	−2,091 5	1,083	0,752 7
12	−2,373 916 8	1,439 5	2	2	−0,799 5	2	−2,43	1,290 6	0,57
13	0,014 936 97	1,623	2	2	−0,91	2	−0,488	0,928	2,2
14	−3,774 926 4	0,643	1	2	−0,357 4	2	−1,1	0,934	−0,243
15	0,000 625 435	1,13	3	2	−1,21	2	−0,85	0,919	2,96
16	−0,000 017 359	4,5	3	2	−4,14	2	−1,14	1,852	3,02
17	−0,134 620 33	1	1	2	−22,56	2	−945,64	1,058 97	0,957 4
18	0,077 490 728	4	1	2	−22,68	2	−993,85	1,052 77	0,957 6

For ammonia (R717), the final two terms in the summation of Formula (2) (i.e., k= 19,20) have a slightly different form, see Formula (22):

$$\phi_r = \sum_{k=19}^{20} N_k \tau^{t_k} \delta^{d_k} \exp\left[-\alpha_k (\delta - \varepsilon_k)^{l_k}\right] \exp\left[\frac{1}{\chi_k (\tau - \gamma_k)^{m_k} + b_k}\right] \tag{22}$$

Table 9 — Coefficients and exponents for k = 19 up to 20

k	N_k	t_k	d_k	l_k	α_k	m_k	χ_k	γ_k	ε_k	b_k
19	−1,690 985 8	4,331 5	1	2	−2,845 2	2	0,369 6	1,108	0,447 8	1,244
20	0,937 390 74	4,015	1	2	−2,834 2	2	0,296 2	1,313	0,446 89	0,682 6

5.3.4 Reducing parameters, molar mass, and gas constant

T^* = 405,56 K, ρ^* = 13,696 mol/l, M = 17,030 52 g/mol, R = 8,314 459 8 J/(mol·K)

5.3.5 Reference state parameters

T_{ref} = 273,15 K, p_{ref} = 1,0 kPa, h_{ref} = 28 044,796 J/mol, s_{ref} = 156,239 4 J/(mol·K)

R717 property values along the liquid-vapour saturation boundary are listed in Table 10.

Table 10 — R717 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	MPa	kg/m³	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
liquid	−77,66[a]	0,006 05	733,9	−145,67	−145,67	−0,483 5	2,967 5	4,305 3	2 011,3	−0,219 6
vapour			0,063 7	1 248,25	1 343,27	7,132 9	1,516 2	2,022 9	355,26	180,96
liquid	−75,00	0,007 47	730,8	−134,21	−134,20	−0,425 3	2,968 7	4,312 3	1 994,6	−0,218 4
vapour			0,077 6	1 251,91	1 348,16	7,055 7	1,522 5	2,031 9	357,48	169,43
liquid	−70,00	0,010 9	725	−112,62	−112,60	−0,317 6	2,970 1	4,327 7	1 963,4	−0,215 8
vapour			0,111	1 258,72	1 357,25	6,917 7	1,535 6	2,050 7	361,55	150,11
liquid	−65,00	0,015 6	719,3	−90,94	−90,92	−0,212 2	2,969 9	4,345 1	1 932,3	−0,212 8
vapour			0,155	1 265,41	1 366,19	6,788 1	1,550 5	2,072 6	365,49	133,43
liquid	−60,00	0,021 8	713,5	−69,17	−69,14	−0,108 9	2,967 7	4,363 6	1 901,4	−0,209 5
vapour			0,212	1 271,99	1 374,98	6,666 3	1,567 5	2,097 5	369,29	118,99
liquid	−55,00	0,030 1	707,6	−47,31	−47,27	−0,007 5	2,963 3	4,382 7	1 870,6	−0,205 8
vapour			0,286	1 278,43	1 383,58	6,551 5	1,586 5	2,125 9	372,93	106,44
liquid	−50,00	0,040 8	701,7	−25,35	−25,29	0,092	2,956 7	4,401 9	1 839,7	−0,201 8
vapour			0,38	1 284,72	1 391,98	6,443 3	1,607 7	2,157 8	376,41	95,48
liquid	−45,00	0,054 4	695,8	−3,30	−3,23	0,189 8	2,948	4,421	1 808,8	−0,197 5
vapour			0,498	1 290,86	1 400,17	6,341	1,631 1	2,193 4	379,73	85,9
liquid	−40,00	0,071 6	689,8	18,84	18,94	0,285 8	2,937 6	4,44	1 777,6	−0,192 9
vapour			0,644	1 296,83	1 408,14	6,244 1	1,656 7	2,232 8	382,86	77,48
liquid	−35,00	0,093	683,7	41,07	41,21	0,380 1	2,925 7	4,458 9	1 746,3	−0,187 9
vapour			0,822	1 302,63	1 415,86	6,152 3	1,684 4	2,276 1	385,81	70,08
liquid	−33,32[b]	0,101 3	681,6	48,58	48,73	0,411 5	2,921 4	4,465 3	1 735,6	−0,186 1
vapour			0,89	1 304,55	1 418,4	6,122 4	1,694 2	2,291 6	386,76	67,78
liquid	−30,00	0,119 4	677,5	63,4	63,57	0,472 9	2,912 7	4,478	1 714,6	−0,182 6
vapour			1,037	1 308,25	1 423,32	6,065 1	1,714 3	2,323 5	388,57	63,55
liquid	−25,00	0,151 4	671,3	85,81	86,04	0,564 1	2,899 1	4,497 4	1 682,5	−0,176 8
vapour			1,296	1 313,68	1 430,51	5,982 1	1,746 1	2,374 9	391,12	57,78
liquid	−20,00	0,19	665	108,32	108,6	0,654	2,885 2	4,517 3	1 650	−0,170 6
vapour			1,604	1 318,9	1 437,41	5,903	1,779 8	2,430 5	393,47	52,68
liquid	−15,00	0,236 1	658,5	130,92	131,28	0,742 4	2,871 2	4,538 2	1 617,1	−0,163 9
vapour			1,966	1 323,91	1 444	5,827 5	1,815 2	2,490 2	395,61	48,17
liquid	−10,00	0,290 6	652	153,62	154,06	0,829 5	2,857 4	4,560 4	1 583,7	−0,156 7
vapour			2,391	1 328,7	1 450,27	5,755 2	1,852 3	2,554 3	397,53	44,16
liquid	−5,00	0,354 7	645,4	176,42	176,97	0,915 3	2,844 1	4,584 1	1 549,9	−0,148 9
vapour			2,885	1 333,26	1 456,2	5,685 9	1,890 7	2,622 9	399,23	40,61
liquid	0	0,429 2	638,6	199,33	200	1	2,831 4	4,609 7	1 515,6	−0,140 4
vapour			3,456	1 337,57	1 461,77	5,619 3	1,930 4	2,696 2	400,7	37,44
liquid	5	0,515 6	631,8	222,36	223,17	1,083 6	2,819 4	4,637 6	1 480,8	−0,131 1
vapour			4,113	1 341,62	1 466,96	5,555 2	1,971 4	2,774 5	401,94	34,61
liquid	10	0,614 8	624,8	245,51	246,49	1,166 1	2,808 3	4,668 2	1 445,5	−0,120 9
vapour			4,866	1 345,38	1 471,73	5,493 3	2,013 4	2,858 3	402,95	32,09
liquid	15	0,728 2	617,7	268,8	269,98	1,247 7	2,798	4,701 8	1 409,8	−0,109 8

[a] Triple point

[b] Normal boiling point

* The values of C_v, C_p, and w at the critical point are not included as part of this document.

Table 10 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
vapour			5,724	1 348,84	1 476,07	5,433 3	2,056 5	2,948 1	403,7	29,82
liquid	20	0,857	610,4	292,24	293,64	1,328 4	2,788 6	4,738 9	1 373,6	−0,097 6
vapour			6,698	1 351,99	1 479,94	5,375 1	2,100 6	3,044 5	404,21	27,79
liquid	25	1,002 7	603	315,84	317,5	1,408 3	2,780 2	4,78	1 336,9	−0,084 2
vapour			7,801	1 354,78	1 483,32	5,318 4	2,145 8	3,148 6	404,46	25,96
liquid	30	1,166 5	595,4	339,61	341,57	1,487 4	2,772 7	4,825 7	1 299,7	−0,069 4
vapour			9,046	1 357,2	1 486,16	5,263 1	2,192 2	3,261 1	404,44	24,3
liquid	35	1,35	587,6	363,58	365,88	1,565 9	2,766 1	4,876 5	1 262,1	−0,052 9
vapour			10,448	1 359,22	1 488,44	5,208 8	2,239 6	3,383 6	404,15	22,79
liquid	40	1,554 5	579,6	387,76	390,45	1,643 9	2,760 4	4,933 3	1 223,9	−0,034 6
vapour			12,024	1 360,81	1 490,1	5,155 5	2,288 4	3,517 4	403,57	21,42
liquid	45	1,781 7	571,4	412,18	415,3	1,721 4	2,755 7	4,997	1 185,2	−0,014 2
vapour			13,792	1 361,93	1 491,11	5,102 8	2,338 5	3,664 6	402,68	20,16
liquid	50	2,033	563	436,85	440,46	1,798 5	2,752	5,068 8	1 146	0,008 7
vapour			15,775	1 362,54	1 491,41	5,050 7	2,390 2	3,827 4	401,49	19,01
liquid	55	2,31	554,3	461,81	465,97	1,875 3	2,749 2	5,149 9	1 106,1	0,034 4
vapour			17,996	1 362,59	1 490,95	4,998 8	2,443 6	4,008 8	399,96	17,95
liquid	60	2,614 5	545,3	487,08	491,87	1,951 9	2,747 5	5,242 4	1 065,6	0,063 6
vapour			20,484	1 362,04	1 489,67	4,947	2,498 9	4,212 6	398,09	16,97
liquid	65	2,948 1	536	512,7	518,2	2,028 5	2,747	5,348 6	1 024,4	0,096 8
vapour			23,274	1 360,81	1 487,48	4,895	2,556 2	4,443 4	395,84	16,06
liquid	70	3,312 5	526,3	538,72	545,02	2,105 2	2,747 9	5,471 6	982,4	0,135
vapour			26,404	1 358,86	1 484,31	4,842 5	2,615 9	4,707 4	393,21	15,21
liquid	75	3,709 6	516,3	565,19	572,38	2,182 2	2,750 2	5,615 7	939,5	0,179 1
vapour			29,924	1 356,08	1 480,05	4,789 3	2,678 1	5,013	390,16	14,41
liquid	80	4,141 3	505,7	592,18	600,37	2,259 6	2,754 3	5,787	895,6	0,230 7
vapour			33,892	1 352,38	1 474,57	4,735 1	2,743 1	5,371 4	386,66	13,66
liquid	85	4,609 5	494,6	619,77	629,08	2,337 7	2,760 5	5,993 8	850,5	0,291 6
vapour			38,384	1 347,63	1 467,72	4,679 3	2,811 2	5,798 4	382,67	12,95
liquid	90	5,116 4	482,8	648,06	658,65	2,416 8	2,769 4	6,248 9	804,2	0,364 5
vapour			43,493	1 341,68	1 459,32	4,621 6	2,882 8	6,317	378,14	12,27
liquid	95	5,664 1	470,3	677,19	689,24	2,497 3	2,781 7	6,571 6	756,3	0,453 2
vapour			49,346	1 334,32	1 449,1	4,561 3	2,958 3	6,962	373,02	11,62
liquid	100	6,255 1	456,8	707,37	721,07	2,579 8	2,798 3	6,993 3	706,7	0,563 1
vapour			56,112	1 325,26	1 436,74	4,497 7	3,038 3	7,788 8	367,24	10,99
liquid	105	6,891 9	442,1	738,88	754,47	2,664 9	2,820 8	7,568 6	654,9	0,702 7
vapour			64,035	1 314,12	1 421,74	4,429 5	3,122 9	8,892 4	360,7	10,38
liquid	110	7,577 5	425,7	772,13	789,93	2,753 9	2,851 5	8,4	600,8	0,885 1
vapour			73,481	1 300,29	1 403,41	4,355 1	3,212 8	10,454 7	353,3	9,77
liquid	115	8,315 1	407,1	807,81	828,23	2,848 6	2,894 4	9,706 7	543,8	1,132 6
vapour			85,052	1 282,79	1 380,55	4,271 6	3,312 7	12,884 2	344,87	9,15

[a] Triple point

[b] Normal boiling point

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

Table 10 *(continued)*

	Temp. °C	Pressure MPa	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
liquid	120	9,108 8	385,1	847,17	870,82	2,952 5	2,957 5	12,060 4	483	1,487 5
vapour			99,866	1 259,78	1 350,99	4,173 8	3,441 6	17,313	334,87	8,47
liquid	125	9,963 8	357,1	893,01	920,91	3,073 3	3,072 6	17,636 5	414,5	2,051 1
vapour			120,494	1 227,07	1 309,76	4,049 9	3,667 7	28,268 5	321,42	7,64
liquid	130	10,888 3	313,4	955,79	990,53	3,240 1	3,557 2	50,546 8	313	3,245
vapour			156,733	1 168,91	1 238,38	3,854 9	4,384 7	96,671	294,02	6,36
critical	132,41	11,363 4	233,3	1 053,41	1 102,13	3,511 7	*	*	*	4,950 6

[a] Triple point

[b] Normal boiling point

* The values of C_v, C_p, and w at the critical point are not included as part of this document.

5.4 R12 — Dichlorodifluoromethane

5.4.1 Range of validity

The coefficients are valid within the following ranges:

T_{min} = 116,099 K, T_{max} = 525 K; p_{max} = 200 MPa; ρ_{max} = 15,13 mol/l (1 829 kg/m³)

Coefficients and exponents of the ideal-gas part are listed in Table 11. Coefficients and exponents of the real-gas part are listed in Table 12.

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

k	c_k	a_k	b_k
0	4,003 638 529	—	—
1	—	3,160 638 395	1 433,434 2
2	—	0,371 259 877 4	2 430,049 8
3	—	3,562 277 099	685,659 52
4	—	2,121 533 311	412,415 79

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

k	N_k	t_k	d_k	l_k	α_k
1	$0{,}207\,534\,340\,2 \times 10^{1}$	0,5	1	0	0
2	$-0{,}296\,252\,599\,6 \times 10^{1}$	1	1	0	0
3	$0{,}100\,158\,961\,6 \times 10^{-1}$	2	1	0	0
4	$0{,}178\,134\,761\,2 \times 10^{-1}$	2,5	2	0	0
5	$0{,}255\,692\,915\,7 \times 10^{-1}$	−0,5	4	0	0
6	$0{,}235\,214\,263\,7 \times 10^{-2}$	0	6	0	0
7	$-0{,}849\,555\,331\,4 \times 10^{-4}$	0	8	0	0
8	$-0{,}153\,594\,559\,9 \times 10^{-1}$	−0,5	1	1	1
9	−0,210 881 677 6	1,5	1	1	1
10	$-0{,}165\,422\,880\,6 \times 10^{-1}$	2,5	5	1	1
11	$-0{,}118\,131\,613\,0 \times 10^{-1}$	−0,5	7	1	1
12	$-0{,}416\,029\,583\,0 \times 10^{-4}$	0	12	1	1

Table 12 *(continued)*

k	N_k	t_k	d_k	l_k	α_k
13	$0{,}278\,486\,166\,4 \times 10^{-4}$	0,5	12	1	1
14	$0{,}161\,868\,643\,3 \times 10^{-5}$	−0,5	14	1	1
15	−0,106 461 468 6	4	1	2	1
16	$0{,}936\,966\,520\,7 \times 10^{-3}$	4	9	2	1
17	$0{,}259\,009\,544\,7 \times 10^{-1}$	2	1	3	1
18	$-0{,}434\,702\,502\,5 \times 10^{-1}$	4	1	3	1
19	0,101 230 844 9	12	3	3	1
20	−0,110 000 343 8	14	3	3	1
21	$-0{,}336\,101\,200\,9 \times 10^{-2}$	0	5	3	1
22	$0{,}378\,919\,000\,8 \times 10^{-3}$	14	9	4	1

5.4.2 Reducing parameters, molar mass, and gas constant

T^* = 385,12 K, ρ^* = 4,672 781 mol/l, M = 120,913 g/mol, R = 8,314 471 J/(mol·K)

5.4.3 Reference state parameters

T_{ref} = 273,15 K, p_{ref} = 1,0 kPa, h_{ref} = 43 261,068 J/mol, s_{ref} = 237,753 2 J/(mol·K), f_1 = 1,622 697 55, f_2 = 3 621,284 29

R12 property values along the liquid-vapour saturation boundary are listed in Table 13.

Table 13 — R12 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	MPa	kg/m³	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
liquid	−157,05[a]	$2{,}426\times10^{-7}$	1 828,8	66,33	66,33	0,278 0	0,572 5	0,856 1	1 310,0	−0,530 5
vapour			$3{,}038 \times 10^{-5}$	275,23	283,21	2,146 1	0,286 0	0,354 8	99,51	532,60
liquid	−155,00	$3{,}883\times10^{-7}$	1 823,4	68,08	68,08	0,293 0	0,567 4	0,851 0	1 299,6	−0,533 3
vapour			$4{,}779 \times 10^{-5}$	275,82	283,94	2,120 0	0,289 4	0,358 2	100,27	495,55
liquid	−150,00	$1{,}135\times10^{-6}$	1 810,1	72,31	72,31	0,328 0	0,556 7	0,840 4	1 274,4	−0,538 9
vapour			$1{,}340 \times 10^{-4}$	277,29	285,75	2,061 2	0,297 8	0,366 5	102,10	418,14
liquid	−145,00	$3{,}019\times10^{-6}$	1 796,9	76,49	76,49	0,361 3	0,548 2	0,832 1	1 249,5	−0,543 0
vapour			$3{,}426 \times 10^{-4}$	278,80	287,61	2,008 7	0,306 2	0,374 9	103,88	355,64
liquid	−140,00	$7{,}387\times10^{-6}$	1 783,7	80,63	80,63	0,393 0	0,541 5	0,825 7	1 224,8	−0,545 8
vapour			$8{,}068 \times 10^{-4}$	280,35	289,50	1,961 7	0,314 6	0,383 3	105,63	304,78
liquid	−135,00	$1{,}680\times10^{-5}$	1 770,6	84,75	84,75	0,423 4	0,536 3	0,821 0	1 200,3	−0,547 3
vapour			$1{,}768 \times 10^{-3}$	281,94	291,44	1,919 5	0,322 9	0,391 7	107,34	263,05
liquid	−130,00	$3{,}577\times10^{-5}$	1 757,5	88,85	88,85	0,452 5	0,532 4	0,817 7	1 176,0	−0,547 6
vapour			$3{,}635 \times 10^{-3}$	283,57	293,42	1,881 6	0,331 3	0,400 1	109,02	228,57
liquid	−125,00	$7{,}189\times10^{-5}$	1 744,5	92,93	92,93	0,480 5	0,529 6	0,815 7	1 152,0	−0,546 9
vapour			$7{,}058 \times 10^{-3}$	285,25	295,44	1,847 4	0,339 6	0,408 4	110,67	199,86
liquid	−120,00	0,000 137	1 731,4	97,01	97,01	0,507 6	0,527 7	0,814 6	1 128,1	−0,545 3

[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 document.

Table 13 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
vapour			0,013 03	286,96	297,49	1,816 7	0,347 8	0,416 6	112,29	175,81
liquid	−115,00	0,000 250	1 718,4	101,08	101,08	0,533 8	0,526 6	0,814 5	1 104,5	−0,542 8
vapour			0,022 97	288,72	299,59	1,789 0	0,355 9	0,424 8	113,89	155,54
liquid	−110,00	0,000 436	1 705,3	105,15	105,15	0,559 1	0,526 3	0,815 2	1 081,1	−0,539 5
vapour			0,038 87	290,51	301,72	1,764 0	0,364 0	0,433 0	115,45	138,34
liquid	−105,00	0,000 732	1 692,2	109,23	109,23	0,583 8	0,526 5	0,816 6	1 058,0	−0,535 5
vapour			0,063 39	292,34	303,89	1,741 4	0,371 9	0,441 0	116,99	123,68
liquid	−100,00	0,001 19	1 679,1	113,32	113,32	0,607 7	0,527 2	0,818 6	1 035,0	−0,530 8
vapour			0,100 0	294,20	306,09	1,721 0	0,379 8	0,449 1	118,49	111,11
liquid	−95,00	0,001 87	1 666,0	117,42	117,42	0,631 0	0,528 3	0,821 1	1 012,2	−0,525 4
vapour			0,152 9	296,10	308,32	1,702 6	0,387 6	0,457 1	119,96	100,28
liquid	−90,00	0,002 86	1 652,8	121,53	121,53	0,653 8	0,529 8	0,824 1	989,7	−0,519 4
vapour			0,227 5	298,03	310,59	1,686 1	0,395 3	0,465 0	121,39	90,92
liquid	−85,00	0,004 26	1 639,6	125,66	125,66	0,676 1	0,531 6	0,827 5	967,3	−0,512 8
vapour			0,330 2	299,98	312,87	1,671 1	0,403 0	0,473 0	122,79	82,78
liquid	−80,00	0,006 19	1 626,3	129,80	129,81	0,697 8	0,533 7	0,831 3	945,2	−0,505 5
vapour			0,468 3	301,97	315,19	1,657 6	0,410 5	0,481 0	124,14	75,69
liquid	−75,00	0,008 81	1 612,9	133,97	133,98	0,719 1	0,536 1	0,835 5	923,3	−0,497 7
vapour			0,650 3	303,98	317,52	1,645 4	0,418 1	0,489 0	125,45	69,49
liquid	−70,00	0,012 3	1 599,5	138,16	138,17	0,740 0	0,538 6	0,840 0	901,5	−0,489 2
vapour			0,886	306,01	319,87	1,634 4	0,425 5	0,497 1	126,71	64,05
liquid	−65,00	0,016 8	1 586,0	142,37	142,38	0,760 4	0,541 3	0,844 8	879,9	−0,480 1
vapour			1,186	308,07	322,24	1,624 5	0,433 0	0,505 2	127,91	59,26
liquid	−60,00	0,022 6	1 572,3	146,60	146,62	0,780 6	0,544 2	0,849 9	858,5	−0,470 3
vapour			1,563	310,14	324,61	1,615 6	0,440 3	0,513 4	129,06	55,03
liquid	−55,00	0,030 0	1 558,6	150,87	150,88	0,800 3	0,547 2	0,855 3	837,3	−0,459 8
vapour			2,029	312,23	327,00	1,607 6	0,447 7	0,521 8	130,15	51,29
liquid	−50,00	0,039 1	1 544,7	155,15	155,18	0,819 7	0,550 3	0,860 9	816,2	−0,448 6
vapour			2,598	314,34	329,39	1,600 4	0,455 0	0,530 2	131,17	47,97
liquid	−45,00	0,050 4	1 530,7	159,47	159,50	0,838 9	0,553 5	0,866 8	795,3	−0,436 6
vapour			3,286	316,45	331,79	1,594 0	0,462 4	0,538 9	132,11	45,01
liquid	−40,00	0,064 1	1 516,5	163,81	163,86	0,857 7	0,556 8	0,873 0	774,5	−0,423 7
vapour			4,108	318,58	334,18	1,588 2	0,469 7	0,547 7	132,99	42,38
liquid	−35,00	0,080 6	1 502,2	168,19	168,24	0,876 3	0,560 2	0,879 5	753,8	−0,409 9
vapour			5,083	320,71	336,56	1,583 1	0,477 0	0,556 8	133,78	40,02
liquid	−30,00	0,100 3	1 487,7	172,60	172,67	0,894 6	0,563 6	0,886 3	733,3	−0,395 1
vapour			6,228	322,84	338,94	1,578 4	0,484 3	0,566 1	134,49	37,90
liquid	−29,75[b]	0,101 3	1 487,0	172,82	172,89	0,895 5	0,563 7	0,886 6	732,3	−0,394 3
vapour			6,289	322,95	339,06	1,578 2	0,484 7	0,566 6	134,52	37,81
liquid	−25,00	0,123 5	1 473,0	177,04	177,12	0,912 7	0,567 0	0,893 4	712,9	−0,379 2
vapour			7,563	324,98	341,30	1,574 3	0,491 7	0,575 7	135,10	36,00

[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 document.

Table 13 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
liquid	−20,00	0,150 7	1 458,1	181,51	181,62	0,930 5	0,570 5	0,900 7	692,5	−0,362 0
vapour			9,109	327,11	343,65	1,570 6	0,499 0	0,585 7	135,63	34,29
liquid	−15,00	0,182 3	1 443,0	186,02	186,15	0,948 2	0,574 1	0,908 5	672,3	−0,343 4
vapour			10,889	329,24	345,98	1,567 3	0,506 4	0,596 0	136,05	32,75
liquid	−10,00	0,218 8	1 427,6	190,57	190,72	0,965 6	0,577 6	0,916 6	652,1	−0,323 3
vapour			12,925	331,36	348,29	1,564 4	0,513 9	0,606 8	136,38	31,35
liquid	−5,00	0,260 6	1 412,0	195,15	195,34	0,982 9	0,581 2	0,925 1	632,0	−0,301 5
vapour			15,244	333,47	350,56	1,561 8	0,521 3	0,618 0	136,59	30,09
liquid	0,00	0,308 1	1 396,1	199,78	200,00	1,000 0	0,584 9	0,934 1	611,9	−0,277 7
vapour			17,873	335,56	352,81	1,559 4	0,528 9	0,629 8	136,69	28,94
liquid	5,00	0,362 0	1 379,8	204,45	204,71	1,016 9	0,588 5	0,943 6	591,9	−0,251 6
vapour			20,842	337,64	355,01	1,557 3	0,536 5	0,642 3	136,68	27,91
liquid	10,00	0,422 7	1 363,2	209,15	209,46	1,033 7	0,592 2	0,953 7	571,8	−0,223 0
vapour			24,184	339,70	357,18	1,555 4	0,544 1	0,655 5	136,54	26,97
liquid	15,00	0,490 6	1 346,3	213,91	214,27	1,050 4	0,596 0	0,964 5	551,8	−0,191 5
vapour			27,935	341,73	359,30	1,553 7	0,551 9	0,669 6	136,28	26,11
liquid	20,00	0,566 4	1 328,9	218,71	219,14	1,066 9	0,599 7	0,976 1	531,7	−0,156 5
vapour			32,135	343,73	361,36	1,552 1	0,559 7	0,684 6	135,88	25,34
liquid	25,00	0,650 6	1 311,0	223,56	224,06	1,083 4	0,603 6	0,988 5	511,5	−0,117 6
vapour			36,828	345,70	363,37	1,550 6	0,567 6	0,700 8	135,34	24,65
liquid	30,00	0,743 7	1 292,7	228,47	229,04	1,099 7	0,607 5	1,002 1	491,3	−0,074 0
vapour			42,066	347,63	365,31	1,549 2	0,575 7	0,718 4	134,65	24,02
liquid	35,00	0,846 2	1 273,8	233,43	234,10	1,116 0	0,611 4	1,016 9	471,0	−0,024 8
vapour			47,906	349,51	367,18	1,547 8	0,583 8	0,737 7	133,82	23,46
liquid	40,00	0,958 8	1 254,3	238,46	239,22	1,132 2	0,615 5	1,033 2	450,5	0,031 1
vapour			54,416	351,34	368,96	1,546 5	0,592 1	0,758 9	132,82	22,96
liquid	45,00	1,082 1	1 234,0	243,55	244,42	1,148 4	0,619 7	1,051 4	429,7	0,095 0
vapour			61,673	353,11	370,66	1,545 1	0,600 6	0,782 7	131,65	22,52
liquid	50,00	1,216 6	1 213,0	248,71	249,71	1,164 5	0,624 2	1,071 9	408,8	0,168 8
vapour			69,771	354,81	372,24	1,543 7	0,609 3	0,809 5	130,30	22,14
liquid	55,00	1,363 0	1 191,1	253,95	255,10	1,180 7	0,628 8	1,095 3	387,5	0,254 9
vapour			78,823	356,42	373,72	1,542 1	0,618 2	0,840 4	128,76	21,81
liquid	60,00	1,521 9	1 168,1	259,28	260,58	1,196 9	0,633 8	1,122 5	365,9	0,356 5
vapour			88,966	357,94	375,05	1,540 4	0,627 4	0,876 3	127,02	21,54
liquid	65,00	1,694 1	1 144,0	264,71	266,19	1,213 1	0,639 1	1,154 5	343,9	0,478 3
vapour			100,375	359,35	376,23	1,538 5	0,637 0	0,919 1	125,07	21,31
liquid	70,00	1,880 2	1 118,3	270,26	271,94	1,229 5	0,645 0	1,193 1	321,3	0,626 4
vapour			113,272	360,62	377,22	1,536 3	0,647 1	0,971 4	122,88	21,14
liquid	75,00	2,081 1	1 090,9	275,94	277,84	1,246 1	0,651 7	1,241 0	298,1	0,810 3
vapour			127,952	361,72	377,99	1,533 7	0,657 8	1,037 0	120,44	21,01
liquid	80,00	2,297 5	1 061,4	281,78	283,94	1,262 9	0,659 4	1,302 4	274,1	1,043 9

[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 document.

Table 13 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
vapour			144,822	362,62	378,48	1,530 6	0,669 3	1,122 5	117,73	20,92
liquid	85,00	2,530 4	1 029,1	287,82	290,27	1,280 1	0,668 4	1,384 4	249,4	1,349 5
vapour			164,464	363,26	378,64	1,526 8	0,681 9	1,239 4	114,73	20,85
liquid	90,00	2,780 8	993,2	294,11	296,91	1,297 8	0,679 5	1,500 6	223,6	1,763 6
vapour			187,766	363,54	378,35	1,522 0	0,696 1	1,410 1	111,41	20,79
liquid	95,00	3,050 1	952,2	300,75	303,95	1,316 3	0,693 6	1,679 4	196,9	2,351 8
vapour			216,208	363,34	377,45	1,515 9	0,712 7	1,683 5	107,75	20,68
liquid	100,00	3,339 9	903,8	307,89	311,58	1,336 0	0,712 2	1,996 3	169,0	3,247 0
vapour			252,577	362,38	375,60	1,507 6	0,733 2	2,192 4	103,73	20,41
liquid	105,00	3,652 5	842,2	315,90	320,24	1,358 1	0,738 7	2,753 9	139,3	4,787 2
vapour			303,473	360,05	372,08	1,495 2	0,761 0	3,457 9	99,28	19,71
liquid	110,00	3,992 4	742,7	326,44	331,82	1,387 4	0,787 0	7,806 1	105,3	8,291 6
vapour			396,337	353,88	363,95	1,471 2	0,808 9	11,440 0	93,96	17,60
critical	111,97	4,136 1	565,0	340,44	347,76	1,428 3	c	c	c	13,369 4

[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 document.

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)

Coefficients and exponents of the ideal-gas part are listed in Table 14. Coefficients and exponents of the real-gas part are listed in Table 15.

Table 14 — Coefficients and exponents of the ideal-gas part [Formulae (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 15 — Coefficients and exponents of the real-gas part [Formula (2)]

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

5.5.2 Reducing parameters, molar mass, and gas constant

T^* = 369,295 K, ρ^* = 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

R22 property values along the liquid-vapour saturation boundary are listed in Table 16.

Table 16 — R22 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	MPa	kg/m³	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
liquid	−157,42[a]	$3,795 \times 10^{-7}$	1 721,3	29,60	29,60	0,076 1	0,716 1	1,075 3	1 410,9	−0,444 6
vapour			$3,410 \times 10^{-5}$	321,58	332,71	2,695 2	0,329 2	0,425 3	119,91	398,80
liquid	−155,00	$6,620 \times 10^{-7}$	1 714,9	32,20	32,20	0,098 3	0,713 9	1,073 5	1 398,2	−0,445 0
vapour			$5,827 \times 10^{-5}$	322,38	333,74	2,650 5	0,331 8	0,428 0	121,05	380,74
liquid	−150,00	$1,934 \times 10^{-6}$	1 701,8	37,56	37,56	0,142 8	0,708 6	1,069 6	1 371,9	−0,445 6
vapour			$1,633 \times 10^{-4}$	324,05	335,90	2,565 3	0,337 5	0,433 6	123,35	344,75
liquid	−145,00	$5,141 \times 10^{-6}$	1 688,8	42,90	42,90	0,185 3	0,702 7	1,066 3	1 346,3	−0,445 6
vapour			$4,172 \times 10^{-4}$	325,76	338,08	2,488 7	0,343 3	0,439 4	125,60	311,19
liquid	−140,00	$1,258 \times 10^{-5}$	1 675,8	48,22	48,22	0,226 0	0,697 2	1,064 1	1 321,4	−0,444 9
vapour			$9,826 \times 10^{-4}$	327,49	340,29	2,419 5	0,349 2	0,445 4	127,78	280,46
liquid	−135,00	$2,860 \times 10^{-5}$	1 662,8	53,54	53,54	0,265 2	0,692 3	1,062 8	1 296,8	−0,443 6
vapour			$2,153 \times 10^{-3}$	329,25	342,53	2,357 1	0,355 2	0,451 4	129,92	252,63
liquid	−130,00	$6,091 \times 10^{-5}$	1 649,8	58,85	58,85	0,303 0	0,688 2	1,062 2	1 272,4	−0,441 7
vapour			$4,426 \times 10^{-3}$	331,04	344,80	2,300 5	0,361 4	0,457 6	132,01	227,61
liquid	−125,00	0,000 122	1 636,8	64,16	64,16	0,339 5	0,684 7	1,062 0	1 248,0	−0,439 6
vapour			0,008 59	332,85	347,10	2,249 2	0,367 6	0,463 9	134,05	205,23
liquid	−120,00	0,000 233	1 623,7	69,47	69,47	0,374 7	0,681 5	1,061 9	1 223,7	−0,437 2
vapour			0,015 85	334,70	349,42	2,202 7	0,373 9	0,470 3	136,04	185,26
liquid	−115,00	0,000 424	1 610,7	74,78	74,78	0,408 8	0,678 6	1,061 8	1 199,5	−0,434 6
vapour			0,027 92	336,57	351,77	2,160 3	0,380 3	0,476 8	137,99	167,49
liquid	−110,00	0,000 740	1 597,6	80,09	80,09	0,441 9	0,675 9	1,061 6	1 175,4	−0,431 9
vapour			0,047 19	338,48	354,15	2,121 7	0,386 8	0,483 4	139,90	151,69
liquid	−105,00	0,001 24	1 584,5	85,40	85,40	0,473 9	0,673 2	1,061 4	1 151,4	−0,428 9
vapour			0,076 8	340,40	356,55	2,086 5	0,393 4	0,490 2	141,76	137,65
liquid	−100,00	0,002 01	1 571,3	90,70	90,71	0,505 0	0,670 6	1,061 2	1 127,5	−0,425 7
vapour			0,121 0	342,35	358,97	2,054 3	0,400 0	0,497 2	143,57	125,17
liquid	−95,00	0,003 16	1 558,1	96,01	96,01	0,535 2	0,668 0	1,061 1	1 103,7	−0,422 1
vapour			0,184 7	344,32	361,40	2,024 9	0,406 7	0,504 4	145,34	114,07
liquid	−90,00	0,004 81	1 544,9	101,31	101,32	0,564 6	0,665 5	1,061 2	1 080,1	−0,418 0
vapour			0,274 4	346,31	363,85	1,998 0	0,413 6	0,511 8	147,05	104,20
liquid	−85,00	0,007 15	1 531,6	106,62	106,63	0,593 2	0,663 2	1,061 6	1 056,6	−0,413 4
vapour			0,397 3	348,31	366,31	1,973 4	0,420 6	0,519 5	148,70	95,41
liquid	−80,00	0,010 4	1 518,2	111,93	111,94	0,621 0	0,661 1	1,062 4	1 033,1	−0,408 2
vapour			0,562	350,33	368,77	1,950 8	0,427 7	0,527 6	150,29	87,58
liquid	−75,00	0,014 7	1 504,7	117,24	117,25	0,648 2	0,659 2	1,063 7	1 009,8	−0,402 3
vapour			0,779	352,36	371,24	1,930 0	0,435 0	0,535 9	151,82	80,60
liquid	−70,00	0,020 5	1 491,2	122,56	122,58	0,674 7	0,657 5	1,065 5	986,4	−0,395 6

[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 document.

Table 16 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
vapour			1,060	354,39	373,70	1,910 8	0,442 5	0,544 7	153,28	74,36
liquid	−65,00	0,027 9	1 477,5	127,90	127,91	0,700 6	0,656 2	1,067 9	963,2	−0,388 1
vapour			1,416	356,42	376,15	1,893 2	0,450 2	0,553 9	154,66	68,78
liquid	−60,00	0,037 5	1 463,7	133,24	133,27	0,726 0	0,655 2	1,071 0	939,9	−0,379 6
vapour			1,863	358,46	378,59	1,877 0	0,458 1	0,563 7	155,97	63,78
liquid	−55,00	0,049 6	1 449,7	138,60	138,63	0,750 9	0,654 6	1,074 8	916,6	−0,370 2
vapour			2,414	360,49	381,02	1,861 9	0,466 2	0,573 9	157,18	59,29
liquid	−50,00	0,064 5	1 435,6	143,98	144,03	0,775 2	0,654 3	1,079 3	893,4	−0,359 7
vapour			3,088	362,52	383,42	1,848 0	0,474 5	0,584 7	158,31	55,26
liquid	−45,00	0,082 9	1 421,3	149,38	149,44	0,799 2	0,654 4	1,084 5	870,1	−0,348 1
vapour			3,901	364,53	385,79	1,835 1	0,483 1	0,596 2	159,33	51,63
liquid	−40,81[b]	0,101 3	1 409,2	153,93	154,00	0,818 9	0,654 8	1,089 5	850,6	−0,337 5
vapour			4,704	366,21	387,75	1,825 0	0,490 4	0,606 3	160,11	48,85
liquid	−40,00	0,105 2	1 406,8	154,81	154,89	0,822 7	0,654 9	1,090 5	846,9	−0,335 3
vapour			4,873	366,53	388,13	1,823 1	0,491 9	0,608 3	160,26	48,34
liquid	−30,00	0,163 9	1 377,2	165,76	165,88	0,868 7	0,657 0	1,104 9	800,3	−0,305 7
vapour			7,379	370,48	392,69	1,801 5	0,510 3	0,634 9	161,78	42,68
liquid	−25,00	0,201 4	1 362,0	171,29	171,44	0,891 2	0,658 5	1,113 4	777,0	−0,288 7
vapour			8,958	372,42	394,90	1,791 8	0,519 9	0,649 5	162,36	40,24
liquid	−20,00	0,245 3	1 346,5	176,86	177,04	0,913 5	0,660 4	1,122 7	753,6	−0,270 0
vapour			10,790	374,33	397,06	1,782 6	0,529 9	0,665 0	162,82	38,01
liquid	−15,00	0,296 2	1 330,8	182,47	182,70	0,935 4	0,662 6	1,132 8	730,2	−0,249 5
vapour			12,901	376,20	399,16	1,774 0	0,540 0	0,681 6	163,15	35,98
liquid	−10,00	0,354 8	1 314,7	188,13	188,40	0,957 2	0,665 1	1,143 9	706,8	−0,227 0
vapour			15,322	378,04	401,20	1,765 8	0,550 5	0,699 4	163,35	34,13
liquid	−5,00	0,421 8	1 298,3	193,85	194,17	0,978 7	0,668 0	1,156 1	683,4	−0,202 3
vapour			18,086	379,84	403,16	1,758 1	0,561 3	0,718 4	163,40	32,44
liquid	0,00	0,498 0	1 281,5	199,61	200,00	1,000 0	0,671 1	1,169 2	659,9	−0,175 0
vapour			21,229	381,59	405,05	1,750 7	0,572 3	0,739 0	163,31	30,89
liquid	5,00	0,584 1	1 264,3	205,44	205,90	1,021 2	0,674 5	1,183 6	636,3	−0,144 8
vapour			24,792	383,29	406,85	1,743 6	0,583 6	0,761 1	163,06	29,48
liquid	10,00	0,680 9	1 246,7	211,32	211,87	1,042 2	0,678 2	1,199 3	612,7	−0,111 2
vapour			28,820	384,93	408,56	1,736 8	0,595 3	0,785 2	162,65	28,18
liquid	15,00	0,789 3	1 228,6	217,28	217,92	1,063 0	0,682 2	1,216 6	588,9	−0,073 7
vapour			33,362	386,51	410,16	1,730 2	0,607 2	0,811 5	162,07	26,99
liquid	20,00	0,910 0	1 209,9	223,31	224,06	1,083 8	0,686 4	1,235 6	565,1	−0,031 6
vapour			38,477	388,01	411,66	1,723 8	0,619 5	0,840 4	161,32	25,90
liquid	25,00	1,043 9	1 190,7	229,41	230,29	1,104 5	0,690 9	1,256 8	541,1	0,016 1
vapour			44,232	389,43	413,03	1,717 4	0,632 1	0,872 4	160,38	24,90
liquid	30,00	1,191 9	1 170,7	235,61	236,62	1,125 2	0,695 6	1,280 7	516,8	0,070 4
vapour			50,705	390,76	414,26	1,711 1	0,645 0	0,908 1	159,25	23,98
liquid	35,00	1,354 8	1 150,1	241,89	243,07	1,145 8	0,700 6	1,307 7	492,4	0,133 1
vapour			57,988	391,98	415,34	1,704 8	0,658 4	0,948 5	157,91	23,14
liquid	40,00	1,533 6	1 128,5	248,29	249,65	1,166 5	0,705 9	1,338 9	467,6	0,206 0

[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 document.

Table 16 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m³	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
vapour			66,193	393,08	416,25	1,698 5	0,672 2	0,994 8	156,36	22,37
liquid	45,00	1,729 2	1 106,0	254,80	256,36	1,187 2	0,711 6	1,375 5	442,5	0,291 9
vapour			75,457	394,04	416,95	1,691 9	0,686 5	1,048 7	154,58	21,66
liquid	50,00	1,942 7	1 082,3	261,45	263,25	1,208 0	0,717 6	1,419 1	417,0	0,394 5
vapour			85,952	394,83	417,44	1,685 2	0,701 4	1,112 6	152,56	21,01
liquid	55,00	2,175 1	1 057,2	268,26	270,32	1,229 1	0,724 0	1,472 4	390,9	0,519 0
vapour			97,899	395,43	417,65	1,678 1	0,717 0	1,190 2	150,28	20,41
liquid	60,00	2,427 5	1 030,4	275,26	277,61	1,250 4	0,730 8	1,539 2	364,3	0,673 0
vapour			111,591	395,80	417,55	1,670 5	0,733 5	1,287 2	147,72	19,85
liquid	65,00	2,701 2	1 001,4	282,49	285,18	1,272 2	0,738 4	1,625 9	337,0	0,867 4
vapour			127,430	395,87	417,06	1,662 2	0,751 1	1,412 8	144,85	19,32
liquid	70,00	2,997 4	969,7	290,01	293,10	1,294 5	0,746 7	1,743 4	308,8	1,119 9
vapour			145,991	395,56	416,09	1,652 9	0,770 2	1,583 7	141,66	18,81
liquid	75,00	3,317 7	934,4	297,91	301,46	1,317 7	0,756 3	1,912 7	279,6	1,459 8
vapour			168,158	394,76	414,49	1,642 4	0,791 4	1,832 2	138,11	18,28
liquid	80,00	3,663 8	893,7	306,34	310,44	1,342 3	0,768 0	2,181 4	248,8	1,942 0
vapour			195,404	393,26	412,01	1,629 9	0,815 7	2,230 8	134,15	17,70
liquid	85,00	4,037 8	844,8	315,60	320,38	1,369 0	0,784 0	2,682 1	215,3	2,684 3
vapour			230,560	390,67	408,19	1,614 2	0,845 0	2,984 1	129,71	16,98
liquid	90,00	4,442 3	780,1	326,39	332,09	1,400 1	0,811 5	3,981 1	177,0	4,000 6
vapour			280,625	386,04	401,87	1,592 2	0,884 3	4,974 9	124,64	15,90
liquid	95,00	4,882 4	662,9	342,19	349,56	1,446 2	0,891 8	17,312 0	128,0	7,285 5
vapour			382,037	374,50	387,28	1,548 6	0,956 6	25,286 3	117,96	13,40
critical	96,15	4,990 0	523,8	357,37	366,90	1,492 7	c	c	c	10,366 1

[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 document.

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/m³)

Coefficients and exponents of the ideal-gas part are listed in Table 17. Coefficients and exponents of the real-gas part are listed in Table 18.

Table 17 — Coefficients and exponents of the ideal-gas part [Formulae (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 18 — Coefficients and exponents of the real-gas part [Formula (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, ρ^* = 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

R32 property values along the liquid-vapour saturation boundary are listed in Table 19.

Table 19 — R32 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	MPa	kg/m³	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
liquid	−136,81[a]	$4{,}800\times10^{-5}$	1 429,3	−19,07	−19,07	−0,105 0	1,065 8	1,592 5	1 414,4	−0,337 6
vapour			$2{,}203\times10^{-3}$	422,52	444,31	3,293 7	0,499 5	0,659 7	169,60	881,12
liquid	−135,00	$6{,}339\times10^{-5}$	1 424,9	−16,19	−16,19	−0,084 0	1,061 3	1,590 0	1 404,9	−0,337 5
vapour			$2{,}872\times10^{-3}$	423,42	445,49	3,257 9	0,500 7	0,660 9	170,67	823,35
liquid	−130,00	0,000 131	1 412,7	−8,26	−8,26	−0,027 6	1,049 4	1,583 5	1 378,4	−0,336 9
vapour			0,005 74	425,90	448,77	3,165 1	0,504 1	0,664 6	173,59	686,24
liquid	−125,00	0,000 257	1 400,6	−0,36	−0,36	0,026 7	1,038 0	1,577 7	1 352,1	−0,335 9
vapour			0,010 85	428,39	452,05	3,080 4	0,508 0	0,668 9	176,44	576,21

[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 document.

Table 19 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
liquid	−120,00	0,000 478	1 388,4	7,52	7,52	0,079 0	1,027 4	1,572 6	1 325,8	−0,334 5
vapour			0,019 54	430,88	455,33	3,003 0	0,512 3	0,673 8	179,21	487,31
liquid	−115,00	0,000 850	1 376,1	15,37	15,37	0,129 4	1,017 3	1,568 2	1 299,5	−0,332 7
vapour			0,033 69	433,37	458,60	2,932 0	0,517 3	0,679 6	181,91	415,01
liquid	−110,00	0,001 45	1 363,8	23,20	23,20	0,178 2	1,007 9	1,564 7	1 273,4	−0,330 4
vapour			0,055 8	435,85	461,86	2,866 8	0,522 9	0,686 3	184,52	355,78
liquid	−105,00	0,002 39	1 351,5	31,02	31,02	0,225 4	0,999 1	1,561 9	1 247,3	−0,327 7
vapour			0,089 4	438,32	465,10	2,806 8	0,529 3	0,694 0	187,05	306,92
liquid	−100,00	0,003 81	1 339,0	38,82	38,83	0,271 1	0,991 0	1,560 0	1 221,2	−0,324 4
vapour			0,138 5	440,77	468,31	2,751 5	0,536 5	0,703 0	189,50	266,28
liquid	−95,00	0,005 90	1 326,5	46,62	46,62	0,315 5	0,983 4	1,558 8	1 195,3	−0,320 5
vapour			0,208 4	443,20	471,48	2,700 3	0,544 6	0,713 4	191,84	232,23
liquid	−90,00	0,008 87	1 313,9	54,41	54,42	0,358 6	0,976 4	1,558 6	1 169,3	−0,316 0
vapour			0,305 6	445,59	474,61	2,652 9	0,553 8	0,725 4	194,09	203,45
liquid	−85,00	0,013 0	1 301,2	62,20	62,21	0,400 6	0,970 0	1,559 2	1 143,4	−0,310 9
vapour			0,438	447,96	477,70	2,608 9	0,564 1	0,739 0	196,24	178,95
liquid	−80,00	0,018 7	1 288,4	70,00	70,02	0,441 5	0,964 1	1,560 6	1 117,5	−0,305 1
vapour			0,613	450,29	480,72	2,567 9	0,575 5	0,754 3	198,26	157,95
liquid	−75,00	0,026 2	1 275,4	77,81	77,83	0,481 4	0,958 8	1,563 0	1 091,7	−0,298 6
vapour			0,842	452,57	483,68	2,529 6	0,588 0	0,771 4	200,18	139,85
liquid	−70,00	0,036 1	1 262,4	85,63	85,66	0,520 4	0,954 0	1,566 3	1 065,8	−0,291 3
vapour			1,135	454,81	486,57	2,493 9	0,601 5	0,790 3	201,96	124,19
liquid	−65,00	0,048 8	1 249,1	93,46	93,50	0,558 5	0,949 7	1,570 6	1 039,9	−0,283 1
vapour			1,507	456,99	489,38	2,460 4	0,616 0	0,811 0	203,62	110,58
liquid	−60,00	0,065 0	1 235,7	101,32	101,38	0,595 8	0,946 0	1,575 8	1 014,1	−0,274 0
vapour			1,969	459,12	492,11	2,428 9	0,631 5	0,833 5	205,14	98,73
liquid	−55,00	0,085 2	1 222,1	109,21	109,28	0,632 4	0,942 7	1,582 1	988,2	−0,264 0
vapour			2,538	461,19	494,74	2,399 3	0,647 7	0,857 6	206,52	88,40
liquid	−50,00	0,110 1	1 208,4	117,13	117,22	0,668 3	0,940 0	1,589 5	962,2	−0,252 8
vapour			3,232	463,19	497,27	2,371 4	0,664 6	0,883 5	207,75	79,39
liquid	−51,65[b]	0,101 3	1 212,9	114,51	114,59	0,656 5	0,940 8	1,586 9	970,8	−0,256 6
vapour			2,988	462,54	496,45	2,380 5	0,658 9	0,874 8	207,36	82,23
liquid	−45,00	0,140 6	1 194,4	125,08	125,20	0,703 5	0,937 7	1,598 0	936,3	−0,240 4
vapour			4,067	465,13	499,70	2,345 0	0,682 0	0,911 0	208,83	71,52
liquid	−40,00	0,177 4	1 180,2	133,08	133,23	0,738 2	0,935 9	1,607 7	910,2	−0,226 7
vapour			5,065	466,99	502,02	2,320 0	0,699 8	0,940 1	209,74	64,65
liquid	−35,00	0,221 4	1 165,7	141,12	141,31	0,772 3	0,934 6	1,618 7	884,0	−0,211 5
vapour			6,248	468,78	504,21	2,296 2	0,718 0	0,970 9	210,49	58,63
liquid	−30,00	0,273 4	1 151,0	149,21	149,45	0,806 0	0,933 8	1,631 1	857,8	−0,194 7
vapour			7,639	470,48	506,27	2,273 5	0,736 5	1,003 5	211,07	53,37
liquid	−25,00	0,334 6	1 135,9	157,36	157,66	0,839 2	0,933 4	1,645 1	831,4	−0,176 1

[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 document.

Table 19 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
vapour			9,266	472,09	508,20	2,251 8	0,755 2	1,038 0	211,47	48,75
liquid	−20,00	0,405 8	1 120,6	165,58	165,94	0,872 0	0,933 5	1,660 7	804,9	−0,155 3
vapour			11,157	473,61	509,97	2,231 0	0,774 0	1,074 7	211,68	44,70
liquid	−15,00	0,488 1	1 104,9	173,86	174,31	0,904 4	0,934 1	1,678 3	778,3	−0,132 2
vapour			13,346	475,01	511,58	2,210 9	0,793 0	1,113 9	211,69	41,13
liquid	−10,00	0,582 6	1 088,8	182,23	182,76	0,936 5	0,935 1	1,698 0	751,4	−0,106 3
vapour			15,870	476,31	513,02	2,191 5	0,812 1	1,156 0	211,50	37,98
liquid	−5,00	0,690 6	1 072,2	190,68	191,33	0,968 4	0,936 6	1,720 1	724,3	−0,077 2
vapour			18,769	477,47	514,26	2,172 7	0,831 5	1,201 5	211,10	35,20
liquid	0,00	0,813 1	1 055,3	199,23	200,00	1,000 0	0,938 6	1,745 0	696,9	−0,044 4
vapour			22,091	478,49	515,30	2,154 3	0,851 0	1,251 1	210,48	32,72
liquid	5,00	0,951 4	1 037,7	207,88	208,80	1,031 4	0,941 2	1,773 3	669,2	−0,007 1
vapour			25,891	479,36	516,11	2,136 3	0,870 9	1,305 8	209,63	30,51
liquid	10,00	1,106 9	1 019,7	216,66	217,74	1,062 8	0,944 3	1,805 6	641,2	0,035 4
vapour			30,232	480,05	516,66	2,118 5	0,891 1	1,366 7	208,54	28,54
liquid	15,00	1,280 8	1 000,9	225,56	226,84	1,094 0	0,948 0	1,842 8	612,7	0,084 3
vapour			35,190	480,54	516,93	2,100 8	0,911 8	1,435 3	207,20	26,76
liquid	20,00	1,474 6	981,4	234,62	236,12	1,125 3	0,952 4	1,885 9	583,7	0,141 0
vapour			40,856	480,81	516,90	2,083 1	0,933 1	1,513 6	205,60	25,16
liquid	25,00	1,689 6	961,0	243,84	245,60	1,156 6	0,957 7	1,936 7	554,2	0,207 6
vapour			47,339	480,82	516,51	2,065 2	0,955 0	1,604 5	203,72	23,69
liquid	30,00	1,927 5	939,6	253,27	255,32	1,188 1	0,963 8	1,997 3	524,0	0,286 5
vapour			54,776	480,54	515,72	2,047 1	0,977 9	1,711 8	201,54	22,36
liquid	35,00	2,189 8	917,0	262,92	265,30	1,219 8	0,971 2	2,071 0	493,0	0,381 5
vapour			63,343	479,91	514,48	2,028 5	1,001 9	1,841 2	199,04	21,13
liquid	40,00	2,478 3	893,0	272,84	275,61	1,252 0	0,980 0	2,162 9	461,0	0,497 6
vapour			73,268	478,88	512,71	2,009 1	1,027 2	2,001 2	196,19	19,98
liquid	45,00	2,794 8	867,3	283,09	286,31	1,284 7	0,990 7	2,280 9	428,0	0,642 8
vapour			84,859	477,36	510,29	1,988 8	1,054 2	2,205 6	192,96	18,90
liquid	50,00	3,141 2	839,3	293,74	297,49	1,318 3	1,003 9	2,438 5	393,6	0,828 8
vapour			98,550	475,23	507,10	1,967 0	1,083 4	2,477 3	189,31	17,86
liquid	55,00	3,519 9	808,3	304,93	309,29	1,353 1	1,020 7	2,661 0	357,6	1,075 1
vapour			114,989	472,32	502,93	1,943 2	1,115 6	2,859 4	185,16	16,85
liquid	60,00	3,933 2	773,3	316,84	321,93	1,389 8	1,042 8	3,000 7	319,7	1,415 7
vapour			135,213	468,35	497,44	1,916 6	1,151 9	3,441 2	180,43	15,83
liquid	65,00	4,384 3	732,3	329,81	335,80	1,429 3	1,073 2	3,588 0	279,4	1,916 0
vapour			161,092	462,84	490,05	1,885 5	1,194 7	4,446 2	174,95	14,75
liquid	70,00	4,876 8	680,9	344,57	351,73	1,474 0	1,119 4	4,865 3	235,8	2,723 3
vapour			196,688	454,72	479,52	1,846 4	1,248 8	6,638 8	168,40	13,49
liquid	75,00	5,416 8	605,9	363,45	372,39	1,531 4	1,206 4	10,134 7	186,1	4,309 3
vapour			255,587	440,53	461,72	1,788 0	1,331 0	15,601 6	159,64	11,74

[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 document.

Table 19 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
critical	78,11	5,782 0	424,0	400,51	414,15	1,648 6	c	c	c	8,073 1

[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 document.

5.7 R123 — 2,2–dichloro–1,1,1–trifluoroethane

5.7.1 Range of validity

The coefficients are valid within the following ranges:

T_{min} = 166 K, T_{max} = 600 K; p_{max} = 40 MPa; ρ_{max} = 11,6 mol/l (1 774 kg/m^3)

Coefficients and exponents of the ideal-gas part are listed in Table 20. Coefficients and exponents of the real-gas part are listed in Table 21.

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

k	c_k	t_k
0	2,046 006	—
1	4,866 562 × 10^{-2}	1
2	−5,586 382 × 10^{-5}	2
3	2,823 279 × 10^{-8}	3

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

k	N_k	t_k	d_k	l_k	α_k
1	−0,100 242 647 494 × 10^{2}	3	0	0	0
2	−0,280 607 656 419	4	0	0	0
3	0,206 814 471 606 × 10^{-1}	5	0	0	0
4	−0,284 379 431 451	0	1	0	0
5	0,593 928 110 321 × 10^{1}	0,5	1	0	0
6	−0,936 560 389 528 × 10^{1}	1	1	0	0
7	0,416 660 793 675 × 10^{1}	2	1	0	0
8	−0,174 023 292 951 × 10^{1}	3	1	0	0
9	0,177 019 905 365	0	2	0	0
10	−0,154 721 692 26 × 10^{1}	1	2	0	0
11	0,161 820 495 59 × 10^{1}	2	2	0	0
12	0,288 903 529 383 × 10^{1}	3	2	0	0
13	−0,118 493 874 757	0	3	0	0
14	0,130 952 266 209 × 10^{1}	1	3	0	0
15	−0,117 308 103 711 × 10^{1}	2	3	0	0
16	−0,128 125 131 950	1	4	0	0
17	−0,786 087 387 513 × 10^{-1}	2	5	0	0
18	−0,816 000 499 305 × 10^{-1}	3	5	0	0
19	0,536 451 054 311 × 10^{-1}	2	6	0	0
20	−0,680 078 211 929 × 10^{-2}	2	7	0	0
21	0,701 264 082 191 × 10^{-2}	3	7	0	0
22	−0,901 762 397 311 × 10^{-3}	3	8	0	0

Table 21 *(continued)*

k	N_k	t_k	d_k	l_k	α_k
23	0,100 242 647 494 × 10^{2}	3	0	2	1
24	0,280 607 656 419	4	0	2	1
25	−0,206 814 471 606 × 10^{-1}	5	0	2	1
26	0,798 923 878 145 × 10^{1}	3	2	2	1
27	−0,547 972 072 476	4	2	2	1
28	−0,206 814 470 584 × 10^{-1}	5	2	2	1
29	0,249 142 724 365 × 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 × 10^{-1}	4	6	2	1
34	0,786 672 874 826 × 10^{-1}	5	6	2	1
35	0,708 085 874 508 × 10^{-1}	3	8	2	1
36	−0,150 114 389 748 × 10^{-1}	4	8	2	1
37	0,182 205 199 477 × 10^{-2}	5	8	2	1
38	0,314 978 575 163 × 10^{-2}	3	10	2	1
39	0,784 455 573 794 × 10^{-2}	4	10	2	1
40	0,364 410 397 155 × 10^{-3}	5	10	2	1

5.7.2 Reducing parameters, molar mass, and gas constant

T^* = 456,831 K, ρ^* = 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

R123 property values along the liquid-vapour saturation boundary are listed in Table 22.

Table 22 — 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	MPa	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
liquid	−107,15[a]	4,202×10^{-6}	1 771,0	98,81	98,81	0,531 1	0,629 5	0,928 9	1 243,8	−0,475 5
vapour			4,656×10^{-4}	313,47	322,50	1,878 6	0,419 4	0,473 8	100,97	335,67
liquid	−105,00	5,765×10^{-6}	1 766,0	100,80	100,80	0,543 0	0,630 6	0,928 0	1 235,3	−0,476 2
vapour			6,306×10^{-4}	314,38	323,52	1,867 5	0,423 2	0,477 6	101,57	319,10
liquid	−100,00	1,161×10^{-5}	1 754,5	105,44	105,44	0,570 2	0,632 1	0,926 1	1 215,3	−0,477 2
vapour			1,233×10^{-3}	316,51	325,93	1,843 6	0,431 9	0,486 3	102,95	284,41
liquid	−95,00	2,233×10^{-5}	1 743,2	110,07	110,07	0,596 5	0,632 8	0,924 5	1 195,0	−0,477 5
vapour			2,306×10^{-3}	318,69	328,38	1,822 0	0,440 5	0,494 9	104,31	254,37
liquid	−90,00	4,120×10^{-5}	1 732,0	114,68	114,68	0,622 1	0,633 3	0,923 5	1 174,6	−0,477 1
vapour			4,138×10^{-3}	320,92	330,87	1,802 5	0,449 1	0,503 5	105,65	228,26
liquid	−85,00	7,317×10^{-5}	1 720,8	119,30	119,30	0,647 0	0,633 8	0,923 2	1 153,9	−0,475 9

[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 document.

Table 22 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
vapour			7,154×10^{-3}	323,18	333,41	1,784 9	0,457 5	0,511 9	106,97	205,49
liquid	−80,00	0,000 125	1 709,6	123,92	123,92	0,671 2	0,634 6	0,923 6	1 133,1	−0,474 0
vapour			0,011 95	325,49	335,98	1,769 1	0,465 8	0,520 2	108,27	185,55
liquid	−75,00	0,000 208	1 698,5	128,54	128,54	0,694 8	0,635 6	0,924 7	1 112,1	−0,471 4
vapour			0,019 35	327,83	338,60	1,754 9	0,474 0	0,528 5	109,55	168,05
liquid	−70,00	0,000 336	1 687,4	133,17	133,17	0,717 9	0,637 1	0,926 6	1 091,1	−0,468 1
vapour			0,030 45	330,21	341,25	1,742 2	0,482 1	0,536 7	110,81	152,63
liquid	−65,00	0,000 528	1 676,2	137,80	137,80	0,740 4	0,638 8	0,929 0	1 069,9	−0,464 3
vapour			0,046 66	332,63	343,94	1,730 7	0,490 2	0,544 8	112,06	139,01
liquid	−60,00	0,000 808	1 665,1	142,46	142,46	0,762 5	0,641 0	0,932 0	1 048,7	−0,459 9
vapour			0,069 77	335,09	346,66	1,720 6	0,498 2	0,552 9	113,27	126,94
liquid	−55,00	0,001 21	1 653,9	147,13	147,13	0,784 2	0,643 5	0,935 4	1 027,6	−0,455 0
vapour			0,102 0	337,58	349,42	1,711 5	0,506 1	0,561 0	114,47	116,22
liquid	−50,00	0,001 77	1 642,6	151,81	151,81	0,805 4	0,646 2	0,939 3	1 006,4	−0,449 6
vapour			0,146 1	340,11	352,21	1,703 4	0,513 9	0,569 0	115,64	106,68
liquid	−45,00	0,002 54	1 631,3	156,52	156,52	0,826 3	0,649 3	0,943 5	985,3	−0,443 7
vapour			0,205 2	342,66	355,03	1,696 4	0,521 7	0,577 0	116,78	98,17
liquid	−40,00	0,003 58	1 620,0	161,25	161,25	0,846 8	0,652 6	0,948 0	964,3	−0,437 5
vapour			0,283 1	345,25	357,88	1,690 1	0,529 5	0,585 0	117,90	90,55
liquid	−35,00	0,004 95	1 608,5	166,00	166,00	0,866 9	0,656 1	0,952 8	943,4	−0,430 9
vapour			0,384 3	347,87	360,75	1,684 7	0,537 2	0,593 1	118,98	83,73
liquid	−30,00	0,006 75	1 597,0	170,77	170,78	0,886 8	0,659 7	0,957 8	922,6	−0,423 9
vapour			0,513 6	350,51	363,65	1,680 0	0,544 8	0,601 1	120,03	77,60
liquid	−25,00	0,009 06	1 585,4	175,58	175,58	0,906 3	0,663 5	0,962 9	901,9	−0,416 6
vapour			0,676 7	353,19	366,57	1,676 0	0,552 5	0,609 2	121,04	72,09
liquid	−20,00	0,012 0	1 573,8	180,40	180,41	0,925 6	0,667 4	0,968 2	881,3	−0,408 8
vapour			0,880	355,88	369,52	1,672 6	0,560 1	0,617 4	122,01	67,13
liquid	−15,00	0,015 7	1 562,0	185,26	185,27	0,944 6	0,671 4	0,973 5	860,9	−0,400 7
vapour			1,130	358,60	372,47	1,669 8	0,567 7	0,625 6	122,94	62,65
liquid	−10,00	0,020 2	1 550,1	190,14	190,15	0,963 3	0,675 5	0,979 0	840,7	−0,392 3
vapour			1,435	361,34	375,45	1,667 5	0,575 3	0,633 9	123,82	58,60
liquid	−5,00	0,025 8	1 538,2	195,04	195,06	0,981 8	0,679 7	0,984 6	820,6	−0,383 4
vapour			1,802	364,10	378,44	1,665 6	0,582 8	0,642 3	124,66	54,93
liquid	0,00	0,032 6	1 526,1	199,98	200,00	1,000 0	0,683 9	0,990 2	800,7	−0,374 0
vapour			2,242	366,87	381,44	1,664 2	0,590 4	0,650 8	125,44	51,61
liquid	5,00	0,040 8	1 513,9	204,94	204,97	1,018 0	0,688 1	0,995 9	780,9	−0,364 3
vapour			2,762	369,67	384,44	1,663 3	0,597 9	0,659 4	126,17	48,60
liquid	10,00	0,050 6	1 501,6	209,93	209,97	1,035 8	0,692 4	1,001 7	761,3	−0,354 0
vapour			3,374	372,47	387,46	1,662 6	0,605 5	0,668 2	126,84	45,86
liquid	15,00	0,062 1	1 489,2	214,95	214,99	1,053 4	0,696 7	1,007 6	741,9	−0,343 1
vapour			4,088	375,29	390,48	1,662 4	0,613 0	0,677 1	127,45	43,37

[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 document.

Table 22 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
liquid	20,00	0,075 6	1 476,6	220,00	220,05	1,070 7	0,701 1	1,013 5	722,6	−0,331 6
vapour			4,917	378,12	393,49	1,662 4	0,620 6	0,686 1	127,99	41,10
liquid	25,00	0,091 4	1 463,9	225,08	225,14	1,087 9	0,705 4	1,019 6	703,4	−0,319 5
vapour			5,872	380,95	396,51	1,662 7	0,628 1	0,695 3	128,47	39,03
liquid	27,82[b]	0,101 3	1 456,6	227,96	228,03	1,097 5	0,707 9	1,023 0	692,7	−0,312 3
vapour			6,471	382,56	398,22	1,663 0	0,632 4	0,700 6	128,71	37,95
liquid	30,00	0,109 6	1 451,0	230,18	230,26	1,104 9	0,709 7	1,025 7	684,4	−0,306 6
vapour			6,966	383,80	399,53	1,663 3	0,635 7	0,704 7	128,88	37,15
liquid	35,00	0,130 5	1 438,0	235,32	235,41	1,121 7	0,714 1	1,032 0	665,5	−0,292 9
vapour			8,213	386,64	402,54	1,664 1	0,643 2	0,714 4	129,21	35,43
liquid	40,00	0,154 5	1 424,8	240,48	240,59	1,138 3	0,718 5	1,038 5	646,8	−0,278 2
vapour			9,630	389,49	405,54	1,665 1	0,650 8	0,724 3	129,46	33,86
liquid	45,00	0,181 7	1 411,4	245,68	245,81	1,154 8	0,722 9	1,045 1	628,2	−0,262 5
vapour			11,230	392,35	408,53	1,666 2	0,658 3	0,734 4	129,64	32,42
liquid	50,00	0,212 5	1 397,8	250,91	251,06	1,171 1	0,727 3	1,051 9	609,6	−0,245 6
vapour			13,031	395,20	411,50	1,667 6	0,665 9	0,744 8	129,73	31,11
liquid	55,00	0,247 1	1 384,0	256,17	256,34	1,187 3	0,731 7	1,058 9	591,2	−0,227 4
vapour			15,051	398,04	414,46	1,669 1	0,673 5	0,755 6	129,73	29,91
liquid	60,00	0,285 9	1 370,0	261,46	261,67	1,203 3	0,736 2	1,066 3	572,9	−0,207 6
vapour			17,311	400,88	417,40	1,670 7	0,681 1	0,766 7	129,64	28,82
liquid	65,00	0,329 2	1 355,7	266,78	267,03	1,219 1	0,740 6	1,074 0	554,6	−0,186 1
vapour			19,830	403,72	420,31	1,672 5	0,688 7	0,778 3	129,46	27,82
liquid	70,00	0,377 2	1 341,2	272,14	272,42	1,234 9	0,745 1	1,082 0	536,4	−0,162 7
vapour			22,632	406,54	423,20	1,674 3	0,696 3	0,790 4	129,17	26,92
liquid	75,00	0,430 4	1 326,4	277,54	277,86	1,250 5	0,749 7	1,090 6	518,2	−0,137 0
vapour			25,743	409,34	426,06	1,676 2	0,704 0	0,803 0	128,79	26,09
liquid	80,00	0,489 1	1 311,2	282,98	283,35	1,266 0	0,754 2	1,099 6	500,0	−0,108 7
vapour			29,188	412,14	428,89	1,678 1	0,711 7	0,816 2	128,30	25,34
liquid	85,00	0,553 6	1 295,7	288,45	288,88	1,281 4	0,758 9	1,109 3	481,9	−0,077 3
vapour			33,000	414,91	431,68	1,680 1	0,719 4	0,830 2	127,69	24,66
liquid	90,00	0,624 2	1 279,9	293,97	294,45	1,296 7	0,763 6	1,119 7	463,8	−0,042 5
vapour			37,213	417,65	434,43	1,682 2	0,727 2	0,845 0	126,97	24,05
liquid	95,00	0,701 4	1 263,6	299,53	300,08	1,312 0	0,768 3	1,131 0	445,6	−0,003 6
vapour			41,863	420,37	437,13	1,684 2	0,735 0	0,860 9	126,12	23,51
liquid	100,00	0,785 5	1 246,9	305,14	305,77	1,327 1	0,773 1	1,143 3	427,5	0,040 2
vapour			46,996	423,06	439,77	1,686 2	0,742 9	0,878 0	125,14	23,03
liquid	105,00	0,876 9	1 229,7	310,80	311,51	1,342 2	0,778 1	1,156 8	409,2	0,089 6
vapour			52,661	425,71	442,36	1,688 2	0,750 9	0,896 5	124,02	22,61
liquid	110,00	0,976 0	1 211,9	316,51	317,32	1,357 2	0,783 1	1,171 7	391,0	0,146 0
vapour			58,914	428,31	444,88	1,690 2	0,759 0	0,916 8	122,76	22,24
liquid	115,00	1,083 2	1 193,5	322,28	323,19	1,372 3	0,788 3	1,188 4	372,6	0,210 6

[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 document.

Table 22 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
vapour			65,824	430,86	447,32	1,692 0	0,767 2	0,939 2	121,34	21,94
liquid	120,00	1,199 0	1 174,4	328,13	329,15	1,387 2	0,793 6	1,207 2	354,1	0,285 4
vapour			73,471	433,35	449,67	1,693 8	0,775 5	0,964 3	119,76	21,69
liquid	125,00	1,323 7	1 154,4	334,04	335,18	1,402 2	0,799 1	1,228 7	335,5	0,372 8
vapour			81,950	435,78	451,93	1,695 5	0,784 0	0,992 8	118,00	21,51
liquid	130,00	1,457 8	1 133,6	340,03	341,32	1,417 3	0,804 8	1,253 6	316,7	0,475 9
vapour			91,379	438,12	454,07	1,696 9	0,792 7	1,025 7	116,05	21,38
liquid	135,00	1,601 8	1 111,6	346,12	347,56	1,432 3	0,810 7	1,282 8	297,8	0,599 2
vapour			101,904	440,37	456,08	1,698 2	0,801 7	1,064 3	113,89	21,32
liquid	140,00	1,756 3	1 088,3	352,31	353,92	1,447 5	0,817 0	1,317 8	278,6	0,748 7
vapour			113,711	442,50	457,94	1,699 2	0,811 0	1,110 6	111,51	21,32
liquid	145,00	1,921 7	1 063,5	358,62	360,43	1,462 8	0,823 6	1,360 6	259,1	0,933 4
vapour			127,044	444,48	459,61	1,700 0	0,820 7	1,167 7	108,88	21,39
liquid	150,00	2,098 7	1 036,8	365,08	367,10	1,478 2	0,830 7	1,414 6	239,3	1,166 4
vapour			142,231	446,30	461,05	1,700 3	0,830 9	1,240 5	105,99	21,53
liquid	155,00	2,287 9	1 007,8	371,72	373,99	1,494 0	0,838 4	1,485 5	219,0	1,468 6
vapour			159,735	447,89	462,22	1,700 0	0,841 7	1,337 1	102,80	21,75
liquid	160,00	2,490 1	975,7	378,58	381,13	1,510 1	0,846 9	1,583 6	198,2	1,874 8
vapour			180,242	449,20	463,01	1,699 1	0,853 4	1,472 8	99,29	22,05
liquid	165,00	2,706 2	939,4	385,74	388,62	1,526 7	0,856 5	1,730 3	176,6	2,447 8
vapour			204,853	450,11	463,32	1,697 2	0,866 2	1,679 0	95,40	22,41
liquid	170,00	2,937 2	896,9	393,33	396,61	1,544 3	0,867 7	1,979 2	154,0	3,314 7
vapour			235,543	450,42	462,89	1,693 9	0,880 6	2,033 2	91,07	22,81
liquid	175,00	3,184 5	843,9	401,67	405,44	1,563 5	0,881 7	2,510 2	129,6	4,777 9
vapour			276,595	449,73	461,25	1,688 0	0,897 5	2,793 5	86,20	23,12
liquid	180,00	3,450 6	765,9	411,72	416,22	1,586 7	0,901 9	4,548 6	102,3	7,810 6
vapour			341,950	446,73	456,82	1,676 3	0,919 4	5,661 3	80,62	22,79
critical	183,68	3,661 8	550,0	430,74	437,39	1,632 5	c	c	c	16,565 8

[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 document.

5.8 R125 — Pentafluoroethane

5.8.1 Range of validity

The coefficients are valid within the following ranges:

T_{min} = 172,52 K, T_{max} = 500 K; p_{max} = 60 MPa; ρ_{max} = 14,09 mol/l (1 691 kg/m^3)

Coefficients and exponents of the ideal-gas part are listed in Table 23. Coefficients and exponents of the real-gas part are listed in Table 24.

Table 23 — Coefficients and exponents of the ideal-gas part [Formulae (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 24 — Coefficients and exponents of the real-gas part [Formula (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, ρ^* = 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

R125 property values along the liquid-vapour saturation boundary are listed in Table 25.

Table 25 — R125 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	MPa	kg/m³	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
liquid	−100,63[a]	0,002 91	1 690,7	87,13	87,13	0,490 2	0,677 6	1,034 6	932,6	−0,383 7

[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 document.

Table 25 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
vapour			0,244 6	265,48	277,39	1,593 1	0,498 4	0,568 9	116,43	90,26
liquid	−100,00	0,003 09	1 688,7	87,78	87,78	0,494 0	0,678 1	1,035 1	929,2	−0,383 0
vapour			0,258 3	265,79	277,74	1,591 1	0,499 7	0,570 3	116,61	89,08
liquid	−95,00	0,004 81	1 672,5	92,97	92,97	0,523 5	0,681 8	1,039 6	903,2	−0,376 6
vapour			0,391 8	268,25	280,54	1,576 4	0,509 9	0,581 0	118,03	80,43
liquid	−90,00	0,007 29	1 656,2	98,18	98,18	0,552 4	0,686 0	1,045 0	877,5	−0,369 4
vapour			0,577 9	270,75	283,36	1,563 4	0,520 1	0,591 9	119,39	72,87
liquid	−85,00	0,010 7	1 639,9	103,42	103,42	0,580 6	0,690 6	1,051 2	852,3	−0,361 4
vapour			0,831	273,28	286,20	1,552 0	0,530 4	0,603 1	120,69	66,26
liquid	−80,00	0,015 5	1 623,4	108,69	108,70	0,608 2	0,695 5	1,058 1	827,5	−0,352 5
vapour			1,169	275,83	289,06	1,542 1	0,540 9	0,614 6	121,92	60,44
liquid	−75,00	0,021 8	1 606,7	114,00	114,01	0,635 4	0,700 6	1,065 6	802,9	−0,342 8
vapour			1,610	278,41	291,94	1,533 3	0,551 4	0,626 4	123,07	55,33
liquid	−70,00	0,030 1	1 589,9	119,34	119,36	0,662 0	0,706 0	1,073 6	778,6	−0,332 3
vapour			2,177	281,01	294,83	1,525 7	0,562 0	0,638 5	124,13	50,81
liquid	−65,00	0,040 8	1 572,9	124,73	124,75	0,688 2	0,711 5	1,082 2	754,5	−0,320 8
vapour			2,892	283,62	297,71	1,519 1	0,572 7	0,651 1	125,11	46,82
liquid	−60,00	0,054 3	1 555,7	130,16	130,19	0,714 0	0,717 1	1,091 2	730,6	−0,308 3
vapour			3,783	286,24	300,60	1,513 5	0,583 6	0,664 1	125,98	43,28
liquid	−55,00	0,071 3	1 538,2	135,63	135,68	0,739 4	0,722 9	1,100 7	706,8	−0,294 7
vapour			4,879	288,88	303,48	1,508 6	0,594 6	0,677 6	126,75	40,14
liquid	−50,00	0,092 2	1 520,5	141,15	141,21	0,764 4	0,728 8	1,110 7	683,2	−0,279 9
vapour			6,211	291,51	306,35	1,504 4	0,605 8	0,691 6	127,41	37,35
liquid	−48,09[b]	0,101 3	1 513,6	143,27	143,34	0,773 9	0,731 1	1,114 6	674,2	−0,273 8
vapour			6,790	292,52	307,44	1,503 0	0,610 1	0,697 1	127,63	36,36
liquid	−45,00	0,117 6	1 502,4	146,72	146,80	0,789 1	0,734 9	1,121 2	659,6	−0,263 6
vapour			7,814	294,15	309,20	1,500 9	0,617 1	0,706 3	127,94	34,86
liquid	−40,00	0,148 3	1 484,0	152,34	152,44	0,813 4	0,741 0	1,132 3	636,1	−0,245 8
vapour			9,725	296,79	312,03	1,498 0	0,628 6	0,721 6	128,35	32,65
liquid	−35,00	0,184 9	1 465,3	158,01	158,14	0,837 5	0,747 3	1,144 0	612,6	−0,226 2
vapour			11,985	299,41	314,84	1,495 5	0,640 2	0,737 6	128,61	30,67
liquid	−30,00	0,228 1	1 446,1	163,74	163,90	0,861 4	0,753 7	1,156 5	589,1	−0,204 4
vapour			14,639	302,03	317,61	1,493 5	0,652 0	0,754 5	128,73	28,91
liquid	−25,00	0,278 6	1 426,5	169,53	169,73	0,884 9	0,760 2	1,169 8	565,7	−0,180 3
vapour			17,736	304,63	320,34	1,491 9	0,664 0	0,772 4	128,70	27,33
liquid	−20,00	0,337 3	1 406,4	175,38	175,62	0,908 3	0,766 8	1,184 0	542,2	−0,153 2
vapour			21,331	307,22	323,03	1,490 6	0,676 1	0,791 2	128,50	25,91
liquid	−15,00	0,405 0	1 385,8	181,30	181,59	0,931 4	0,773 6	1,199 4	518,7	−0,122 8
vapour			25,486	309,78	325,67	1,489 5	0,688 2	0,811 2	128,11	24,66
liquid	−10,00	0,482 5	1 364,5	187,29	187,64	0,954 4	0,780 5	1,216 1	495,2	−0,088 3
vapour			30,271	312,30	328,24	1,488 7	0,700 3	0,832 4	127,54	23,55

[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 document.

Table 25 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m³	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
liquid	−5,00	0,570 7	1 342,6	193,35	193,77	0,977 3	0,787 6	1,234 4	471,6	−0,048 9
vapour			35,768	314,79	330,74	1,488 1	0,712 2	0,855 0	126,77	22,61
liquid	0,00	0,670 5	1 319,8	199,49	200,00	1,000 0	0,794 8	1,254 7	448,0	−0,003 6
vapour			42,070	317,22	333,16	1,487 5	0,724 0	0,879 7	125,80	21,81
liquid	5,00	0,782 9	1 296,2	205,72	206,33	1,022 6	0,802 1	1,277 3	424,3	0,049 2
vapour			49,291	319,59	335,47	1,486 9	0,735 9	0,907 3	124,60	21,15
liquid	10,00	0,908 8	1 271,5	212,05	212,76	1,045 2	0,809 5	1,302 9	400,4	0,111 3
vapour			57,564	321,87	337,66	1,486 3	0,748 3	0,939 2	123,17	20,61
liquid	15,00	1,049 2	1 245,6	218,48	219,32	1,067 8	0,817 2	1,332 3	376,3	0,185 1
vapour			67,054	324,06	339,71	1,485 6	0,761 7	0,977 0	121,49	20,18
liquid	20,00	1,205 2	1 218,3	225,03	226,02	1,090 4	0,825 2	1,366 6	352,0	0,274 2
vapour			77,966	326,12	341,58	1,484 6	0,776 4	1,023 0	119,55	19,83
liquid	25,00	1,377 9	1 189,4	231,71	232,87	1,113 1	0,833 5	1,407 4	327,4	0,383 5
vapour			90,557	328,05	343,26	1,483 4	0,792 8	1,079 8	117,32	19,53
liquid	30,00	1,568 5	1 158,4	238,55	239,91	1,135 9	0,842 5	1,457 5	302,4	0,520 2
vapour			105,170	329,80	344,71	1,481 7	0,811 1	1,151 7	114,78	19,29
liquid	35,00	1,778 3	1 125,0	245,57	247,16	1,159 1	0,852 2	1,520 9	276,9	0,695 6
vapour			122,270	331,33	345,88	1,479 4	0,831 5	1,245 2	111,88	19,08
liquid	40,00	2,008 5	1 088,4	252,82	254,67	1,182 6	0,863 0	1,605 2	250,8	0,928 2
vapour			142,522	332,60	346,69	1,476 4	0,854 2	1,371 6	108,58	18,91
liquid	45,00	2,260 7	1 047,7	260,36	262,52	1,206 7	0,875 5	1,724 4	223,8	1,250 1
vapour			166,954	333,50	347,05	1,472 4	0,879 6	1,553 5	104,82	18,78
liquid	50,00	2,536 8	1 001,1	268,29	270,83	1,231 8	0,890 7	1,910 2	195,6	1,724 7
vapour			197,293	333,89	346,75	1,466 7	0,908 3	1,842 5	100,51	18,67
liquid	55,00	2,838 9	945,4	276,82	279,83	1,258 5	0,910 6	2,251 7	165,3	2,494 8
vapour			236,916	333,46	345,44	1,458 4	0,942 1	2,386 0	95,57	18,51
liquid	60,00	3,170 3	872,1	286,46	290,10	1,288 4	0,941 1	3,139 2	131,5	3,975 2
vapour			294,367	331,44	342,21	1,444 8	0,985 6	3,832 9	89,84	18,06
liquid	65,00	3,537 0	735,1	300,06	304,88	1,331 1	1,013 9	13,669 2	90,0	8,295 5
vapour			416,565	323,75	332,24	1,412 0	1,060 4	20,073 5	82,63	15,85
critical	66,02	3,617 7	573,6	311,75	318,06	1,369 6	c	c	c	12,360 8

[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 document.

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/m³)

Coefficients and exponents of the ideal-gas part are listed in Table 26. Coefficients and exponents of the real-gas part are listed in Table 27.

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

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

Table 27 — Coefficients and exponents of the real-gas part [Formula (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, ρ^* = 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

R134a property values along the liquid-vapour saturation boundary are listed in Table 28.

Table 28 — R134a 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	MPa	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
liquid	−103,30[a]	0,000 390	1 591,1	71,45	71,46	0,412 6	0,792 2	1,183 8	1 120,0	−0,381 5
vapour			0,028 17	321,11	334,94	1,963 9	0,503 0	0,585 3	126,79	373,57
liquid	−100,00	0,000 559	1 582,4	75,36	75,36	0,435 4	0,791 2	1,184 2	1 103,2	−0,379 3
vapour			0,039 69	322,76	336,85	1,945 6	0,510 7	0,593 2	127,87	318,13
liquid	−95,00	0,000 939	1 569,1	81,29	81,29	0,469 1	0,791 0	1,186 1	1 077,7	−0,375 3
vapour			0,064 79	325,29	339,78	1,920 1	0,522 4	0,605 2	129,47	253,65
liquid	−90,00	0,001 52	1 555,8	87,22	87,23	0,502 0	0,792 0	1,189 2	1 052,3	−0,370 7
vapour			0,102 4	327,87	342,76	1,897 2	0,534 1	0,617 3	131,03	206,26
liquid	−85,00	0,002 40	1 542,5	93,18	93,18	0,534 1	0,794 0	1,193 3	1 027,0	−0,365 6
vapour			0,157 0	330,49	345,77	1,876 6	0,545 7	0,629 4	132,56	170,88
liquid	−80,00	0,003 67	1 529,0	99,16	99,16	0,565 4	0,796 8	1,198 1	1 001,8	−0,359 9
vapour			0,234 3	333,15	348,83	1,858 0	0,557 3	0,641 7	134,04	144,05
liquid	−75,00	0,005 48	1 515,5	105,16	105,17	0,596 1	0,800 2	1,203 6	976,8	−0,353 6
vapour			0,341 2	335,85	351,91	1,841 4	0,568 9	0,654 0	135,47	123,38
liquid	−70,00	0,007 98	1 501,9	111,19	111,20	0,626 2	0,804 0	1,209 6	952,0	−0,346 9
vapour			0,485 7	338,59	355,02	1,826 4	0,580 6	0,666 5	136,84	107,19
liquid	−65,00	0,011 4	1 488,2	117,26	117,26	0,655 7	0,808 2	1,216 1	927,4	−0,339 6
vapour			0,677	341,35	358,16	1,813 0	0,592 3	0,679 3	138,16	94,32
liquid	−60,00	0,015 9	1 474,3	123,35	123,36	0,684 6	0,812 7	1,223 0	903,0	−0,331 8
vapour			0,927	344,15	361,31	1,801 0	0,604 0	0,692 4	139,41	83,91
liquid	−55,00	0,021 8	1 460,4	129,48	129,50	0,713 1	0,817 5	1,230 4	878,8	−0,323 4
vapour			1,246	346,96	364,48	1,790 2	0,615 9	0,705 8	140,59	75,36
liquid	−50,00	0,029 5	1 446,3	135,65	135,67	0,741 0	0,822 4	1,238 1	854,7	−0,314 3
vapour			1,650	349,80	367,65	1,780 6	0,628 0	0,719 7	141,69	68,25
liquid	−45,00	0,039 1	1 432,1	141,86	141,89	0,768 5	0,827 6	1,246 2	830,9	−0,304 6
vapour			2,152	352,65	370,83	1,772 0	0,640 2	0,734 1	142,70	62,23
liquid	−40,00	0,051 2	1 417,7	148,11	148,14	0,795 6	0,832 8	1,254 6	807,2	−0,294 1
vapour			2,769	355,51	374,00	1,764 3	0,652 6	0,749 0	143,63	57,08
liquid	−35,00	0,066 1	1 403,1	154,40	154,44	0,822 3	0,838 2	1,263 5	783,7	−0,282 8
vapour			3,521	358,38	377,17	1,757 5	0,665 2	0,764 6	144,45	52,63
liquid	−30,00	0,084 4	1 388,4	160,73	160,79	0,848 6	0,843 8	1,272 9	760,3	−0,270 6
vapour			4,426	361,25	380,32	1,751 5	0,678 1	0,780 9	145,18	48,74
liquid	−26,07[b]	0,101 3	1 376,7	165,74	165,81	0,869 0	0,848 2	1,280 5	742,0	−0,260 2
vapour			5,258	363,51	382,78	1,747 2	0,688 4	0,794 2	145,67	46,01
liquid	−25,00	0,106 4	1 373,4	167,11	167,19	0,874 6	0,849 4	1,282 7	737,0	−0,257 3
vapour			5,506	364,12	383,45	1,746 1	0,691 2	0,797 9	145,79	45,31
liquid	−20,00	0,132 7	1 358,3	173,54	173,64	0,900 2	0,855 1	1,293 0	713,8	−0,242 8
vapour			6,784	366,99	386,55	1,741 3	0,704 6	0,815 8	146,28	42,26
liquid	−15,00	0,163 9	1 342,8	180,02	180,14	0,925 6	0,860 9	1,304 0	690,7	−0,227 0
vapour			8,287	369,85	389,63	1,737 1	0,718 3	0,834 6	146,65	39,54
liquid	−10,00	0,200 6	1 327,1	186,55	186,70	0,950 6	0,866 9	1,315 6	667,6	−0,209 6

[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 document.

Table 28 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
vapour			10,041	372,69	392,66	1,733 4	0,732 2	0,854 4	146,89	37,11
liquid	−5,00	0,243 3	1 311,1	193,13	193,32	0,975 4	0,872 9	1,327 9	644,6	−0,190 5
vapour			12,077	375,51	395,66	1,730 0	0,746 4	0,875 2	146,99	34,92
liquid	0,00	0,292 8	1 294,8	199,77	200,00	1,000 0	0,879 1	1,341 0	621,6	−0,169 5
vapour			14,428	378,31	398,60	1,727 1	0,760 8	0,897 2	146,94	32,95
liquid	5,00	0,349 7	1 278,1	206,48	206,75	1,024 3	0,885 4	1,355 2	598,7	−0,146 1
vapour			17,131	381,08	401,49	1,724 5	0,775 5	0,920 6	146,74	31,17
liquid	10,00	0,414 6	1 261,0	213,25	213,58	1,048 5	0,891 8	1,370 4	575,7	−0,120 0
vapour			20,226	383,82	404,32	1,722 1	0,790 4	0,945 5	146,38	29,57
liquid	15,00	0,488 4	1 243,4	220,09	220,48	1,072 4	0,898 3	1,386 9	552,7	−0,090 7
vapour			23,758	386,52	407,07	1,720 0	0,805 6	0,972 1	145,85	28,12
liquid	20,00	0,571 7	1 225,3	227,00	227,47	1,096 2	0,905 0	1,404 9	529,6	−0,057 8
vapour			27,780	389,17	409,75	1,718 0	0,821 0	1,000 7	145,15	26,81
liquid	25,00	0,665 4	1 206,7	233,99	234,55	1,119 9	0,911 9	1,424 6	506,5	−0,020 4
vapour			32,350	391,77	412,33	1,716 2	0,836 7	1,031 6	144,26	25,64
liquid	30,00	0,770 2	1 187,5	241,07	241,72	1,143 5	0,918 9	1,446 5	483,2	0,022 3
vapour			37,535	394,30	414,82	1,714 5	0,852 7	1,065 5	143,16	24,58
liquid	35,00	0,887 0	1 167,5	248,25	249,01	1,167 0	0,926 2	1,470 9	459,9	0,071 4
vapour			43,416	396,76	417,19	1,712 8	0,869 1	1,102 8	141,86	23,63
liquid	40,00	1,016 6	1 146,7	255,52	256,41	1,190 5	0,933 6	1,498 4	436,4	0,128 5
vapour			50,085	399,13	419,43	1,711 1	0,885 8	1,144 5	140,34	22,78
liquid	45,00	1,159 9	1 125,1	262,91	263,94	1,213 9	0,941 4	1,529 8	412,8	0,195 3
vapour			57,657	401,40	421,52	1,709 2	0,902 9	1,191 7	138,57	22,02
liquid	50,00	1,317 9	1 102,3	270,43	271,62	1,237 5	0,949 4	1,566 1	389,0	0,274 6
vapour			66,272	403,55	423,44	1,707 2	0,920 5	1,246 1	136,55	21,36
liquid	55,00	1,491 5	1 078,3	278,09	279,47	1,261 1	0,957 9	1,608 9	364,9	0,369 8
vapour			76,104	405,55	425,15	1,705 0	0,938 7	1,309 9	134,25	20,77
liquid	60,00	1,681 8	1 052,9	285,91	287,50	1,284 8	0,966 8	1,660 2	340,5	0,486 1
vapour			87,379	407,38	426,63	1,702 4	0,957 7	1,386 8	131,66	20,27
liquid	65,00	1,889 8	1 025,6	293,92	295,76	1,308 8	0,976 4	1,723 4	315,7	0,630 8
vapour			100,398	408,99	427,82	1,699 3	0,977 5	1,482 2	128,74	19,83
liquid	70,00	2,116 8	996,2	302,16	304,28	1,333 2	0,986 9	1,803 9	290,3	0,815 7
vapour			115,572	410,33	428,65	1,695 6	0,998 6	1,605 1	125,46	19,46
liquid	75,00	2,364 1	964,1	310,68	313,13	1,358 0	0,998 8	1,911 5	264,1	1,059 9
vapour			133,494	411,32	429,03	1,690 9	1,021 2	1,771 4	121,80	19,14
liquid	80,00	2,633 2	928,2	319,55	322,39	1,383 6	1,012 9	2,064 8	236,6	1,397 3
vapour			155,078	411,83	428,81	1,685 0	1,046 0	2,012 2	117,69	18,86
liquid	85,00	2,925 8	887,2	328,93	332,22	1,410 4	1,030 8	2,306 4	207,4	1,893 6
vapour			181,853	411,67	427,76	1,677 1	1,073 9	2,397 1	113,09	18,57
liquid	90,00	3,244 2	837,8	339,06	342,93	1,439 0	1,055 6	2,755 9	175,9	2,693 6
vapour			216,761	410,45	425,42	1,666 2	1,106 8	3,120 7	107,90	18,20

[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 document.

Table 28 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m³	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
liquid	95,00	3,591 2	772,7	350,60	355,25	1,471 5	1,093 8	3,938 5	141,2	4,191 6
vapour			267,139	407,23	420,67	1,649 2	1,148 9	5,019 5	101,91	17,51
liquid	100,00	3,972 4	651,2	367,20	373,30	1,518 8	1,173 7	17,591 5	101,0	8,198 5
vapour			373,011	397,03	407,68	1,610 9	1,218 0	25,350 3	93,95	15,30
critical	101,06	4,059 3	511,9	381,71	389,64	1,562 1	c	c	c	11,931 2

[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 document.

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/m³)

Coefficients and exponents of the ideal-gas part are listed in Table 29. Coefficients and exponents of the real-gas part are listed in Table 30.

Table 29 — Coefficients and exponents of the ideal-gas part [Formulae (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 30 — Coefficients and exponents of the real-gas part [Formula (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

Table 30 *(continued)*

k	N_k	t_k	d_k	l_k	α_k
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

R143a property values along the liquid-vapour saturation boundary are listed in Table 31.

Table 31 — R143a 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	MPa	kg/m³	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
liquid	−111,81[a]	0,001 07	1 330,5	52,52	52,52	0,314 2	0,813 8	1,211 2	1 058,1	−0,439 4
vapour			0,067 5	303,67	319,59	1,969 5	0,528 3	0,629 9	137,57	385,09
liquid	−110,00	0,001 29	1 326,2	54,71	54,71	0,327 7	0,812 8	1,211 9	1 049,4	−0,437 5
vapour			0,080 5	304,59	320,68	1,957 9	0,533 1	0,635 0	138,22	354,60
liquid	−105,00	0,002 11	1 314,1	60,78	60,78	0,364 3	0,811 4	1,215 1	1 025,5	−0,431 6
vapour			0,127 4	307,17	323,73	1,928 1	0,546 7	0,649 5	139,98	284,35
liquid	−100,00	0,003 33	1 301,9	66,87	66,87	0,400 0	0,811 5	1,219 9	1 001,7	−0,424 7
vapour			0,195 6	309,78	326,81	1,901 2	0,560 4	0,664 2	141,68	230,56
liquid	−95,00	0,005 10	1 289,6	72,98	72,98	0,434 8	0,813 1	1,226 0	977,9	−0,417 1
vapour			0,291 7	312,43	329,92	1,877 0	0,574 2	0,679 2	143,32	189,21
liquid	−90,00	0,007 61	1 277,2	79,13	79,13	0,468 8	0,815 7	1,233 3	954,2	−0,408 6
vapour			0,423 8	315,11	333,06	1,855 3	0,588 1	0,694 4	144,89	157,26
liquid	−85,00	0,011 1	1 264,8	85,31	85,32	0,502 1	0,819 4	1,241 5	930,4	−0,399 4
vapour			0,601	317,83	336,22	1,835 7	0,602 1	0,710 0	146,39	132,44
liquid	−80,00	0,015 7	1 252,2	91,54	91,55	0,534 8	0,823 8	1,250 4	906,6	−0,389 5
vapour			0,835	320,58	339,40	1,818 0	0,616 2	0,725 8	147,81	113,01
liquid	−75,00	0,021 9	1 239,5	97,81	97,83	0,566 9	0,828 8	1,260 1	882,8	−0,378 9
vapour			1,138	323,36	342,60	1,802 1	0,630 4	0,742 1	149,13	97,68
liquid	−70,00	0,029 9	1 226,7	104,14	104,16	0,598 4	0,834 4	1,270 4	859,1	−0,367 4
vapour			1,523	326,16	345,80	1,787 9	0,644 8	0,758 9	150,37	85,45
liquid	−65,00	0,040 2	1 213,7	110,51	110,54	0,629 4	0,840 5	1,281 3	835,3	−0,355 1
vapour			2,005	328,98	349,01	1,775 0	0,659 3	0,776 3	151,50	75,60
liquid	−60,00	0,053 1	1 200,6	116,94	116,99	0,659 9	0,847 0	1,292 8	811,5	−0,341 9
vapour			2,601	331,81	352,21	1,763 5	0,674 1	0,794 4	152,51	67,57
liquid	−55,00	0,069 1	1 187,3	123,43	123,49	0,690 0	0,853 8	1,304 9	787,7	−0,327 7
vapour			3,329	334,66	355,41	1,753 1	0,689 2	0,813 3	153,41	60,93

[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 document.

Table 31 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
liquid	−50,00	0,088 7	1 173,9	129,97	130,05	0,719 7	0,860 8	1,317 5	763,9	−0,312 3
vapour			4,210	337,51	358,58	1,743 8	0,704 6	0,833 1	154,19	55,38
liquid	−47,24[b]	0,101 3	1 166,4	133,61	133,70	0,735 9	0,864 8	1,324 8	750,8	−0,303 2
vapour			4,769	339,08	360,33	1,739 1	0,713 2	0,844 4	154,55	52,70
liquid	−45,00	0,112 5	1 160,3	136,58	136,68	0,749 0	0,868 1	1,330 9	740,1	−0,295 6
vapour			5,264	340,36	361,74	1,735 4	0,720 3	0,853 9	154,82	50,69
liquid	−40,00	0,141 1	1 146,4	143,26	143,38	0,777 9	0,875 6	1,344 8	716,3	−0,277 4
vapour			6,514	343,20	364,86	1,727 9	0,736 3	0,875 8	155,31	46,68
liquid	−35,00	0,175 0	1 132,3	150,00	150,15	0,806 5	0,883 3	1,359 6	692,5	−0,257 6
vapour			7,988	346,04	367,95	1,721 1	0,752 6	0,898 9	155,65	43,21
liquid	−30,00	0,214 9	1 117,9	156,81	157,00	0,834 8	0,891 1	1,375 2	668,6	−0,235 8
vapour			9,711	348,86	370,99	1,714 9	0,769 3	0,923 3	155,84	40,20
liquid	−25,00	0,261 4	1 103,3	163,70	163,93	0,862 9	0,899 1	1,391 8	644,7	−0,211 8
vapour			11,716	351,67	373,98	1,709 3	0,786 3	0,949 2	155,85	37,55
liquid	−20,00	0,315 4	1 088,3	170,66	170,95	0,890 7	0,907 2	1,409 4	620,8	−0,185 2
vapour			14,036	354,44	376,91	1,704 3	0,803 5	0,976 7	155,68	35,22
liquid	−15,00	0,377 4	1 072,9	177,71	178,06	0,918 3	0,915 4	1,428 3	596,8	−0,155 5
vapour			16,709	357,18	379,76	1,699 6	0,821 1	1,006 1	155,33	33,16
liquid	−10,00	0,448 2	1 057,2	184,84	185,27	0,945 7	0,923 7	1,448 7	572,8	−0,122 3
vapour			19,778	359,88	382,54	1,695 3	0,839 0	1,037 7	154,78	31,33
liquid	−5,00	0,528 7	1 041,0	192,07	192,58	0,972 9	0,932 2	1,470 9	548,6	−0,084 7
vapour			23,292	362,53	385,23	1,691 3	0,857 1	1,071 7	154,03	29,69
liquid	0,00	0,619 7	1 024,3	199,40	200,00	1,000 0	0,940 8	1,495 1	524,3	−0,042 0
vapour			27,306	365,11	387,81	1,687 6	0,875 6	1,108 7	153,06	28,24
liquid	5,00	0,721 9	1 007,0	206,83	207,54	1,027 0	0,949 5	1,521 9	499,8	0,006 9
vapour			31,885	367,63	390,27	1,683 9	0,894 4	1,149 2	151,87	26,94
liquid	10,00	0,836 3	989,1	214,37	215,22	1,053 9	0,958 5	1,551 7	475,1	0,063 5
vapour			37,107	370,06	392,60	1,680 4	0,913 5	1,194 2	150,43	25,79
liquid	15,00	0,963 7	970,4	222,05	223,04	1,080 9	0,967 8	1,585 4	450,2	0,129 5
vapour			43,062	372,39	394,77	1,676 8	0,933 1	1,244 7	148,74	24,76
liquid	20,00	1,105 2	950,8	229,86	231,02	1,107 8	0,977 3	1,623 9	425,0	0,207 5
vapour			49,864	374,60	396,76	1,673 2	0,953 1	1,302 4	146,77	23,84
liquid	25,00	1,261 6	930,2	237,83	239,19	1,134 9	0,987 3	1,668 7	399,5	0,300 7
vapour			57,653	376,66	398,54	1,669 3	0,973 7	1,369 5	144,51	23,04
liquid	30,00	1,434 0	908,4	245,98	247,56	1,162 1	0,997 8	1,721 8	373,5	0,414 0
vapour			66,605	378,54	400,07	1,665 2	0,995 1	1,449 4	141,93	22,33
liquid	35,00	1,623 6	885,2	254,33	256,16	1,189 5	1,009 1	1,786 3	347,0	0,554 3
vapour			76,954	380,21	401,31	1,660 6	1,017 3	1,547 2	139,02	21,71
liquid	40,00	1,831 4	860,3	262,91	265,04	1,217 4	1,021 3	1,867 0	319,8	0,731 9
vapour			89,018	381,61	402,19	1,655 3	1,040 8	1,671 5	135,73	21,17
liquid	45,00	2,058 9	833,1	271,79	274,26	1,245 7	1,035 0	1,972 5	291,8	0,963 6

[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 document.

Table 31 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
vapour			103,245	382,66	402,61	1,649 1	1,065 9	1,836 6	132,04	20,69
liquid	50,00	2,307 3	803,0	281,02	283,90	1,274 8	1,050 9	2,118 1	262,7	1,277 7
vapour			120,307	383,25	402,43	1,641 6	1,093 2	2,070 0	127,89	20,26
liquid	55,00	2,578 5	768,9	290,74	294,09	1,305 1	1,070 2	2,336 9	232,2	1,727 3
vapour			141,302	383,20	401,44	1,632 2	1,123 7	2,430 2	123,22	19,84
liquid	60,00	2,874 4	728,9	301,15	305,09	1,337 1	1,095 1	2,714 3	199,5	2,423 7
vapour			168,236	382,16	399,24	1,619 7	1,159 5	3,068 5	117,93	19,37
liquid	65,00	3,197 7	678,3	312,73	317,45	1,372 6	1,131 2	3,563 5	163,8	3,652 9
vapour			205,645	379,39	394,94	1,601 8	1,204 4	4,532 3	111,84	18,67
liquid	70,00	3,552 7	600,8	327,28	333,19	1,417 2	1,198 4	7,719 7	122,4	6,473 3
vapour			270,096	372,27	385,42	1,569 4	1,272 0	11,500 8	104,25	17,07
critical	72,71	3,761 0	431,0	350,18	358,91	1,490 6	c	c	c	12,396 9

[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 document.

5.11 R152a — 1,1–difluoroethane

5.11.1 Range of validity

The coefficients are valid within the following ranges:

T_{min} = 154,5 K, T_{max} = 500 K; p_{max} = 60 MPa; ρ_{max} = 18,07 mol/l (1 194 kg/m^3)

Coefficients and exponents of the ideal-gas part are listed in Table 32. Coefficients and exponents of the real-gas part are listed in Table 33.

Table 32 — Coefficients and exponents of the ideal-gas part [Formulae (3) to (5)]

k	c_k	t_k
0	3,354 952	—
1	1,098 649 × 10^{-2}	1
2	2,501 616 × 10^{-5}	2
3	−2,787 445 × 10^{-8}	3

Table 33 — Coefficients and exponents of the real-gas part [Formula (2)]

k	N_k	t_k	d_k	l_k	α_k
1	−0,354 657 949 982 × 10^1	3	0	0	0
2	−0,364 631 280 620	4	0	0	0
3	0,333 233 335 558 × 10^{-1}	5	0	0	0
4	−0,680 968 435 117	0	1	0	0
5	0,735 212 646 801 × 10^1	0,5	1	0	0
6	−0,112 473 063 838 × 10^2	1	1	0	0
7	0,549 916 715 657 × 10^1	2	1	0	0
8	−0,240 186 327 322 × 10^1	3	1	0	0

Table 33 *(continued)*

k	N_k	t_k	d_k	l_k	α_k
9	$-0{,}709\,036\,447\,042 \times 10^{-1}$	0	2	0	0
10	$-0{,}213\,200\,886\,814$	1	2	0	0
11	$0{,}197\,839\,736\,368$	2	2	0	0
12	$0{,}182\,494\,769\,909 \times 10^{1}$	3	2	0	0
13	$-0{,}860\,546\,479\,693 \times 10^{-1}$	0	3	0	0
14	$0{,}888\,137\,366\,540$	1	3	0	0
15	$-0{,}966\,127\,346\,370$	2	3	0	0
16	$-0{,}985\,223\,479\,324 \times 10^{-1}$	1	4	0	0
17	$0{,}183\,419\,368\,472 \times 10^{-1}$	2	5	0	0
18	$-0{,}338\,550\,204\,252 \times 10^{-1}$	3	5	0	0
19	$0{,}124\,921\,101\,016 \times 10^{-1}$	2	6	0	0
20	$-0{,}221\,056\,706\,423 \times 10^{-2}$	2	7	0	0
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), $f_1 = 4{,}360\,056$, $f_2 = 2\,654{,}673\,62$

R152a property values along the liquid-vapour saturation boundary are listed in Table 34.

Table 34 — R152a 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	MPa	kg/m³	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
liquid	−118,59[a]	6,414×10⁻⁵	1 192,9	13,79	13,79	0,111 9	0,994 8	1,477 4	1 400,9	−0,432 6
vapour			3,297×10⁻³	399,87	419,32	2,735 7	0,572 6	0,698 7	154,04	336,54
liquid	−115,00	0,000 103	1 186,3	19,13	19,13	0,146 0	1,009 0	1,492 1	1 372,8	−0,426 6
vapour			0,005 16	401,93	421,84	2,692 4	0,580 3	0,706 4	155,63	308,12
liquid	−110,00	0,000 191	1 177,1	26,62	26,62	0,192 7	1,021 0	1,505 3	1 337,3	−0,420 3
vapour			0,009 28	404,85	425,38	2,636 8	0,591 1	0,717 3	157,80	273,32
liquid	−105,00	0,000 339	1 167,9	34,17	34,17	0,238 3	1,027 1	1,513 1	1 305,0	−0,415 4
vapour			0,016 00	407,81	428,96	2,586 1	0,602 0	0,728 4	159,93	243,29
liquid	−100,00	0,000 579	1 158,7	41,75	41,75	0,282 7	1,029 7	1,517 8	1 274,9	−0,411 2
vapour			0,026 58	410,82	432,59	2,539 9	0,613 1	0,739 8	162,01	217,25
liquid	−95,00	0,000 956	1 149,4	49,35	49,35	0,325 9	1,030 5	1,521 0	1 246,3	−0,407 2
vapour			0,042 68	413,87	436,26	2,497 8	0,624 4	0,751 4	164,04	194,62
liquid	−90,00	0,001 53	1 140,1	56,96	56,96	0,368 1	1,030 4	1,523 7	1 218,9	−0,403 0
vapour			0,066 4	416,96	439,97	2,459 3	0,635 8	0,763 4	166,02	174,86
liquid	−85,00	0,002 37	1 130,7	64,58	64,59	0,409 1	1,030 2	1,526 5	1 192,3	−0,398 6
vapour			0,100 5	420,10	443,71	2,424 2	0,647 5	0,775 8	167,95	157,56
liquid	−80,00	0,003 59	1 121,3	72,22	72,23	0,449 2	1,030 2	1,529 8	1 166,3	−0,393 7
vapour			0,148 3	423,26	447,48	2,392 0	0,659 5	0,788 6	169,81	142,37
liquid	−75,00	0,005 30	1 111,9	79,88	79,89	0,488 4	1,030 7	1,533 9	1 140,7	−0,388 3
vapour			0,213 6	426,46	451,27	2,362 6	0,671 8	0,801 9	171,62	128,99
liquid	−70,00	0,007 65	1 102,4	87,56	87,57	0,526 6	1,031 7	1,538 8	1 115,5	−0,382 4
vapour			0,301 2	429,69	455,08	2,335 7	0,684 3	0,815 7	173,36	117,18
liquid	−65,00	0,010 8	1 092,8	95,27	95,28	0,564 1	1,033 4	1,544 6	1 090,4	−0,375 8
vapour			0,416	432,94	458,90	2,311 1	0,697 2	0,830 1	175,03	106,73
liquid	−60,00	0,015 0	1 083,2	103,01	103,02	0,600 9	1,035 7	1,551 3	1 065,6	−0,368 5
vapour			0,566	436,21	462,74	2,288 5	0,710 4	0,845 2	176,62	97,46
liquid	−55,00	0,020 4	1 073,5	110,78	110,80	0,636 9	1,038 7	1,558 9	1 040,9	−0,360 6
vapour			0,755	439,50	466,57	2,267 7	0,724 0	0,860 9	178,12	89,21
liquid	−50,00	0,027 4	1 063,7	118,59	118,62	0,672 3	1,042 2	1,567 4	1 016,4	−0,352 0
vapour			0,994	442,80	470,40	2,248 7	0,737 9	0,877 4	179,54	81,87
liquid	−45,00	0,036 2	1 053,8	126,45	126,48	0,707 1	1,046 3	1,576 8	991,8	−0,342 7
vapour			1,289	446,10	474,21	2,231 3	0,752 2	0,894 6	180,86	75,31
liquid	−40,00	0,047 2	1 043,8	134,35	134,40	0,741 4	1,050 9	1,587 0	967,4	−0,332 6
vapour			1,651	449,41	478,02	2,215 2	0,766 9	0,912 7	182,08	69,45
liquid	−35,00	0,060 7	1 033,7	142,31	142,37	0,775 2	1,055 8	1,597 9	943,0	−0,321 6
vapour			2,089	452,72	481,79	2,200 4	0,782 0	0,931 7	183,19	64,20
liquid	−30,00	0,077 2	1 023,5	150,32	150,39	0,808 5	1,061 2	1,609 7	918,6	−0,309 8
vapour			2,615	456,03	485,55	2,186 8	0,797 5	0,951 6	184,18	59,49
liquid	−25,00	0,097 0	1 013,2	158,39	158,48	0,841 3	1,066 9	1,622 2	894,2	−0,297 0
vapour			3,241	459,33	489,26	2,174 3	0,813 3	0,972 4	185,06	55,26
liquid	−24,02[b]	0,101 3	1 011,2	159,97	160,07	0,847 7	1,068 1	1,624 7	889,5	−0,294 4

[a] Triple point.

[b] Normal boiling point.

[c] The values of C_r, C_p, and w at the critical point are not included as part of this document.

Table 34 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
vapour			3,376	459,97	489,98	2,171 9	0,816 4	0,976 6	185,21	54,48
liquid	−20,00	0,120 7	1 002,7	166,52	166,64	0,873 7	1,073 0	1,635 5	869,9	−0,283 2
vapour			3,979	462,61	492,94	2,162 7	0,829 5	0,994 3	185,80	51,45
liquid	−15,00	0,148 7	992,1	174,71	174,86	0,905 8	1,079 3	1,649 6	845,5	−0,268 2
vapour			4,844	465,88	496,57	2,152 0	0,846 0	1,017 2	186,41	48,02
liquid	−10,00	0,181 5	981,3	182,98	183,16	0,937 5	1,085 9	1,664 5	821,0	−0,252 0
vapour			5,852	469,12	500,15	2,142 1	0,862 9	1,041 4	186,88	44,93
liquid	−5,00	0,219 8	970,3	191,31	191,54	0,968 9	1,092 7	1,680 4	796,6	−0,234 3
vapour			7,017	472,34	503,66	2,132 9	0,880 2	1,066 7	187,20	42,13
liquid	0,00	0,264 0	959,1	199,72	200,00	1,000 0	1,099 7	1,697 2	772,0	−0,214 9
vapour			8,359	475,53	507,11	2,124 3	0,897 8	1,093 5	187,37	39,60
liquid	5,00	0,314 8	947,7	208,22	208,55	1,030 8	1,106 9	1,715 1	747,4	−0,193 8
vapour			9,896	478,68	510,49	2,116 4	0,915 7	1,121 8	187,37	37,31
liquid	10,00	0,372 8	936,1	216,79	217,19	1,061 4	1,114 4	1,734 2	722,7	−0,170 6
vapour			11,651	481,79	513,78	2,108 9	0,933 9	1,151 7	187,21	35,23
liquid	15,00	0,438 6	924,2	225,45	225,93	1,091 7	1,122 0	1,754 6	697,9	−0,144 9
vapour			13,647	484,85	516,99	2,101 8	0,952 5	1,183 4	186,87	33,35
liquid	20,00	0,512 9	912,0	234,21	234,77	1,121 9	1,129 9	1,776 5	673,0	−0,116 5
vapour			15,910	487,85	520,09	2,095 2	0,971 4	1,217 3	186,36	31,64
liquid	25,00	0,596 4	899,5	243,07	243,73	1,151 9	1,137 9	1,800 1	647,9	−0,084 9
vapour			18,469	490,79	523,09	2,088 8	0,990 6	1,253 6	185,65	30,09
liquid	30,00	0,689 8	886,6	252,03	252,80	1,181 7	1,146 2	1,825 8	622,7	−0,049 5
vapour			21,357	493,66	525,96	2,082 8	1,010 1	1,292 6	184,74	28,69
liquid	35,00	0,793 9	873,4	261,10	262,01	1,211 4	1,154 8	1,853 9	597,3	−0,009 6
vapour			24,613	496,44	528,70	2,076 9	1,030 0	1,334 9	183,63	27,41
liquid	40,00	0,909 3	859,7	270,29	271,35	1,241 1	1,163 6	1,884 7	571,7	0,035 7
vapour			28,280	499,13	531,28	2,071 1	1,050 2	1,381 1	182,30	26,25
liquid	45,00	1,036 8	845,5	279,62	280,84	1,270 7	1,172 8	1,919 0	545,9	0,087 3
vapour			32,408	501,71	533,70	2,065 5	1,070 7	1,432 0	180,74	25,20
liquid	50,00	1,177 4	830,8	289,08	290,50	1,300 3	1,182 3	1,957 4	519,9	0,146 8
vapour			37,058	504,16	535,93	2,059 8	1,091 7	1,488 7	178,94	24,24
liquid	55,00	1,331 7	815,4	298,70	300,34	1,329 9	1,192 2	2,000 9	493,5	0,215 9
vapour			42,300	506,47	537,95	2,054 0	1,113 1	1,552 6	176,89	23,38
liquid	60,00	1,500 7	799,4	308,50	310,38	1,359 6	1,202 6	2,051 0	466,9	0,297 0
vapour			48,222	508,60	539,72	2,048 0	1,135 0	1,625 7	174,57	22,60
liquid	65,00	1,685 3	782,5	318,49	320,64	1,389 5	1,213 5	2,109 4	440,0	0,393 4
vapour			54,933	510,53	541,21	2,041 8	1,157 5	1,710 9	171,96	21,90
liquid	70,00	1,886 4	764,6	328,70	331,16	1,419 6	1,225 1	2,178 9	412,6	0,509 6
vapour			62,569	512,22	542,37	2,035 1	1,180 6	1,812 2	169,04	21,27
liquid	75,00	2,105 1	745,6	339,16	341,98	1,450 1	1,237 5	2,263 7	384,8	0,652 2
vapour			71,312	513,62	543,14	2,027 9	1,204 5	1,936 0	165,79	20,71

[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 document.

Table 34 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m³	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
liquid	80,00	2,342 4	725,2	349,92	353,15	1,481 0	1,250 9	2,370 3	356,4	0,830 9
vapour			81,403	514,66	543,43	2,019 8	1,229 4	2,092 4	162,17	20,20
liquid	85,00	2,599 6	703,0	361,04	364,74	1,512 6	1,265 5	2,509 9	327,4	1,060 9
vapour			93,185	515,23	543,13	2,010 7	1,255 5	2,298 5	158,15	19,74
liquid	90,00	2,878 0	678,5	372,63	376,87	1,545 1	1,281 8	2,703 4	297,4	1,367 5
vapour			107,172	515,21	542,06	2,000 0	1,283 2	2,586 3	153,69	19,32
liquid	95,00	3,179 1	650,9	384,82	389,71	1,579 0	1,300 4	2,994 7	266,3	1,796 1
vapour			124,192	514,35	539,95	1,987 1	1,313 0	3,022 8	148,70	18,90
liquid	100,00	3,505 0	618,5	397,93	403,59	1,615 1	1,322 3	3,495 1	233,5	2,437 8
vapour			145,754	512,23	536,28	1,970 7	1,345 9	3,775 9	143,11	18,43
liquid	105,00	3,858 3	578,1	412,57	419,25	1,655 2	1,350 2	4,594 7	198,0	3,508 2
vapour			175,224	507,95	529,97	1,947 9	1,383 8	5,424 5	136,73	17,78
liquid	110,00	4,243 2	517,4	431,02	439,22	1,705 8	1,392 1	9,261 4	157,9	5,710 4
vapour			224,256	498,39	517,31	1,909 6	1,431 7	12,215 0	129,14	16,42
critical	113,26	4,516 8	368,0	465,28	477,55	1,803 7	c	c	c	11,292 0

[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 document.

5.12 R404A — R125/143a/134a (44/52/4)

5.12.1 Composition of R404A

The Composition of R404A is listed in Table 35.

Table 35 — 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/m³)

5.12.3 Interaction parameters (Formulae 19 and 20)

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

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

Coefficients and exponents of the excess functions of R125/134a binary pair and R143a/134a binary pair are listed in Table 36.

Table 36 — 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 $\phi_{ij,\text{excess}}$ 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 $\phi_{ij,\text{excess}}$ function for the R143a/134a pair is identical to that for the R125/143a pair.

5.12.5 Reference state parameters

$f_3 = 0{,}753\ 387\ 285, f_4 = 17{,}495\ 997\ 7$

R404A property values of liquid on the bubble line and vapour on the dew line are listed in Table 37.

Table 37 — R404A 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/m³	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
bubble	0,010 0	−84,93	1 421,3	91,82	91,83	0,529 6	0,771 0	1,213 8	932,6	−0,354 5
dew		−83,84	0,626	300,87	316,83	1,722 9	0,571 9	0,663 5	135,39	113,71
bubble	0,015 0	−79,30	1 404,8	98,65	98,66	0,565 4	0,779 5	1,213 7	895,9	−0,349 5
dew		−78,28	0,916	303,83	320,21	1,706 4	0,586 0	0,679 3	136,88	96,75
bubble	0,020 0	−75,05	1 392,4	103,80	103,81	0,591 7	0,785 4	1,215 2	870,1	−0,344 4
dew		−74,08	1,199	306,10	322,78	1,695 3	0,596 8	0,691 5	137,93	86,40
bubble	0,025 0	−71,61	1 382,3	107,99	108,01	0,612 6	0,789 9	1,217 3	850,1	−0,339 6
dew		−70,66	1,477	307,94	324,87	1,687 0	0,605 5	0,701 6	138,74	79,22
bubble	0,030 0	−68,68	1 373,7	111,56	111,58	0,630 2	0,793 7	1,219 7	833,7	−0,334 9
dew		−67,76	1,752	309,52	326,65	1,680 5	0,613 0	0,710 4	139,39	73,86
bubble	0,040 0	−63,85	1 359,4	117,45	117,48	0,658 7	0,799 8	1,224 6	807,5	−0,326 2
dew		−62,97	2,293	312,13	329,58	1,670 7	0,625 5	0,725 2	140,40	66,23
bubble	0,050 0	−59,92	1 347,7	122,28	122,31	0,681 5	0,804 6	1,229 5	786,8	−0,318 1
dew		−59,07	2,825	314,28	331,97	1,663 5	0,635 9	0,737 7	141,14	60,94
bubble	0,060 0	−56,57	1 337,7	126,40	126,44	0,700 7	0,808 8	1,234 2	769,6	−0,310 6
dew		−55,75	3,351	316,10	334,00	1,657 8	0,644 7	0,748 7	141,72	56,99
bubble	0,080 0	−51,03	1 321,0	133,25	133,31	0,732 0	0,815 6	1,243 0	741,6	−0,296 7
dew		−50,25	4,390	319,13	337,36	1,649 4	0,659 6	0,767 5	142,57	51,36
bubble	0,100 0	−46,50	1 307,1	138,89	138,97	0,757 1	0,821 2	1,251 1	719,2	−0,283 9
dew		−45,74	5,415	321,62	340,08	1,643 4	0,672 0	0,783 6	143,16	47,44
bubble	0,101 3[a]	−46,22	1 306,3	139,24	139,31	0,758 6	0,821 5	1,251 6	717,9	−0,283 1
dew		−45,47	5,483	321,77	340,25	1,643 0	0,672 8	0,784 6	143,19	47,22
bubble	0,120 0	−42,63	1 295,1	143,74	143,83	0,778 3	0,826 0	1,258 7	700,4	−0,272 0
dew		−41,90	6,430	323,74	342,40	1,638 7	0,682 8	0,797 8	143,57	44,50
bubble	0,140 0	−39,24	1 284,5	148,01	148,12	0,796 7	0,830 3	1,265 8	684,0	−0,260 6

[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 document.

Table 37 *(continued)*

	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
dew		−38,53	7,439	325,59	344,41	1,634 9	0,692 3	0,810 8	143,86	42,18
bubble	0,160 0	−36,20	1 275,0	151,85	151,97	0,813 0	0,834 1	1,272 6	669,4	−0,249 8
dew		−35,51	8,442	327,25	346,20	1,631 8	0,700 9	0,822 8	144,07	40,29
bubble	0,180 0	−33,45	1 266,2	155,35	155,49	0,827 7	0,837 7	1,279 0	656,2	−0,239 3
dew		−32,78	9,441	328,75	347,81	1,629 2	0,708 8	0,833 9	144,21	38,70
bubble	0,200 0	−30,93	1 258,0	158,57	158,73	0,841 1	0,840 9	1,285 2	644,2	−0,229 1
dew		−30,27	10,437	330,12	349,28	1,627 0	0,716 1	0,844 5	144,29	37,34
bubble	0,250 0	−25,38	1 239,9	165,72	165,92	0,870 3	0,848 2	1,299 8	617,8	−0,204 6
dew		−24,75	12,920	333,12	352,47	1,622 5	0,732 4	0,868 8	144,34	34,66
bubble	0,300 0	−20,62	1 223,9	171,90	172,14	0,895 0	0,854 6	1,313 4	595,2	−0,181 1
dew		−20,02	15,399	335,67	355,15	1,619 0	0,746 5	0,890 9	144,22	32,64
bubble	0,350 0	−16,44	1 209,6	177,38	177,67	0,916 6	0,860 4	1,326 4	575,4	−0,158 1
dew		−15,86	17,881	337,90	357,47	1,616 3	0,759 2	0,911 4	143,99	31,04
bubble	0,400 0	−12,69	1 196,5	182,35	182,68	0,935 8	0,865 6	1,338 8	557,6	−0,135 5
dew		−12,12	20,369	339,87	359,51	1,614 1	0,770 6	0,930 7	143,66	29,75
bubble	0,450 0	−9,28	1 184,4	186,89	187,27	0,953 1	0,870 4	1,350 9	541,4	−0,113 0
dew		−8,73	22,867	341,65	361,33	1,612 2	0,781 1	0,949 2	143,28	28,67
bubble	0,500 0	−6,15	1 173,0	191,11	191,53	0,969 0	0,875 0	1,362 7	526,5	−0,090 5
dew		−5,61	25,378	343,26	362,96	1,610 5	0,790 7	0,967 0	142,84	27,75
bubble	0,550 0	−3,24	1 162,3	195,04	195,51	0,983 7	0,879 2	1,374 4	512,7	−0,067 9
dew		−2,72	27,905	344,74	364,45	1,609 1	0,799 7	0,984 2	142,36	26,97
bubble	0,600 0	−0,53	1 152,0	198,74	199,26	0,997 3	0,883 2	1,385 9	499,7	−0,045 2
dew		−0,02	30,449	346,11	365,81	1,607 8	0,808 2	1,001 1	141,85	26,28
bubble	0,650 0	2,02	1 142,3	202,24	202,81	1,010 1	0,887 1	1,397 3	487,5	−0,022 2
dew		2,52	33,012	347,37	367,06	1,606 6	0,816 1	1,017 7	141,31	25,68
bubble	0,700 0	4,42	1 132,9	205,57	206,18	1,022 2	0,890 8	1,408 7	476,0	0,001 1
dew		4,91	35,595	348,55	368,21	1,605 5	0,823 7	1,034 2	140,75	25,16
bubble	0,750 0	6,70	1 123,8	208,74	209,41	1,033 6	0,894 3	1,420 1	465,0	0,024 8
dew		7,18	38,201	349,65	369,28	1,604 4	0,830 9	1,050 6	140,17	24,69
bubble	0,800 0	8,87	1 115,1	211,78	212,49	1,044 4	0,897 7	1,431 6	454,5	0,048 9
dew		9,34	40,831	350,68	370,27	1,603 5	0,837 8	1,067 0	139,58	24,27
bubble	0,850 0	10,94	1 106,5	214,70	215,46	1,054 7	0,900 9	1,443 1	444,5	0,073 5
dew		11,40	43,485	351,64	371,19	1,602 5	0,844 5	1,083 5	138,96	23,89
bubble	0,900 0	12,92	1 098,2	217,51	218,32	1,064 6	0,904 1	1,454 7	434,9	0,098 6
dew		13,37	46,167	352,55	372,05	1,601 6	0,851 0	1,100 1	138,34	23,55
bubble	0,950 0	14,81	1 090,2	220,22	221,09	1,074 1	0,907 2	1,466 5	425,6	0,124 4
dew		15,26	48,876	353,41	372,85	1,600 7	0,857 3	1,116 9	137,70	23,24
bubble	1,000 0	16,64	1 082,2	222,84	223,77	1,083 2	0,910 2	1,478 4	416,7	0,150 7
dew		17,08	51,614	354,22	373,59	1,599 9	0,863 4	1,134 0	137,05	22,95
bubble	1,200 0	23,32	1 052,0	232,60	233,75	1,116 6	0,921 7	1,528 0	383,5	0,263 3
dew		23,73	62,884	357,03	376,12	1,596 5	0,886 9	1,205 8	134,36	22,03
bubble	1,400 0	29,22	1 023,4	241,44	242,81	1,146 2	0,932 5	1,582 1	353,8	0,390 1

[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 document.

Table 37 *(continued)*

	Pressure	Temp.	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	MPa	°C	kg/m³	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
dew		29,60	74,728	359,29	378,02	1,593 2	0,909 1	1,285 3	131,56	21,35
bubble	1,600 0	34,51	995,7	249,58	251,19	1,173 0	0,943 1	1,642 7	326,5	0,535 1
dew		34,87	87,247	361,08	379,42	1,589 6	0,930 6	1,375 7	128,65	20,82
bubble	1,800 0	39,33	968,6	257,19	259,05	1,197 7	0,953 5	1,712 2	301,2	0,703 3
dew		39,67	100,56	362,48	380,38	1,585 8	0,951 8	1,481 0	125,66	20,41
bubble	2,000 0	43,75	941,6	264,40	266,52	1,220 8	0,964 3	1,794 1	277,3	0,901 5
dew		44,07	114,81	363,51	380,92	1,581 7	0,972 8	1,607 1	122,58	20,07
bubble	2,200 0	47,85	914,4	271,29	273,70	1,242 7	0,975 5	1,893 5	254,5	1,139 2
dew		48,15	130,20	364,18	381,08	1,577 0	0,993 9	1,762 8	119,43	19,79
bubble	2,400 0	51,68	886,5	277,96	280,66	1,263 5	0,987 5	2,018 5	232,5	1,430 1
dew		51,95	146,99	364,50	380,83	1,571 8	1,015 3	1,962 0	116,19	19,55
bubble	2,600 0	55,26	857,5	284,47	287,50	1,283 7	1,006 9	2,183 2	211,1	1,795 0
dew		55,51	165,54	364,44	380,15	1,565 8	1,037 5	2,229 1	112,87	19,31
bubble	2,800 0	58,63	826,8	290,90	294,29	1,303 6	1,016 1	2,413 6	190,0	2,267 1
dew		58,86	186,43	363,94	378,96	1,558 7	1,060 9	2,609 1	109,47	19,06
bubble	3,000 0	61,81	793,4	297,36	301,15	1,323 4	1,034 3	2,765 3	169,0	2,902 8
dew		62,01	210,55	362,90	377,15	1,550 3	1,086 2	3,197 3	105,97	18,74
bubble	3,200 0	64,82	755,6	304,02	308,25	1,343 8	1,057 0	3,381 2	147,8	3,806 8
dew		64,99	239,56	361,13	374,49	1,539 7	1,114 8	4,233 3	102,35	18,29
critical	3,728 9	72,05	486,5	336,26	343,92	1,445 5	b	b	b	12,334 7

[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 document.

5.13 R407C — R32/125/134a (23/25/52)

The composition of R407C is listed in Table 38.

Table 38 — Composition of R407C

i	Component	Mass fraction	Mole fraction
1	R32	0,23	0,381 109 42
2	R125	0,25	0,179 558 89
3	R134a	0,52	0,439 331 69
M = 86,203 7 g/mol			

5.13.1 Range of validity

The coefficients are valid within the following ranges:

T_{min} = 172,52 K, T_{max} = 435 K; p_{max} = 60 MPa; ρ_{max} = 17,96 mol/l (1 548 kg/m³)

5.13.2 Interaction parameters (Formulae 19 and 20)

ζ_{12} = 28,95; ζ_{12} = −0,006 008; ζ_{13} = 7,909; ζ_{13} = −0,002 039; ζ_{23} = −0,432 6; ζ_{23} = −0,000 345 3

Coefficients and exponents of the excess functions are listed in Table 39.

Table 39 — Coefficients and exponents of the excess functions [Formula (21)]

k	N_k	t_k	d_k	l_k
R32/125 binary pair[a]				
1	−0,007 295 5	4,50	2	1
2	0,078 035	0,57	5	1
3	0,610 07	1,90	1	2
4	0,642 46	1,20	3	2
5	0,014 965	0,50	9	2
6	−0,340 49	2,60	2	3
7	0,085 658	11,40	3	3
8	−0,064 429	4,50	6	3
R32/134a binary pair[b]				
1	0,229 09	1,9	1	1
2	0,094 074	0,25	3	1
3	0,000 398 76	0,07	8	1
4	0,021 133	2,0	1	2
R125/134a binary pair[c]				
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

[a] $i = 1; j = 2; F_{12} = 1{,}00$.

[b] $i = 1; j = 3; F_{13} = 1{,}00$.

[c] $i = 2; j = 3; F_{23} = 1{,}00$.

5.13.3 Reference state parameters

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

R407C property values of liquid on the bubble line and vapour on the dew line are listed in Table 40.

Table 40 — R407C 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/m³	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
bubble	0,010 0	−82,45	1 495,5	90,48	90,48	0,525 9	0,820 0	1,281 5	1 008,4	−0,329 9
dew		−74,81	0,527	347,81	366,78	1,947 1	0,565 4	0,668 1	149,08	115,10
bubble	0,015 0	−76,77	1 479,1	97,75	97,76	0,563 4	0,821 9	1,282 0	976,2	−0,324 6
dew		−69,22	0,771	350,74	370,19	1,925 3	0,578 1	0,682 6	150,70	100,56
bubble	0,020 0	−72,50	1 466,7	103,23	103,24	0,591 0	0,823 5	1,283 5	952,7	−0,319 8
dew		−65,02	1,010	352,95	372,75	1,910 4	0,587 9	0,694 1	151,85	91,36
bubble	0,025 0	−69,03	1 456,6	107,68	107,70	0,613 0	0,825 0	1,285 3	934,1	−0,315 4
dew		−61,61	1,245	354,75	374,83	1,899 1	0,596 0	0,703 8	152,74	84,79
bubble	0,030 0	−66,09	1 448,0	111,46	111,48	0,631 4	0,826 3	1,287 2	918,5	−0,311 3
dew		−58,72	1,477	356,27	376,59	1,890 0	0,603 1	0,712 3	153,46	79,75

[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 document.

Table 40 *(continued)*

	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	0,040 0	−61,25	1 433,7	117,70	117,72	0,661 2	0,828 7	1,291 2	893,3	−0,303 9
dew		−53,95	1,934	358,79	379,47	1,876 1	0,614 9	0,726 9	154,58	72,38
bubble	0,050 0	−57,31	1 422,0	122,79	122,82	0,685 0	0,830 8	1,295 0	873,1	−0,297 2
dew		−50,08	2,384	360,83	381,80	1,865 6	0,624 8	0,739 3	155,43	67,09
bubble	0,060 0	−53,96	1 412,0	127,13	127,17	0,705 0	0,832 7	1,298 7	856,1	−0,291 1
dew		−46,79	2,829	362,56	383,77	1,857 3	0,633 4	0,750 2	156,10	63,04
bubble	0,080 0	−48,42	1 395,3	134,33	134,39	0,737 4	0,836 1	1,305 6	828,3	−0,279 9
dew		−41,34	3,707	365,41	386,99	1,844 5	0,647 9	0,769 2	157,10	57,08
bubble	0,100 0	−43,90	1 381,5	140,24	140,31	0,763 5	0,839 1	1,312 1	805,8	−0,269 8
dew		−36,90	4,574	367,73	389,59	1,834 9	0,660 1	0,785 5	157,81	52,81
bubble	0,101 3[a]	−43,63	1 380,7	140,60	140,67	0,765 0	0,839 3	1,312 5	804,5	−0,269 1
dew		−36,63	4,631	367,87	389,75	1,834 3	0,660 9	0,786 5	157,85	52,57
bubble	0,120 0	−40,05	1 369,7	145,30	145,39	0,785 4	0,841 8	1,318 1	786,8	−0,260 4
dew		−33,11	5,432	369,69	391,78	1,827 3	0,670 7	0,800 1	158,34	49,54
bubble	0,140 0	−36,67	1 359,1	149,75	149,86	0,804 3	0,844 3	1,323 8	770,2	−0,251 5
dew		−29,79	6,283	371,40	393,68	1,821 0	0,680 2	0,813 3	158,74	46,91
bubble	0,160 0	−33,65	1 349,7	153,75	153,86	0,821 1	0,846 6	1,329 2	755,4	−0,243 1
dew		−26,83	7,130	372,92	395,36	1,815 6	0,688 7	0,825 5	159,05	44,74
bubble	0,180 0	−30,92	1 341,0	157,38	157,51	0,836 2	0,848 8	1,334 4	742,1	−0,235 0
dew		−24,15	7,973	374,29	396,86	1,811 0	0,696 5	0,836 9	159,29	42,90
bubble	0,200 0	−28,41	1 333,0	160,72	160,87	0,849 9	0,850 8	1,339 4	729,9	−0,227 2
dew		−21,69	8,813	375,53	398,22	1,806 9	0,703 8	0,847 6	159,47	41,32
bubble	0,250 0	−22,90	1 315,1	168,11	168,30	0,879 8	0,855 5	1,351 3	703,1	−0,208 4
dew		−16,28	10,904	378,24	401,17	1,798 4	0,720 0	0,872 2	159,74	38,14
bubble	0,300 0	−18,19	1 299,5	174,48	174,71	0,905 0	0,859 8	1,362 4	680,1	−0,190 6
dew		−11,66	12,989	380,52	403,62	1,791 7	0,734 0	0,894 5	159,82	35,72
bubble	0,350 0	−14,04	1 285,5	180,12	180,39	0,926 9	0,863 7	1,373 1	660,0	−0,173 3
dew		−7,61	15,071	382,49	405,72	1,786 1	0,746 5	0,915 1	159,79	33,80
bubble	0,400 0	−10,33	1 272,8	185,20	185,52	0,946 5	0,867 3	1,383 4	641,9	−0,156 4
dew		−3,97	17,154	384,24	407,55	1,781 4	0,757 8	0,934 5	159,66	32,22
bubble	0,450 0	−6,95	1 261,1	189,86	190,21	0,964 1	0,870 7	1,393 4	625,5	−0,139 8
dew		−0,67	19,241	385,79	409,18	1,777 2	0,768 2	0,952 8	159,46	30,89
bubble	0,500 0	−3,85	1 250,1	194,16	194,56	0,980 1	0,874 0	1,403 2	610,4	−0,123 3
dew		2,36	21,334	387,20	410,64	1,773 5	0,777 9	0,970 4	159,20	29,76
bubble	0,550 0	−0,98	1 239,8	198,17	198,61	0,995 0	0,877 1	1,412 9	596,3	−0,106 9
dew		5,17	23,435	388,48	411,95	1,770 2	0,786 8	0,987 5	158,91	28,77
bubble	0,600 0	1,70	1 230,0	201,93	202,42	1,008 7	0,880 1	1,422 4	583,2	−0,090 5
dew		7,79	25,545	389,66	413,15	1,767 2	0,795 3	1,004 0	158,58	27,91
bubble	0,650 0	4,22	1 220,7	205,49	206,02	1,021 6	0,883 0	1,431 9	570,8	−0,074 1
dew		10,24	27,665	390,75	414,25	1,764 4	0,803 2	1,020 1	158,22	27,14
bubble	0,700 0	6,60	1 211,7	208,87	209,44	1,033 8	0,885 7	1,441 3	559,1	−0,057 6
dew		12,56	29,796	391,76	415,25	1,761 8	0,810 8	1,036 0	157,83	26,46

[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 document.

Table 40 *(continued)*

	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	0,750 0	8,85	1 203,1	212,08	212,71	1,045 2	0,888 4	1,450 7	548,0	−0,041 0
dew		14,76	31,940	392,70	416,18	1,759 4	0,817 9	1,051 6	157,42	25,84
bubble	0,800 0	11,00	1 194,9	215,16	215,83	1,056 1	0,891 1	1,460 0	537,4	−0,024 2
dew		16,85	34,098	393,57	417,03	1,757 1	0,824 8	1,067 0	157,00	25,29
bubble	0,900 0	15,00	1 179,1	220,95	221,71	1,076 4	0,896 1	1,478 9	517,6	0,009 8
dew		20,74	38,456	395,16	418,57	1,752 9	0,837 8	1,097 6	156,11	24,32
bubble	1,000 0	18,69	1 164,1	226,33	227,19	1,095 0	0,901 0	1,497 9	499,2	0,044 7
dew		24,32	42,877	396,57	419,89	1,749 1	0,849 9	1,128 2	155,16	23,50
bubble	1,200 0	25,30	1 136,2	236,14	237,20	1,128 3	0,910 2	1,537 0	466,0	0,118 0
dew		30,73	51,932	398,92	422,03	1,742 1	0,872 1	1,190 2	153,16	22,18
bubble	1,400 0	31,14	1 110,2	244,98	246,24	1,157 7	0,919 0	1,578 0	436,4	0,196 8
dew		36,37	61,306	400,79	423,63	1,735 8	0,892 6	1,254 9	151,05	21,17
bubble	1,600 0	36,39	1 085,5	253,09	254,57	1,184 3	0,927 4	1,621 9	409,4	0,282 6
dew		41,43	71,047	402,28	424,80	1,729 8	0,912 0	1,324 2	148,85	20,36
bubble	1,800 0	41,18	1 061,7	260,64	262,33	1,208 6	0,935 8	1,669 5	384,5	0,376 9
dew		46,03	81,203	403,44	425,61	1,724 1	0,930 5	1,399 6	146,57	19,69
bubble	2,000 0	45,59	1 038,5	267,74	269,66	1,231 1	0,944 1	1,721 8	361,3	0,481 5
dew		50,25	91,831	404,32	426,10	1,718 4	0,948 4	1,483 1	144,24	19,13
bubble	2,200 0	49,68	1 015,7	274,47	276,64	1,252 2	0,952 6	1,780 4	339,3	0,598 7
dew		54,15	103,00	404,93	426,29	1,712 6	0,966 0	1,577 0	141,84	18,64
bubble	2,400 0	53,51	993,1	280,92	283,34	1,272 3	0,961 3	1,847 0	318,4	0,731 5
dew		57,79	114,78	405,29	426,20	1,706 8	0,983 4	1,684 5	139,40	18,22
bubble	2,600 0	57,11	970,5	287,14	289,82	1,291 4	0,970 5	1,924 4	298,2	0,883 8
dew		61,19	127,27	405,42	425,85	1,700 7	1,000 8	1,809 6	136,90	17,84
bubble	2,800 0	60,51	947,5	293,17	296,12	1,309 7	0,980 2	2,016 1	278,6	1,060 7
dew		64,38	140,60	405,30	425,21	1,694 4	1,018 3	1,958 2	134,35	17,48
bubble	3,000 0	63,73	924,1	299,07	302,31	1,327 6	0,990 9	2,127 9	259,4	1,269 5
dew		67,40	154,93	404,93	424,29	1,687 7	1,036 0	2,139 0	131,75	17,15
bubble	3,200 0	66,80	899,9	304,88	308,43	1,345 0	1,002 8	2,268 2	240,4	1,520 1
dew		70,25	170,45	404,28	423,06	1,680 5	1,054 3	2,364 8	129,09	16,83
bubble	3,400 0	69,73	874,6	310,65	314,54	1,362 2	1,016 4	2,451 1	221,6	1,826 8
dew		72,94	187,47	403,33	421,46	1,672 6	1,073 4	2,656 7	126,38	16,49
bubble	3,600 0	72,53	847,6	316,46	320,71	1,379 5	1,032 2	2,701 1	202,7	2,210 7
dew		75,50	206,40	402,01	419,45	1,663 9	1,093 7	3,050 4	123,59	16,14
bubble	3,800 0	75,22	818,1	322,38	327,02	1,397 0	1,051 2	3,065 3	183,8	2,704 3
dew		77,92	227,89	400,24	416,91	1,654 0	1,115 6	3,613 2	120,73	15,74
bubble	4,000 0	77,82	785,1	328,54	333,64	1,415 2	1,074 7	3,646 9	164,8	3,360 4
dew		80,21	253,04	397,85	413,66	1,642 4	1,140 1	4,486 3	117,75	15,26
bubble	4,200 0	80,32	746,0	335,20	340,83	1,434 8	1,105 0	4,726 1	145,6	4,274 2
dew		82,37	284,01	394,55	409,34	1,628 1	1,168 7	6,028 9	114,58	14,63
critical	4,629 8	86,03	484,2	368,92	378,48	1,538 4	b	b	b	10,392 2

[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 document.

5.14 R410A — R32/125 (50/50)

The composition of R410A is listed in Table 41.

Table 41 — Composition of R410A

i	Component	Mass fraction	Mole fraction
1	R32	0,50	0,697 614 70
2	R125	0,50	0,302 385 30
M = 72,585 5 g/mol			

5.14.1 Range of validity

The coefficients are valid within the following ranges:

T_{min} = 172,52 K, T_{max} = 435 K; p_{max} = 60 MPa; ρ_{max} = 20,2 mol/l(1 496 kg/m^3)

5.14.2 Interaction parameters (Formulae 9 and 20)

ζ_{12} = 28,95; ζ_{12} = −0,006 008

Coefficients and exponents of the excess functions are listed in Table 42.

Table 42 — Coefficients and exponents of the excess functions [Formula (21)]

R32/125 binary pair[a]				
k	N_k	t_k	d_k	l_k
1	−0,007 295 5	4,50	2	1
2	0,078 035	0,57	5	1
3	0,610 07	1,90	1	2
4	0,642 46	1,20	3	2
5	0,014 965	0,50	9	2
6	−0,340 49	2,60	2	3
7	−0,085 658	11,40	3	3
8	−0,064 429	4,50	6	3

[a] F_{12} = 1,00; i = 1, j = 2.

5.14.3 Reference state parameters

f_3 = 0,617 469 323, f_4 = −0,596 795

R410A property values of liquid on the bubble line and vapour on the dew line are listed in Table 43.

Table 43 — R410A 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	0,010 0	−88,23	1 460,6	76,55	76,56	0,458 8	0,866 2	1,344 1	1 004,0	−0,321 5
dew		−88,14	0,476	357,77	378,76	2,092 7	0,544 2	0,668 0	159,71	156,70

[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 document.

Table 43 *(continued)*

	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	0,015 0	−82,84	1 444,9	83,79	83,80	0,497 4	0,862 0	1,344 4	977,6	−0,315 6
dew		−82,75	0,697	360,37	381,90	2,063 5	0,556 9	0,683 6	161,51	137,58
bubble	0,020 0	−78,79	1 432,9	89,24	89,26	0,525 8	0,859 6	1,345 5	957,8	−0,310 5
dew		−78,70	0,912	362,31	384,25	2,043 2	0,567 0	0,696 4	162,79	125,06
bubble	0,025 0	−75,50	1 423,1	93,67	93,69	0,548 4	0,858 0	1,346 8	941,8	−0,306 0
dew		−75,41	1,124	363,88	386,13	2,027 6	0,575 7	0,707 4	163,78	115,92
bubble	0,030 0	−72,71	1 414,8	97,42	97,44	0,567 2	0,856 9	1,348 3	928,2	−0,301 8
dew		−72,63	1,333	365,21	387,71	2,015 1	0,583 3	0,717 2	164,59	108,80
bubble	0,040 0	−68,12	1 401,1	103,61	103,64	0,597 8	0,855 5	1,351 5	905,8	−0,294 4
dew		−68,04	1,745	367,37	390,29	1,995 6	0,596 4	0,734 4	165,84	98,17
bubble	0,050 0	−64,39	1 389,7	108,66	108,70	0,622 2	0,854 8	1,354 6	887,6	−0,287 8
dew		−64,31	2,151	369,11	392,36	1,980 7	0,607 5	0,749 2	166,78	90,44
bubble	0,060 0	−61,22	1 380,0	112,96	113,00	0,642 6	0,854 4	1,357 7	872,1	−0,281 8
dew		−61,14	2,551	370,58	394,10	1,968 7	0,617 2	0,762 4	167,53	84,44
bubble	0,080 0	−55,98	1 363,9	120,08	120,14	0,675 8	0,854 3	1,363 6	846,5	−0,270 8
dew		−55,90	3,342	372,99	396,92	1,950 0	0,633 8	0,785 5	168,66	75,56
bubble	0,100 0	−51,70	1 350,5	125,92	125,99	0,702 4	0,854 6	1,369 3	825,6	−0,260 9
dew		−51,62	4,123	374,92	399,17	1,935 8	0,647 7	0,805 4	169,47	69,16
bubble	0,101 3[a]	−51,44	1 349,7	126,27	126,34	0,704 0	0,854 7	1,369 7	824,3	−0,260 2
dew		−51,36	4,174	375,03	399,31	1,935 0	0,648 6	0,806 6	169,52	68,80
bubble	0,120 0	−48,06	1 339,0	130,90	130,99	0,724 7	0,855 2	1,374 7	807,7	−0,251 6
dew		−47,98	4,895	376,54	401,05	1,924 3	0,659 9	0,823 1	170,08	64,24
bubble	0,140 0	−44,87	1 328,8	135,29	135,39	0,744 1	0,855 9	1,379 9	792,0	−0,243 0
dew		−44,79	5,662	377,95	402,67	1,914 7	0,670 6	0,839 1	170,56	60,30
bubble	0,160 0	−42,02	1 319,6	139,22	139,34	0,761 2	0,856 7	1,385 0	777,9	−0,234 7
dew		−41,94	6,425	379,19	404,09	1,906 5	0,680 4	0,853 9	170,93	57,05
bubble	0,180 0	−39,44	1 311,2	142,79	142,93	0,776 6	0,857 6	1,389 9	765,2	−0,226 7
dew		−39,36	7,183	380,30	405,36	1,899 3	0,689 2	0,867 7	171,22	54,30
bubble	0,200 0	−37,07	1 303,4	146,07	146,23	0,790 5	0,858 5	1,394 6	753,4	−0,219 0
dew		−36,99	7,940	381,31	406,50	1,892 8	0,697 4	0,880 6	171,45	51,94
bubble	0,250 0	−31,88	1 286,1	153,32	153,51	0,820 9	0,860 8	1,406 1	727,5	−0,200 6
dew		−31,79	9,822	383,48	408,93	1,879 4	0,715 5	0,910 0	171,83	47,24
bubble	0,300 0	−27,44	1 271,1	159,56	159,80	0,846 6	0,863 1	1,417 2	705,3	−0,183 0
dew		−27,35	11,697	385,29	410,94	1,868 5	0,731 0	0,936 5	172,01	43,70
bubble	0,350 0	−23,54	1 257,6	165,08	165,36	0,868 9	0,865 5	1,427 9	685,6	−0,166 0
dew		−23,45	13,569	386,84	412,64	1,859 3	0,744 7	0,960 8	172,06	40,90
bubble	0,400 0	−20,04	1 245,3	170,05	170,38	0,888 7	0,867 8	1,438 4	667,8	−0,149 3
dew		−19,95	15,442	388,20	414,10	1,851 4	0,757 0	0,983 4	172,00	38,62
bubble	0,450 0	−16,87	1 233,9	174,60	174,96	0,906 5	0,870 2	1,448 7	651,6	−0,132 9
dew		−16,78	17,318	389,40	415,39	1,844 5	0,768 2	1,004 9	171,87	36,72
bubble	0,500 0	−13,96	1 223,3	178,80	179,21	0,922 8	0,872 5	1,458 9	636,7	−0,116 6
dew		−13,86	19,198	390,48	416,53	1,838 3	0,778 6	1,025 3	171,68	35,10

[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 document.

Table 43 *(continued)*

	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	0,550 0	−11,26	1 213,4	182,72	183,17	0,937 9	0,874 7	1,469 0	622,7	−0,100 4
dew		−11,16	21,085	391,46	417,54	1,832 6	0,788 1	1,045 0	171,44	33,70
bubble	0,600 0	−8,74	1 203,9	186,39	186,89	0,951 8	0,877 0	1,479 1	609,6	−0,084 3
dew		−8,64	22,979	392,34	418,46	1,827 5	0,797 0	1,064 1	171,16	32,48
bubble	0,650 0	−6,38	1 194,9	189,86	190,40	0,964 9	0,879 2	1,489 1	597,3	−0,068 1
dew		−6,28	24,882	393,16	419,28	1,822 7	0,805 4	1,082 7	170,85	31,40
bubble	0,700 0	−4,15	1 186,3	193,15	193,74	0,977 2	0,881 5	1,499 1	585,6	−0,051 9
dew		−4,05	26,795	393,90	420,03	1,818 3	0,813 3	1,100 8	170,52	30,44
bubble	0,750 0	−2,04	1 178,1	196,28	196,92	0,988 8	0,883 7	1,509 2	574,5	−0,035 5
dew		−1,93	28,718	394,59	420,71	1,814 1	0,820 7	1,118 6	170,16	29,58
bubble	0,800 0	−0,03	1 170,1	199,27	199,96	0,999 8	0,885 9	1,519 3	563,9	−0,019 1
dew		0,08	30,652	395,23	421,33	1,810 2	0,827 8	1,136 2	169,78	28,80
bubble	0,900 0	3,72	1 154,9	204,91	205,69	1,020 4	0,890 2	1,539 6	543,9	0,014 2
dew		3,83	34,557	396,37	422,41	1,803 0	0,840 9	1,170 8	168,98	27,45
bubble	1,000 0	7,17	1 140,5	210,15	211,02	1,039 2	0,894 5	1,560 2	525,4	0,048 2
dew		7,27	38,515	397,35	423,31	1,796 4	0,852 9	1,205 1	168,13	26,32
bubble	1,200 0	13,34	1 113,7	219,69	220,76	1,073 0	0,903 0	1,602 5	491,9	0,119 0
dew		13,46	46,611	398,94	424,68	1,784 6	0,874 6	1,274 3	166,32	24,52
bubble	1,400 0	18,79	1 088,8	228,27	229,56	1,102 7	0,911 4	1,646 9	462,0	0,194 3
dew		18,91	54,978	400,12	425,59	1,774 1	0,894 3	1,346 6	164,40	23,14
bubble	1,600 0	23,68	1 065,2	236,15	237,65	1,129 6	0,919 9	1,694 1	434,7	0,275 1
dew		23,80	63,652	400,97	426,11	1,764 4	0,912 8	1,424 1	162,40	22,03
bubble	1,800 0	28,13	1 042,6	243,46	245,19	1,154 2	0,928 5	1,744 7	409,5	0,362 8
dew		28,25	72,672	401,54	426,31	1,755 2	0,930 8	1,509 0	160,33	21,11
bubble	2,000 0	32,22	1 020,7	250,33	252,29	1,176 9	0,937 4	1,799 8	386,0	0,458 6
dew		32,34	82,083	401,87	426,24	1,746 4	0,948 5	1,603 3	158,20	20,33
bubble	2,200 0	36,02	999,2	256,85	259,05	1,198 3	0,946 5	1,860 8	363,8	0,564 3
dew		36,14	91,932	401,97	425,90	1,737 9	0,966 3	1,709 4	156,01	19,64
bubble	2,400 0	39,56	978,0	263,07	265,52	1,218 5	0,956 0	1,929 5	342,7	0,682 1
dew		39,68	102,28	401,86	425,33	1,729 4	0,984 3	1,830 6	153,77	19,03
bubble	2,600 0	42,89	957,0	269,05	271,77	1,237 7	0,966 0	2,008 2	322,4	0,815 0
dew		43,00	113,19	401,54	424,51	1,720 9	1,002 5	1,970 8	151,48	18,47
bubble	2,800 0	46,02	935,8	274,85	277,84	1,256 1	0,976 7	2,100 5	302,9	0,966 5
dew		46,14	124,76	401,02	423,47	1,712 3	1,021 2	2,135 7	149,12	17,96
bubble	3,000 0	48,99	914,5	280,50	283,78	1,274 0	0,988 1	2,211 2	283,8	1,141 6
dew		49,10	137,09	400,29	422,18	1,703 5	1,040 4	2,333 1	146,70	17,47
bubble	3,200 0	51,81	892,6	286,04	289,62	1,291 3	1,000 5	2,347 9	265,2	1,346 9
dew		51,91	150,31	399,33	420,62	1,694 4	1,060 2	2,575 0	144,22	17,01
bubble	3,400 0	54,49	870,0	291,52	295,43	1,308 5	1,014 1	2,521 8	246,8	1,591 3
dew		54,59	164,62	398,12	418,78	1,684 9	1,081 0	2,879 3	141,67	16,55
bubble	3,600 0	57,05	846,3	297,00	301,26	1,325 4	1,029 5	2,751 7	228,5	1,887 4
dew		57,15	180,26	396,63	416,60	1,674 7	1,103 1	3,275 7	139,03	16,09

[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 document.

Table 43 *(continued)*

	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	3,800 0	59,50	821,0	302,53	307,16	1,342 5	1,047 2	3,070 4	210,3	2,253 4
dew		59,59	197,60	394,80	414,03	1,663 8	1,126 7	3,815 4	136,29	15,61
bubble	4,000 0	61,85	793,5	308,20	313,24	1,360 0	1,068 4	3,541 3	191,9	2,716 9
dew		61,93	217,17	392,55	410,97	1,651 7	1,152 7	4,595 7	133,43	15,10
bubble	4,200 0	64,10	762,6	314,14	319,65	1,378 3	1,095 0	4,305 8	173,3	3,322 4
dew		64,17	239,86	389,73	407,24	1,638 0	1,182 0	5,826 3	130,40	14,53
critical	4,902 6	71,36	459,5	357,88	368,55	1,518 1	b	b	b	9,747 7

[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 document.

5.15 R507A — R125/143a (50/50)

The composition of R507A is listed in Table 44.

Table 44 — Composition of R507A

i	Component	Mass fraction	Mole fraction
1	R125	0,50	0,411 839 71
2	R143a	0,50	0,588 160 29
M = 98,859 4 g/mol			

5.15.1 Range of validity

The coefficients are valid within the following ranges:

T_{min} = 172,52 K, T_{max} = 500 K; p_{max} = 60 MPa; ρ_{max} = 14,96 mol/l (1 468 kg/m^3)

5.15.2 Interaction parameters [Formulae (19) and (20)]

ζ_{12} = 5,551; ζ_{12} = −0,000 445 2

Coefficients and exponents of the excess functions are listed in Table 45.

Table 45 — Coefficients and exponents of the excess functions [Formula (21)]

R125/143a binary pair[a]				
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

[a] i = 1; j = 2; F_{12} = 1,169 7.

5.15.3 Reference state parameters

f_3 = 0,630 988 493, f_4 = 19,345 427

R507A property values of liquid on the bubble line and vapour on the dew line are listed in Table 46.

Table 46 — 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/m³	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
bubble	0,010 0	−85,26	1 432,7	92,21	92,21	0,531 0	0,763 3	1,202 6	926,5	−0,354 5
dew		−85,24	0,639	297,04	312,68	1,704 4	0,566 9	0,657 3	133,98	112,99
bubble	0,015 0	−79,66	1 416,1	98,94	98,95	0,566 3	0,772 0	1,202 8	889,9	−0,349 4
dew		−79,65	0,934	300,00	316,06	1,688 4	0,580 9	0,673 0	135,47	96,12
bubble	0,020 0	−75,44	1 403,6	104,02	104,04	0,592 3	0,778 0	1,204 4	864,2	−0,344 2
dew		−75,43	1,223	302,26	318,61	1,677 6	0,591 6	0,685 1	136,53	85,83
bubble	0,025 0	−72,01	1 393,4	108,16	108,17	0,613 0	0,782 6	1,206 7	844,3	−0,339 3
dew		−72,00	1,506	304,10	320,70	1,669 6	0,600 3	0,695 1	137,34	78,70
bubble	0,030 0	−69,10	1 384,7	111,67	111,69	0,630 4	0,786 5	1,209 1	827,9	−0,334 6
dew		−69,09	1,786	305,67	322,47	1,663 3	0,607 7	0,703 9	137,99	73,37
bubble	0,040 0	−64,29	1 370,4	117,49	117,52	0,658 6	0,792 6	1,214 1	801,8	−0,325 8
dew		−64,29	2,337	308,28	325,39	1,653 8	0,620 1	0,718 6	139,00	65,80
bubble	0,050 0	−60,37	1 358,6	122,25	122,29	0,681 2	0,797 6	1,219 1	781,2	−0,317 6
dew		−60,37	2,880	310,41	327,77	1,646 9	0,630 4	0,731 0	139,75	60,55
bubble	0,060 0	−57,04	1 348,5	126,32	126,36	0,700 1	0,801 7	1,223 8	764,1	−0,310 0
dew		−57,04	3,416	312,23	329,79	1,641 5	0,639 2	0,741 8	140,33	56,62
bubble	0,080 0	−51,53	1 331,6	133,08	133,14	0,731 0	0,808 5	1,232 6	736,3	−0,296 0
dew		−51,53	4,474	315,25	333,13	1,633 4	0,654 0	0,760 5	141,18	51,02
bubble	0,100 0	−47,01	1 317,6	138,65	138,73	0,755 9	0,814 1	1,240 8	714,0	−0,283 2
dew		−47,01	5,517	317,72	335,85	1,627 6	0,666 2	0,776 4	141,76	47,13
bubble	0,101 3[a]	−46,74	1 316,8	138,99	139,07	0,757 4	0,814 5	1,241 3	712,7	−0,282 4
dew		−46,74	5,586	317,87	336,01	1,627 3	0,667 0	0,777 4	141,79	46,91
bubble	0,120 0	−43,16	1 305,6	143,44	143,53	0,776 9	0,819 0	1,248 3	695,2	−0,271 2
dew		−43,16	6,551	319,83	338,15	1,623 1	0,676 9	0,790 5	142,17	44,21
bubble	0,140 0	−39,79	1 294,9	147,65	147,76	0,795 1	0,823 2	1,255 5	678,9	−0,259 8
dew		−39,79	7,578	321,68	340,15	1,619 5	0,686 3	0,803 3	142,47	41,91
bubble	0,160 0	−36,77	1 285,2	151,44	151,57	0,811 3	0,827 1	1,262 2	664,3	−0,248 8
dew		−36,77	8,599	323,33	341,93	1,616 6	0,694 8	0,815 2	142,67	40,03
bubble	0,180 0	−34,03	1 276,4	154,90	155,04	0,825 8	0,830 6	1,268 6	651,2	−0,238 3
dew		−34,03	9,616	324,82	343,54	1,614 1	0,702 6	0,826 2	142,82	38,45
bubble	0,200 0	−31,52	1 268,2	158,08	158,24	0,839 0	0,833 9	1,274 8	639,2	−0,228 0
dew		−31,51	10,631	326,19	345,00	1,611 9	0,709 8	0,836 7	142,90	37,11
bubble	0,250 0	−25,99	1 249,8	165,14	165,34	0,867 9	0,841 1	1,289 3	612,9	−0,203 4
dew		−25,99	13,159	329,18	348,18	1,607 7	0,725 9	0,860 7	142,96	34,44
bubble	0,300 0	−21,26	1 233,7	171,24	171,48	0,892 4	0,847 5	1,302 9	590,5	−0,179 7
dew		−21,25	15,682	331,72	350,85	1,604 4	0,739 9	0,882 5	142,84	32,43
bubble	0,350 0	−17,10	1 219,3	176,66	176,95	0,913 7	0,853 2	1,315 8	570,7	−0,156 5

[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 document.

Table 46 *(continued)*

	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
dew		−17,08	18,208	333,93	353,15	1,601 9	0,752 4	0,902 8	142,60	30,85
bubble	0,400 0	−13,36	1 206,1	181,56	181,89	0,932 7	0,858 4	1,328 2	553,0	−0,133 7
dew		−13,35	20,741	335,90	355,18	1,599 8	0,763 7	0,921 9	142,28	29,57
bubble	0,450 0	−9,97	1 193,8	186,05	186,43	0,949 9	0,863 3	1,340 3	536,9	−0,111 1
dew		−9,95	23,284	337,67	356,99	1,598 0	0,774 1	0,940 1	141,89	28,49
bubble	0,500 0	−6,85	1 182,3	190,21	190,63	0,965 7	0,867 8	1,352 0	522,0	−0,088 4
dew		−6,83	25,841	339,28	358,63	1,596 5	0,783 6	0,957 7	141,45	27,59
bubble	0,550 0	−3,96	1 171,5	194,10	194,57	0,980 2	0,872 0	1,363 6	508,3	−0,065 7
dew		−3,94	28,413	340,75	360,11	1,595 1	0,792 4	0,974 7	140,98	26,81
bubble	0,600 0	−1,26	1 161,2	197,75	198,27	0,993 7	0,876 0	1,375 1	495,3	−0,042 7
dew		−1,24	31,003	342,11	361,47	1,593 9	0,800 7	0,991 3	140,47	26,14
bubble	0,650 0	1,28	1 151,3	201,21	201,77	1,006 4	0,879 8	1,386 5	483,2	−0,019 5
dew		1,30	33,612	343,37	362,71	1,592 8	0,808 6	1,007 7	139,93	25,55
bubble	0,700 0	3,67	1 141,8	204,49	205,11	1,018 3	0,883 5	1,397 9	471,7	0,004 0
dew		3,70	36,243	344,55	363,86	1,591 8	0,816 0	1,024 0	139,37	25,03
bubble	0,750 0	5,94	1 132,7	207,63	208,29	1,029 6	0,887 0	1,409 3	460,7	0,027 9
dew		5,97	38,897	345,64	364,92	1,590 8	0,823 0	1,040 1	138,79	24,57
bubble	0,800 0	8,10	1 123,8	210,63	211,34	1,040 4	0,890 3	1,420 7	450,3	0,052 3
dew		8,13	41,575	346,67	365,91	1,589 9	0,829 8	1,056 3	138,19	24,15
bubble	0,900 0	12,13	1 106,8	216,29	217,10	1,060 4	0,896 8	1,443 8	430,7	0,102 5
dew		12,16	47,010	348,54	367,68	1,588 2	0,842 7	1,089 1	136,95	23,45
bubble	1,000 0	15,84	1 090,6	221,56	222,48	1,078 8	0,902 9	1,467 4	412,5	0,155 1
dew		15,87	52,559	350,20	369,22	1,586 5	0,855 0	1,122 7	135,67	22,87
bubble	1,200 0	22,49	1 060,0	231,21	232,34	1,111 9	0,914 3	1,517 0	379,5	0,269 1
dew		22,53	64,044	353,00	371,74	1,583 4	0,878 1	1,194 1	132,98	21,98
bubble	1,400 0	28,36	1 031,0	239,93	241,29	1,141 2	0,925 0	1,571 3	349,9	0,397 7
dew		28,40	76,121	355,25	373,64	1,580 2	0,900 1	1,273 6	130,18	21,31
bubble	1,600 0	33,63	1 003,0	247,98	249,58	1,167 8	0,935 5	1,632 1	322,7	0,544 9
dew		33,67	88,893	357,04	375,04	1,576 7	0,921 6	1,364 4	127,27	20,81
bubble	1,800 0	38,43	975,6	255,51	257,35	1,192 3	0,946 0	1,702 0	297,4	0,716 1
dew		38,46	102,48	358,42	375,99	1,573 1	0,942 8	1,470 7	124,28	20,41
bubble	2,000 0	42,83	948,2	262,63	264,74	1,215 2	0,956 7	1,784 6	273,5	0,918 3
dew		42,87	117,05	359,45	376,53	1,569 0	0,964 0	1,598 5	121,20	20,08
bubble	2,200 0	46,91	920,5	269,45	271,84	1,236 8	0,967 9	1,885 4	250,8	1,161 5
dew		46,95	132,79	360,12	376,68	1,564 4	0,985 2	1,756 9	118,04	19,81
bubble	2,400 0	50,72	892,1	276,04	278,73	1,257 6	0,980 0	2,012 8	228,9	1,460 0
dew		50,75	149,99	360,43	376,43	1,559 2	1,006 9	1,961 0	114,80	19,58
bubble	2,600 0	54,28	862,6	282,49	285,50	1,277 7	0,993 4	2,181 8	207,5	1,836 0
dew		54,32	169,04	360,36	375,74	1,553 2	1,029 4	2,236 8	111,48	19,35
bubble	2,800 0	57,63	831,2	288,87	292,23	1,297 4	1,008 8	2,420 6	186,4	2,325 2
dew		57,67	190,55	359,84	374,53	1,546 2	1,053 1	2,633 8	108,06	19,09
bubble	3,000 0	60,80	796,9	295,28	299,05	1,317 2	1,027 1	2,791 0	165,4	2,989 0

[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 document.

Table 46 *(continued)*

	Pressure	Temp.	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	MPa	°C	kg/m³	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
dew		60,82	215,50	358,77	372,69	1,537 7	1,079 0	3,259 2	104,54	18,77
bubble	3,200 0	63,78	757,9	301,91	306,13	1,337 5	1,050 4	3,458 1	144,1	3,944 0
dew		63,81	245,74	356,93	369,95	1,526 9	1,108 3	4,394 1	100,89	18,30
bubble	3,400 0	66,61	709,9	309,11	313,90	1,359 6	1,082 8	5,054 8	122,2	5,443 2
dew		66,63	285,53	353,82	365,73	1,512 2	1,143 9	7,076 0	97,03	17,52
bubble	3,600 0	68,45	657,9	315,53	320,89	1,379 6	1,123 7	10,265 7	103,6	7,484 7
dew		68,55	679,05	313,87	319,13	1,374 3	1,102 4	6,504 8	112,80	6,40
critical	3,705 0	70,62	490,8	332,90	340,45	1,435 8	b	b	b	12,383 5

[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 document.

5.16 R290 — Propane

5.16.1 Range of validity

The coefficients are valid within the following ranges:

T_{min} = 85,525 K, T_{max} = 650 K; p_{max} = 1 000 MPa; ρ_{max} = 20,6 mol/l (908,4 kg/m³)

5.16.2 Coefficients and exponents of the ideal-gas part (Formulae 3 to 5)

Coefficients and exponents of the ideal-gas part are listed in Table 47 and Table 48. Coefficients and exponents of the real-gas part are listed in Table 49 and Table 50.

Table 47 — Coefficients and exponents for k = 0

k	c_k
0	4,000 0

Table 48 — Coefficients and exponents for k = 1 up to 3

k	a_k	b_k
1	3,043	393,0
2	5,874	1 237,0
3	9,337	1 984,0
4	7,922	4 351,0

5.16.3 Coefficients and exponents of the real-gas part (Formula 2)

Table 49 — Coefficients and exponents for k = 1 up to 11

k	N_k	t_k	d_k	l_k	α_k
1	0,042 910 051	1,00	4	0	0
2	1,731 367 1	0,33	1	0	0
3	-2,451 652 4	0,80	1	0	0
4	0,341 574 66	0,43	2	0	0
5	-0,460 478 98	0,90	2	0	0

Table 49 *(continued)*

k	N_k	t_k	d_k	l_k	α_k
6	-0,668 472 95	2,46	1	1	0
7	0,208 897 05	2,09	3	1	0
8	0,194 213 81	0,88	6	1	0
9	-0,229 178 51	1,09	6	1	0
10	-0,604 058 66	3,25	2	2	0
11	0,066 680 654	4,62	3	2	0

Table 50 — Coefficients and exponents for k = 12 up to 18

k	N_k	t_k	d_k	l_k	α_k	m_k	β_k	γ_k	ε_k
12	0,017 534 618	0,76	1	2	2	0,963	2,33	0,684	1,283
13	0,338 742 42	2,5	1	2	2	1,977	3,47	0,829	0,693 6
14	0,222 287 77	2,75	1	2	2	1,917	3,15	1,419	0,788
15	-0,232 190 62	3,05	2	2	2	2,307	3,19	0,817	0,473
16	-0,092 206 94	2,55	2	2	2	2,546	0,92	1,500	0,857 7
17	-0,475 757 18	8,40	4	2	2	3,28	18,8	1,426	0,271
18	-0,017 486 824	6,75	1	2	2	14,6	547,8	1,093	0,948

5.16.4 Reducing parameters, molar mass, and gas constant

T^* = 369,89 K, ρ^* = 5,000 00 mol/l, M = 44,095 62 g/mol, R = 8,314 459 8 J/(mol·K)

5.16.5 Reference state parameters

T_{ref} = 273,15 K, p_{ref} = 1,0 kPa, h_{ref} = 26 148,457 J/mol, s_{ref} = 157,910 3 J/(mol·K)

R290 (propane) Property values along the liquid-vapour saturation boundary are listed in Table 51.

Table 51 — R290 (propane) 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	MPa	kg/m³	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
liquid	-187,62[a]	$1{,}720 \times 10^{-10}$	733,1	-196,64	-196,64	-1,395 9	1,355 3	1,915 8	2 136,4	-0,625 2
vapour			$1{,}067 \times 10^{-8}$	350,13	366,26	5,185 8	0,690 7	0,879 2	143,28	491,93
liquid	-185	$4{,}853 \times 10^{-10}$	730,4	-191,61	-191,61	-1,338	1,351 8	1,917 9	2 118,6	-0,624 2
vapour			$2{,}920 \times 10^{-8}$	351,96	368,58	5,017	0,701	0,889 6	145,23	453,64
liquid	-180	$2{,}939 \times 10^{-9}$	725,2	-182,01	-182,01	-1,232	1,346 5	1,922 7	2 084,6	-0,621 9
vapour			$1{,}673 \times 10^{-7}$	355,51	373,08	4,727	0,720 8	0,909 3	148,86	391,26
liquid	-175	$1{,}460 \times 10^{-8}$	720	-172,38	-172,38	-1,131 4	1,342 6	1,928 2	2 050,4	-0,619 3
vapour			$7{,}887 \times 10^{-7}$	359,16	377,67	4,472 9	0,740 4	0,928 9	152,38	340,14
liquid	-170	$6{,}126 \times 10^{-8}$	714,9	-162,73	-162,73	-1,035 4	1,339 7	1,934 2	2 016,2	-0,616 5
vapour			$3{,}149 \times 10^{-6}$	362,91	382,36	4,249 1	0,759 6	0,948 1	155,81	297,85
liquid	-165	$2{,}225 \times 10^{-7}$	709,8	-153,04	-153,04	-0,943 7	1,337 6	1,940 6	1 982	-0,613 3

[a] Triple point

[b] Normal boiling point

* The values of C_v, C_p, and w at the critical point are not included as part of this document.

Table 51 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
vapour			1,09 × 10^{-5}	366,76	387,15	4,051 2	0,778 4	0,966 9	159,16	262,59
liquid	-160	7,137 × 10^{-7}	704,7	-143,32	-143,32	-0,855 8	1,336 1	1,947 3	1 947,9	-0,609 9
vapour			3,35 × 10^{-5}	370,7	392,03	3,875 5	0,796 7	0,985 2	162,43	232,95
liquid	-155	2,054 × 10^{-6}	699,7	-133,57	-133,57	-0,771 5	1,335 1	1,954 3	1 913,9	-0,606 3
vapour			9,22 × 10^{-5}	374,73	397	3,719 2	0,814 5	1,003 1	165,63	207,84
liquid	-150	5,380 × 10^{-6}	694,6	-123,78	-123,78	-0,690 3	1,334 5	1,961 6	1 880	-0,602 4
vapour			2,317 × 10^{-4}	378,84	402,06	3,579 6	0,831 9	1,020 5	168,77	186,44
liquid	-145	1,297 × 10^{-5}	689,6	-113,95	-113,95	-0,612 1	1,334 3	1,969 1	1 846,2	-0,598 2
vapour			5,366 × 10^{-4}	383,04	407,21	3,454 6	0,848 9	1,037 4	171,84	168,1
liquid	-140	2,904 × 10^{-5}	684,5	-104,09	-104,09	-0,536 6	1,334 4	1,977	1 812,5	-0,593 8
vapour			1,157 × 10^{-3}	3 387,33	412,43	3,342 6	0,865 5	1,054 1	174,85	152,32
liquid	-135	6,095 × 10^{-5}	679,5	-94,18	-94,18	-0,463 6	1,334 9	1,985 2	1 779	-0,589 1
vapour			2,340 × 10^{-3}	391,69	417,74	3,241 9	0,881 8	1,070 4	177,81	138,68
liquid	-130	0,000 121	674,4	-84,23	-84,23	-0,392 9	1,335 7	1,993 7	1 745,5	-0,584
vapour			0,004 47	396,14	423,12	3,151 4	0,897 9	1,086 6	180,7	126,85
liquid	-125	0,000 227	669,3	-74,24	-74,24	-0,324 3	1,337	2,002 6	1 712	-0,578 6
vapour			0,008 13	400,66	428,58	3,069 8	0,913 8	1,102 6	183,53	116,55
liquid	-120	0,000 408	664,3	-64,21	-64,21	-0,257 6	1,338 6	2,011 9	1 678,6	-0,572 8
vapour			0,014 13	405,25	434,11	2,996 2	0,929 7	1,118 6	186,31	107,51
liquid	-115	0,000 702	659,2	-54,12	-54,12	-0,192 8	1,340 7	2,021 7	1 645,2	-0,566 6
vapour			0,023 57	409,92	439,71	2,929 7	0,945 5	1,134 7	189,02	99,51
liquid	-110	0,001 16	654	-43,99	-43,99	-0,129 8	1,343 3	2,031 8	1 611,8	-0,56
vapour			0,037 9	414,65	445,37	2,869 7	0,961 4	1,151	191,67	92,38
liquid	-105	0,001 87	648,9	-33,8	-33,8	-0,068 3	1,346 4	2,042 6	1 578,4	-0,553
vapour			0,059	419,45	451,1	2,815 5	0,977 5	1,167 5	194,24	85,93
liquid	-100	0,002 9	643,7	-23,56	-23,56	-0,008 3	1,350 2	2,053 8	1 544,9	-0,545 6
vapour			0,089	424,32	456,88	2,766 4	0,993 7	1,184 5	196,75	80,06
liquid	-95	0,004 38	638,5	-13,27	-13,26	0,050 4	1,354 6	2,065 7	1 511,5	-0,537 7
vapour			0,130 9	429,24	462,71	2,722 1	1,010 3	1,201 9	199,18	74,67
liquid	-90	0,006 45	633,3	-2,91	-2,9	0,107 7	1,359 8	2,078 3	1 478	-0,529 2
vapour			0,187 6	434,22	468,58	2,682	1,027 2	1,22	201,53	69,69
liquid	-85	0,009 27	628,1	7,52	7,53	0,163 9	1,365 7	2,091 7	1 444,6	-0,520 2
vapour			0,263	439,25	474,49	2,645 7	1,044 6	1,238 7	203,78	65,08
liquid	-80	0,013	622,8	18,01	18,03	0,218 9	1,372 3	2,105 9	1 411,2	-0,510 6
vapour			0,361	444,32	480,44	2,613	1,062 5	1,258 3	205,94	60,81
liquid	-75	0,018	617,4	28,57	28,6	0,272 9	1,379 7	2,120 9	1 377,8	-0,500 3
vapour			0,487	449,45	486,41	2,583 3	1,081	1,278 9	207,99	56,85
liquid	-70	0,024 4	612	39,21	39,25	0,325 9	1,387 8	2,136 9	1 344,6	-0,489 3
vapour			0,646	454,61	492,41	2,556 6	1,100 1	1,300 3	209,94	53,19
liquid	-65	0,032 5	606,6	49,93	49,99	0,378 1	1,396 7	2,154	1 311,4	-0,477 6
vapour			0,843	459,82	498,42	2,532 4	1,119 7	1,322 9	211,76	49,82

[a] Triple point

[b] Normal boiling point

* The values of C_v, C_p, and w at the critical point are not included as part of this document.

Table 51 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
liquid	-60	0,042 7	601,1	60,74	60,81	0,429 4	1,406 3	2,172	1 278,4	-0,465 1
vapour			1,084	465,05	504,44	2,510 7	1,14	1,346 5	213,46	46,72
liquid	-55	0,055 2	595,5	71,64	71,73	0,479 9	1,416 6	2,191 2	1 245,4	-0,451 8
vapour			1,376	470,32	510,46	2,491	1,160 8	1,371 2	215,03	43,88
liquid	-50	0,070 6	589,9	82,63	82,75	0,529 8	1,427 6	2,211 5	1 212,5	-0,437 4
vapour			1,727	475,61	516,48	2,473 4	1,182 3	1,397 1	216,45	41,27
liquid	-45	0,089 1	584,2	93,73	93,88	0,578 9	1,439 3	2,233	1 179,7	-0,422 1
vapour			2,143	480,93	522,49	2,457 5	1,204 3	1,424 2	217,73	38,9
liquid	-42,11[b]	0,101 3	580,9	100,18	100,36	0,607	1,446 3	2,246	1 160,8	-0,412 8
vapour			2,416	484,01	525,95	2,449 1	1,217 3	1,440 4	218,4	37,63
liquid	-40	0,111 1	578,4	104,93	105,12	0,627 5	1,451 5	2,255 8	1 147	-0,405 7
vapour			2,633	486,27	528,48	2,443 3	1,226 9	1,452 6	218,85	36,74
liquid	-35	0,137 2	572,6	116,25	116,49	0,675 5	1,464 4	2,279 9	1 114,4	-0,388
vapour			3,204	491,62	534,45	2,430 6	1,25	1,482 2	219,81	34,77
liquid	-30	0,167 8	566,6	127,68	127,97	0,723 1	1,477 9	2,305 4	1 081,7	-0,369 1
vapour			3,867	496,98	540,38	2,419 2	1,273 6	1,513 3	220,6	32,98
liquid	-25	0,203 4	560,6	139,24	139,6	0,770 1	1,492	2,332 3	1 049,1	-0,348 6
vapour			4,63	502,35	546,28	2,409	1,297 8	1,546	221,21	31,35
liquid	-20	0,244 5	554,5	150,92	151,36	0,816 8	1,506 8	2,360 8	1 016,5	-0,326 5
vapour			5,505	507,71	552,13	2,399 9	1,322 5	1,580 3	221,64	29,88
liquid	-15	0,291 6	548,2	162,74	163,28	0,863	1,522 1	2,391	983,8	-0,302 6
vapour			6,501	513,07	557,93	2,391 8	1,347 8	1,616 5	221,87	28,54
liquid	-10	0,345 3	541,8	174,71	175,35	0,909	1,538 1	2,423	951,1	-0,276 7
vapour			7,632	518,41	563,65	2,384 6	1,373 7	1,654 8	221,89	27,33
liquid	-5	0,406	535,3	186,83	187,59	0,954 6	1,554 6	2,457	918,3	-0,248 4
vapour			8,91	523,73	569,3	2,378 1	1,400 2	1,695 4	221,7	26,23
liquid	0	0,474 5	528,6	199,1	200	1	1,571 8	2,493 2	885,5	-0,217 4
vapour			10,351	529,03	574,87	2,372 4	1,427 4	1,738 7	221,3	25,24
liquid	5	0,551 1	521,8	211,54	212,6	1,045 2	1,589 6	2,531 8	852,5	-0,183 3
vapour			11,969	534,28	580,33	2,367 2	1,455 3	1,785 2	220,65	24,35
liquid	10	0,636 6	514,7	224,16	225,4	1,090 2	1,608 1	2,573 3	819,4	-0,145 7
vapour			13,783	539,48	585,67	2,362 6	1,484 1	1,835 3	219,77	23,55
liquid	15	0,731 5	507,5	236,96	238,4	1,135 1	1,627 1	2,617 9	786,2	-0,103 9
vapour			15,813	544,63	590,89	2,358 3	1,513 7	1,889 7	218,63	22,83
liquid	20	0,836 5	500,1	249,96	251,64	1,179 9	1,646 8	2,666 2	752,9	-0,057
vapour			18,082	549,69	595,95	2,354 4	1,544 2	1,949 2	217,22	22,19
liquid	25	0,952 1	492,4	263,17	265,11	1,224 7	1,667 1	2,718 9	719,3	-0,004 3
vapour			20,618	554,66	600,84	2,350 7	1,575 9	2,014 7	215,53	21,61
liquid	30	1,079	484,4	276,61	278,83	1,269 5	1,688 1	2,776 7	685,5	0,055 6
vapour			23,451	559,53	605,54	2,347 1	1,608 6	2,087 7	213,53	21,1
liquid	35	1,217 9	476,1	290,28	292,84	1,314 3	1,709 7	2,840 8	651,4	0,124 4

[a] Triple point

[b] Normal boiling point

* The values of C_v, C_p, and w at the critical point are not included as part of this document.

Table 51 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
vapour			26,618	564,25	610,01	2,343 6	1,642 6	2,169 7	211,22	20,66
liquid	40	1,369 4	467,5	304,22	307,15	1,359 4	1,732 2	2,912 7	617	0,204 1
vapour			30,165	568,82	614,21	2,339 9	1,677 9	2,263 2	208,57	20,27
liquid	45	1,534 3	458,4	318,44	321,79	1,404 6	1,755 5	2,994 6	582,1	0,297 7
vapour			34,146	573,18	618,12	2,336	1,714 8	2,371 3	205,56	19,94
liquid	50	1,713 3	448,9	332,98	336,8	1,450 2	1,779 8	3,089 3	546,8	0,409 1
vapour			38,63	577,31	621,66	2,331 7	1,753 4	2,498 7	202,17	19,66
liquid	55	1,907 2	438,8	347,88	352,23	1,496 2	1,805 3	3,201 3	510,9	0,544 1
vapour			43,706	581,14	624,77	2,326 8	1,793 8	2,651 9	198,35	19,44
liquid	60	2,116 7	428	363,19	368,14	1,542 9	1,832 3	3,337 5	474,2	0,710 9
vapour			49,493	584,59	627,36	2,321	1,835 9	2,841 4	194,07	19,27
liquid	65	2,342 9	416,3	378,98	384,6	1,590 3	1,861	3,508 9	436,6	0,922 3
vapour			56,152	587,56	629,29	2,313 9	1,880 4	3,086 3	189,32	19,16
liquid	70	2,586 8	403,6	395,34	401,75	1,638 9	1,892 3	3,734 9	397,9	1,199 1
vapour			63,916	589,9	630,37	2,305 2	1,929 6	3,421 4	184,05	19,1
liquid	75	2,849 3	389,5	412,45	419,76	1,689 1	1,927 2	4,052 9	357,5	1,577
vapour			73,14	591,37	630,33	2,293 9	1,987 1	3,914	178,18	19,04
liquid	80	3,131 9	373,3	430,54	438,93	1,741 7	1,968 8	4,544 5	314,9	2,123 1
vapour			84,406	591,62	628,73	2,279 1	2,057 1	4,706 7	171,59	18,95
liquid	85	3,436 1	354	450,1	459,81	1,798	2,023 1	5,432 8	269,1	2,98
vapour			98,818	589,98	624,75	2,258 5	2,144 2	6,182 4	164,14	18,73
liquid	90	3,764 1	328,8	472,26	483,71	1,861 6	2,107	7,623 3	218,3	4,519 8
vapour			118,995	584,84	616,47	2,227 2	2,260 3	9,887 6	155,53	18,17
liquid	95	4,119 5	286,5	501,95	516,33	1,947 6	2,302 4	23,59 4	158,1	8,238 5
vapour			156,308	569,45	595,81	2,163 5	2,467 5	36,065 7	144,07	16,38
critical	96,74	4,251 2	220,5	535,95	555,23	2,051 6	*	*	*	12,899 5

[a] Triple point

[b] Normal boiling point

* The values of C_v, C_p, and w at the critical point are not included as part of this document.

5.17 R600a – Isobutane

5.17.1 Range of validity

T_{min} = 113,73 K, T_{max} = 575 K; p_{max} = 35 MPa; ρ_{max} = 12,9 mol/l (749,8 kg/m^3)

5.17.2 Coefficients and exponents of the ideal-gas part (Formulae 3 to 5)

Coefficients and exponents of the ideal-gas part are listed in Table 52 and Table 53. Coefficients and exponents of the real-gas part are listed in Table 54 and Table 55.

Table 52 — Coefficients and exponents for k = 0

k	c_k
0	4,059 566 19

Table 53 — Coefficients and exponents for k = 1 up to 4

k	a_k	b_k
1	4,946 410 14	387,940 64
2	4,094 751 97	973,807 82
3	15,663 282 4	1 772,711 03
4	9,739 181 22	4 228,524 24

5.17.3 Coefficients and exponents of the real-gas part (Formula 2)

Table 54 — Coefficients and exponents for k = 1 up to 23

k	N_k	t_k	d_k	l_k	α_k
1	2,068 682 073	0,5	1	0	0
2	-3,640 009 862	1	1	0	0
3	0,519 687 544	1,5	1	0	0
4	0,177 458 459	0	2	0	0
5	-0,123 618 079	0,5	3	0	0
6	0,045 145 314	0,5	4	0	0
7	0,030 476 48	0,75	4	0	0
8	0,755 083 877	2	1	1	0
9	-0,858 853 81	2,5	1	1	0
10	0,036 324 01	2,5	2	1	0
11	-0,019 548 799	1,5	7	1	0
12	-0,004 445 239	1	8	1	0
13	0,004 641 076	1,5	8	1	0
14	-0,071 444 098	4	1	2	0
15	-0,080 765 06	7	2	2	0
16	0,155 604 609	3	3	2	0
17	0,002 031 875	7	3	2	0
18	-0,106 248 836	3	4	2	0
19	0,039 807 691	1	5	2	0
20	0,016 371 431	6	5	2	0
21	0,000 532 122	0	10	2	0
22	-0,007 868 156	6	2	3	0
23	-0,003 098 119	13	6	3	0

Table 55 — Coefficients and exponents for k = 24 up to 25

k	N_k	t_k	d_k	l_k	α_k	m_k	β_k	γ_k	ε_k
24	-0,042 276 037	2	1	2	2	-10	-150	1,16	0,85
25	-0,005 300 104	0	2	2	2	-10	-200	1,13	1

5.17.4 Reducing parameters, molar mass, and gas constant

T^* = 407,81 K, ρ^* = 3,879 756 788 mol/l, M = 58,122 2 g/mol, R = 8,314 459 8 J/(mol·K)

5.17.5 Reference state parameters

T_{ref} = 273,15 K, p_{ref} = 1,0 kPa, h_{ref} = 32 638,234 J/mol, s_{ref} = 176,637 3 J/(mol·K)

R600a (isobutane) Property values along the liquid-vapour saturation boundary are listed in Table 56.

Table 56 — R600a (isobutane) 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	MPa	kg/m³	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
liquid	-159,42[a]	2,289 × 10^{-8}	740,3	-112,38	-112,38	-0,679 8	1,174 1	1,688 8	1 999,8	-0,683 8
vapour			1,407 × 10^{-6}	352,05	368,32	3,546 8	0,736 6	0,879 6	139,39	577,37
liquid	-155	6,886 × 10^{-8}	736,2	-104,88	-104,88	-0,615 2	1,183 2	1,702 7	1 961,2	-0,676 9
vapour			4,074 × 10^{-6}	355,35	372,25	3,423 2	0,757 1	0,900 1	141,76	498,97
liquid	-150	2,156 × 10^{-7}	731,4	-96,33	-96,33	-0,544 3	1,193 9	1,718 7	1 918,9	-0,669
vapour			1,224 × 10^{-5}	359,19	376,81	3,297 7	0,779 8	0,922 9	144,39	426,39
liquid	-145	6,122 × 10^{-7}	726,7	-87,69	-87,69	-0,475 6	1,204 7	1,734 9	1 878,1	-0,661 1
vapour			3,339 × 10^{-5}	363,15	381,48	3,185 6	0,802	0,945 1	146,98	367,2
liquid	-140	1,594 × 10^{-6}	722,0	-78,98	-78,98	-0,408 9	1,215 5	1,751	1 838,8	-0,653 1
vapour			8,369 × 10^{-5}	367,21	386,26	3,085 2	0,823 8	0,966 9	149,51	318,49
liquid	-135	3,845 × 10^{-6}	717,3	-70,18	-70,18	-0,344	1,226 2	1,767	1 800,6	-0,645 2
vapour			1,945 × 10^{-4}	371,39	391,15	2,995 3	0,845 1	0,988 2	152,01	278,06
liquid	-130	8,660 × 10^{-6}	712,5	-61,31	-61,31	-0,280 9	1,236 8	1,783	1 763,6	-0,637 3
vapour			4,229 × 10^{-4}	375,66	396,14	2,914 7	0,866 1	1,009 2	154,46	244,24
liquid	-125	1,835 × 10^{-5}	707,8	-52,35	-52,35	-0,219 4	1,247 3	1,798 8	1 727,5	-0,629 3
vapour			8,658 × 10^{-4}	380,04	401,24	2,842 3	0,886 8	1,029 9	156,88	215,75
liquid	-120	3,679 × 10^{-5}	703,0	-43,32	-43,32	-0,159 5	1,257 8	1,814 7	1 692,3	-0,621 4
vapour			1,680 × 10^{-3}	384,53	406,43	2,777 2	0,907 2	1,050 3	159,25	191,58
liquid	-115	7,023 × 10^{-5}	698,3	-34,21	-34,21	-0,100 9	1,268 3	1,830 4	1 657,8	-0,613 3
vapour			3,105 × 10^{-3}	389,11	411,73	2,718 8	0,927 4	1,070 5	161,58	170,94
liquid	-110	0,000 128	693,5	-25,02	-25,02	-0,043 7	1,278 8	1,846 3	1 624	-0,605 2
vapour			0,005 49	393,79	417,12	2,666 3	0,947 4	1,090 6	163,87	153,22
liquid	-105	0,000 225	688,7	-15,75	-15,75	0,012 3	1,289 5	1,862 1	1 590,8	-0,597
vapour			0,009 34	398,56	422,61	2,619 2	0,967 3	1,110 7	166,12	137,92
liquid	-100	0,000 379	683,9	-6,4	-6,39	0,067 1	1,300 3	1,878 1	1 558,1	-0,588 6
vapour			0,015 33	403,44	428,19	2,577	0,987 2	1,130 7	168,33	124,65
liquid	-95	0,000 62	679,1	3,04	3,04	0,120 8	1,311 3	1,894 3	1 525,8	-0,580 1
vapour			0,024 34	408,4	433,86	2,539 1	1,007 1	1,150 8	170,5	113,08
liquid	-90	0,000 982	674,2	12,55	12,55	0,173 4	1,322 6	1,910 6	1 494	-0,571 3
vapour			0,037 53	413,45	439,62	2,505 2	1,027	1,171	172,62	102,95
liquid	-85	0,001 51	669,4	22,14	22,14	0,225 1	1,334 1	1,927 2	1 462,5	-0,562 4
vapour			0,056 3	418,6	445,46	2,475	1,047 1	1,191 4	174,69	94,04
liquid	-80	0,002 27	664,5	31,82	31,82	0,275 9	1,345 9	1,944 1	1 431,3	-0,553 2
vapour			0,082 4	423,83	451,39	2,448 1	1,067 3	1,212 1	176,71	86,19
liquid	-75	0,003 33	659,5	41,58	41,59	0,325 8	1,358	1,961 3	1 400,5	-0,543 7
vapour			0,117 8	429,14	457,4	2,424 2	1,087 6	1,233	178,67	79,24

[a] Triple point

[b] Normal boiling point

* The values of C_v, C_p, and w at the critical point are not included as part of this document.

Table 56 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
liquid	-70	0,004 78	654,6	51,43	51,44	0,374 9	1,370 5	1,978 9	1 369,9	-0,533 9
vapour			0,165	434,54	463,48	2,403 1	1,108 2	1,254 3	180,57	73,07
liquid	-65	0,006 71	649,6	61,37	61,38	0,423 2	1,383 4	1,996 9	1 339,5	-0,523 8
vapour			0,226 8	440,02	469,63	2,384 5	1,129 1	1,276 1	182,41	67,57
liquid	-60	0,009 27	644,6	71,4	71,41	0,470 8	1,396 7	2,015 3	1 309,4	-0,513 4
vapour			0,306 2	445,58	475,85	2,368 3	1,150 2	1,298 3	184,18	62,66
liquid	-55	0,012 6	639,5	81,52	81,54	0,517 7	1,410 3	2,034 2	1 279,6	-0,502 5
vapour			0,407	451,22	482,14	2,354 1	1,171 7	1,321 1	185,88	58,26
liquid	-50	0,016 8	634,4	91,74	91,76	0,564	1,424 3	2,053 6	1 249,9	-0,491 2
vapour			0,532	456,92	488,49	2,341 9	1,193 5	1,344 4	187,49	54,31
liquid	-45	0,022 1	629,3	102,05	102,09	0,609 8	1,438 8	2,073 5	1 220,4	-0,479 5
vapour			0,687	462,7	494,89	2,331 5	1,215 6	1,368 3	189,01	50,76
liquid	-40	0,028 7	624,1	112,47	112,51	0,654 9	1,453 7	2,094	1 191,1	-0,467 2
vapour			0,875	468,55	501,35	2,322 7	1,238 2	1,392 9	190,45	47,55
liquid	-35	0,036 8	618,9	122,98	123,04	0,699 5	1,469	2,115 2	1 161,9	-0,454 4
vapour			1,102	474,46	507,85	2,315 4	1,261 1	1,418 3	191,79	44,66
liquid	-30	0,046 6	613,6	133,61	133,68	0,743 7	1,484 7	2,136 9	1 132,9	-0,441
vapour			1,373	480,44	514,4	2,309 5	1,284 4	1,444 3	193,02	42,04
liquid	-25	0,058 4	608,3	144,34	144,43	0,787 4	1,500 8	2,159 3	1 104	-0,427
vapour			1,693	486,48	520,99	2,304 8	1,308 1	1,471 2	194,14	39,67
liquid	-20	0,072 5	602,9	155,18	155,3	0,830 6	1,517 3	2,182 4	1 075,3	-0,412 2
vapour			2,069	492,57	527,61	2,301 3	1,332 3	1,498 9	195,14	37,51
liquid	-15	0,089 1	597,4	166,14	166,29	0,873 5	1,534 2	2,206 3	1 046,7	-0,396 6
vapour			2,506	498,72	534,26	2,298 9	1,356 8	1,527 5	196,03	35,55
liquid	-11,75[b]	0,101 3	593,8	173,32	173,5	0,901 2	1,545 4	2,222 2	1 028,1	-0,386 1
vapour			2,827	502,75	538,59	2,297 9	1,373	1,546 6	196,53	34,37
liquid	-10	0,108 4	591,9	177,21	177,4	0,916	1,551 5	2,230 9	1 018,2	-0,380 2
vapour			3,012	504,92	540,93	2,297 5	1,381 8	1,557	196,78	33,76
liquid	-5	0,131 0	586,3	188,41	188,63	0,958 2	1,569 2	2,256 4	989,8	-0,362 8
vapour			3,593	511,17	547,63	2,296 9	1,407 2	1,587 5	197,4	32,13
liquid	0	0,157 0	580,6	199,73	200	1	1,587 3	2,282 7	961,5	-0,344 4
vapour			4,257	517,47	554,34	2,297 2	1,432 9	1,619	197,87	30,65
liquid	5	0,186 7	574,8	211,18	211,5	1,041 5	1,605 7	2,31	933,2	-0,324 7
vapour			5,012	523,8	561,06	2,298 2	1,459 1	1,651 7	198,2	29,29
liquid	10	0,220 6	568,9	222,76	223,15	1,082 8	1,624 5	2,338 2	905	-0,303 7
vapour			5,867	530,17	567,78	2,3	1,485 7	1,685 6	198,38	28,06
liquid	15	0,259 0	562,9	234,48	234,94	1,123 9	1,643 6	2,367 6	876,9	-0,281 2
vapour			6,831	536,58	574,5	2,302 3	1,512 6	1,720 8	198,39	26,93
liquid	20	0,302 2	556,9	246,34	246,88	1,164 7	1,663 1	2,398 2	848,8	-0,257
vapour			7,913	543,02	581,21	2,305 1	1,54	1,757 3	198,24	25,9
liquid	25	0,350 7	550,7	258,34	258,98	1,205 3	1,682 9	2,43	820,7	-0,230 8

[a] Triple point

[b] Normal boiling point

* The values of C_v, C_p, and w at the critical point are not included as part of this document.

Table 56 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
vapour			9,126	549,47	587,9	2,308 5	1,567 7	1,795 4	197,9	24,97
liquid	30	0,404 7	544,3	270,5	271,24	1,245 8	1,703	2,463 3	792,5	-0,202 4
vapour			10,48	555,95	594,57	2,312 3	1,595 8	1,835 3	197,39	24,11
liquid	35	0,464 8	537,8	282,81	283,67	1,286 1	1,723 4	2,498 2	764,4	-0,171 5
vapour			11,988	562,44	601,21	2,316 5	1,624 3	1,877 1	196,68	23,34
liquid	40	0,531 2	531,2	295,28	296,28	1,326 3	1,744 2	2,534 9	736,2	-0,137 5
vapour			13,666	568,93	607,8	2,321 1	1,653 3	1,921	195,77	22,64
liquid	45	0,604 4	524,4	307,92	309,07	1,366 4	1,765 3	2,573 7	707,9	-0,100 1
vapour			15,529	575,42	614,34	2,325 9	1,682 6	1,967 5	194,64	22,01
liquid	50	0,684 9	517,4	320,74	322,06	1,406 4	1,786 8	2,614 8	679,6	-0,058 5
vapour			17,595	581,9	620,82	2,330 9	1,712 3	2,016 7	193,29	21,45
liquid	55	0,773 0	510,2	333,74	335,25	1,446 4	1,808 5	2,658 7	651,1	-0,012 1
vapour			19,886	588,35	627,22	2,336 1	1,742 3	2,069 2	191,7	20,95
liquid	60	0,869 2	502,7	346,93	348,66	1,486 3	1,830 7	2,705 8	622,4	0,040 2
vapour			22,426	594,77	633,53	2,341 4	1,772 4	2,125 3	189,86	20,51
liquid	65	0,973 9	495	360,32	362,29	1,526 3	1,853 3	2,756 7	593,5	0,099 5
vapour			25,242	601,14	639,72	2,346 7	1,802 4	2,185 8	187,75	20,15
liquid	70	1,087 5	487	373,94	376,17	1,566 4	1,876 3	2,812 3	564,4	0,167 5
vapour			28,369	607,43	645,77	2,352	1,832 6	2,251 9	185,36	19,86
liquid	75	1,210 7	478,6	387,78	390,31	1,606 5	1,899 8	2,873 6	534,9	0,246 3
vapour			31,846	613,63	651,64	2,357 2	1,863	2,325 5	182,67	19,64
liquid	80	1,343 8	469,9	401,87	404,73	1,646 9	1,923 8	2,942 1	505,1	0,338 6
vapour			35,721	619,69	657,31	2,362 1	1,894 2	2,409 4	179,65	19,49
liquid	85	1,487 4	460,7	416,24	419,46	1,687 4	1,948 5	3,019 9	474,9	0,448 3
vapour			40,057	625,6	662,73	2,366 7	1,926 8	2,507 4	176,29	19,42
liquid	90	1,642 0	451,1	430,9	434,54	1,728 3	1,974	3,11	444,2	0,581
vapour			44,927	631,31	667,86	2,370 8	1,961 5	2,624 8	172,56	19,42
liquid	95	1,808 1	440,7	445,9	450	1,769 6	2,000 5	3,216 8	412,8	0,744 5
vapour			50,43	636,76	672,62	2,374 3	1,998 9	2,768 9	168,42	19,49
liquid	100	1,986 5	429,6	461,28	465,9	1,811 4	2,028 2	3,347 3	380,7	0,951
vapour			56,697	641,9	676,94	2,376 9	2,039 4	2,951	163,83	19,62
liquid	105	2,177 8	417,6	477,11	482,33	1,853 9	2,057 7	3,513 5	347,6	1,219 6
vapour			63,91	646,62	680,7	2,378 5	2,083 5	3,189 3	158,74	19,82
liquid	110	2,382 6	404,3	493,5	499,39	1,897 4	2,089 7	3,736 5	313,3	1,582 1
vapour			72,331	650,8	683,74	2,378 5	2,131 8	3,517 3	153,11	20,1
liquid	115	2,601 9	389,4	510,58	517,26	1,942 3	2,125 7	4,059 4	277,6	2,096
vapour			82,372	654,22	685,81	2,376 5	2,185 3	4,002 4	146,86	20,44
liquid	120	2,836 6	372	528,63	536,26	1,989 3	2,168 5	4,584 6	240	2,875 7
vapour			94,741	656,52	686,46	2,371 4	2,246 5	4,806	139,9	20,84
liquid	125	3,088 0	350,6	548,2	557,01	2,04	2,223 8	5,628 6	200	4,186 3
vapour			110,866	656,96	684,81	2,361	2,320 8	6,428 2	132,07	21,21

[a] Triple point

[b] Normal boiling point

* The values of C_v, C_p, and w at the critical point are not included as part of this document.

Table 56 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
liquid	130	3,357 8	321	570,79	581,25	2,098 5	2,309 3	8,908 1	156,3	6,819 8
vapour			134,723	653,51	678,44	2,339 6	2,424 3	11,556 8	123,05	21,22
critical	134,66	3,629 0	225,5	617,84	633,94	2,225 9	*	*	*	16,282 2

[a] Triple point

[b] Normal boiling point

* The values of C_v, C_p, and w at the critical point are not included as part of this document.

5.18 R1336mzz(Z) – (cis-1,1,1,4,4,4-hexafluorobutene)

5.18.1 Range of validity

T_{min} = 230,0 K, T_{max} = 500 K; p_{max} = 46 MPa; ρ_{max} = 9,725 mol/l (1 595,5 kg/m^3)

5.18.2 Coefficients and exponents of the ideal-gas part (Formulae 3 to 5)

Coefficients and exponents of the ideal-gas part are listed in Table 57 and Table 58. Coefficients and exponents of the real-gas part are listed in Table 59 and Table 60.

Table 57 — Coefficients and exponents for k = 0

k	c_k
0	4,00

Table 58 — Coefficients and exponents for k = 1 up to 2

k	a_k	b_k
1	20,2	736,0
2	5,275	2 299,0

5.18.3 Coefficients and exponents of the real-gas part (Formula 2)

Table 59 — Coefficients and exponents for k = 1 up to 10

k	N_k	t_k	d_k	l_k	α_k
1	0,036 673 095	1	4	0	1
2	1,195 661 9	0,26	1	0	1
3	-1,846 237 6	1	1	0	1
4	-0,605 992 97	1	2	0	1
5	0,249 738 33	0,515	3	0	1
6	-1,254 827 8	2,6	1	2	1
7	-1,438 961 2	3	3	2	1
8	0,351 688 87	0,74	2	1	1
9	-0,821 040 51	2,68	2	2	1
10	-0,031 747 538	0,96	7	1	1

Table 60 — Coefficients and exponents for k = 11 up to 18

k	N_k	t_k	d_k	l_k	α_k	m_k	β_k	γ_k	ε_k
11	1,028 138 8	1,06	1	2	2	-0,746	-1,118	0,962	1,225
12	0,210 940 74	3,4	1	2	2	-2,406	-3,065	1,111	0,161
13	0,701 701	1,617	3	2	2	-0,780 4	-0,727 4	1,135	1,231
14	0,246 385 28	1,865	2	2	2	-1,25	-0,843 5	1,163	1,395
15	-1,529 503 4	1,737	3	2	2	-0,682 6	-0,675 4	0,969	0,907 2
16	0,334 249 78	3,29	2	2	2	-1,677	-0,436	1,286	0,958
17	1,011 324	1,242	2	2	2	-1,762	-3,808	1,274	0,412
18	-0,023 457 179	2	1	2	2	-21	-1 888	1,056	0,944

5.18.4 Reducing parameters, molar mass, and gas constant

T^* = 444,5 K, ρ^* = 3,044 mol/l, M = 164,056 g/mol, R = 8,314 459 8 J/(mol·K)

5.18.5 Reference state parameters

T_{ref} = 273,15 K, p_{ref} = 1,0 kPa, h_{ref} = 62 425,495 J/mol, s_{ref} = 298,993 7 J/(mol·K)

Property values along the liquid-vapour saturation boundary are listed in Table 61.

Table 61 — R1336mzz(Z) (cis-1,1,1,4,4,4-hexafluorobutene) — 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	MPa	kg/m³	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
liquid	-40	0,002 35	1 522,9	-154,9	154,9	0,821 7	0,785 9	1,084 2	874,9	-0,391 3
vapour			0,199 2	339,26	351,04	1,663	0,627 6	0,679 2	112,71	92,58
liquid	-35	0,003 32	1 511,3	160,35	160,35	0,844 8	0,795 8	1,095 1	854,6	-0,382 7
vapour			0,276 5	342,4	354,42	1,659 7	0,642 5	0,694 4	113,72	86,39
liquid	-30	0,004 62	1 499,7	165,85	165,86	0,867 7	0,805 6	1,106	834,4	-0,374 1
vapour			0,377 4	345,6	357,85	1,657 3	0,657	0,709 3	114,69	80,71
liquid	-25	0,006 33	1 487,9	171,41	171,41	0,890 3	0,815 2	1,116 8	814,6	-0,365 3
vapour			0,507 1	348,85	361,34	1,655 7	0,671 3	0,724	115,64	75,47
liquid	-20	0,008 54	1 476,1	177,02	177,03	0,912 7	0,824 6	1,127 4	795	-0,356 2
vapour			0,671 6	352,16	364,88	1,654 8	0,685 3	0,738 6	116,54	70,63
liquid	-15	0,011 4	1 464,2	182,68	182,69	0,934 9	0,833 9	1,138	775,5	-0,346 9
vapour			0,878	355,52	368,46	1,654 5	0,699	0,753	117,41	66,16
liquid	-10	0,014 9	1 452,2	188,4	188,41	0,956 8	0,843 1	1,148 5	756,3	-0,337 3
vapour			1,133	358,93	372,09	1,654 8	0,712 6	0,767 4	118,22	62,03
liquid	-5	0,019 3	1 440,1	194,16	194,18	0,978 5	0,852	1,158 9	737,3	-0,327 4
vapour			1,445	362,39	375,76	1,655 7	0,726	0,781 7	118,99	58,22
liquid	0	0,024 7	1 427,8	199,98	200	1	0,860 9	1,169 2	718,5	-0,317
vapour			1,823	365,88	379,46	1,657	0,739 2	0,795 9	119,7	54,69
liquid	5	0,031 4	1 415,5	205,85	205,87	1,021 3	0,869 6	1,179 6	699,9	-0,306 3
vapour			2,277	369,42	383,19	1,658 8	0,752 2	0,810 2	120,36	51,43

[b] Normal boiling point

* The values of C_v, C_p, and w at the critical point are not included as part of this document.

Table 61 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
liquid	10	0,039 4	1 403	211,77	211,8	1,042 4	0,878 1	1,189 8	681,4	-0,295
vapour			2,818	372,99	386,95	1,661	0,765 2	0,824 5	120,95	48,43
liquid	15	0,048 9	1 390,4	217,74	217,78	1,063 3	0,886 5	1,200 1	663,1	-0,283 2
vapour			3,458	376,6	390,74	1,663 5	0,778	0,838 9	121,47	45,67
liquid	20	0,060 2	1 377,6	223,77	223,81	1,084	0,894 7	1,210 4	644,9	-0,270 7
vapour			4,207	380,23	394,55	1,666 4	0,790 7	0,853 4	121,93	43,13
liquid	25	0,073 6	1 364,7	229,84	229,89	1,104 6	0,902 8	1,220 7	626,9	-0,257 4
vapour			5,081	383,89	398,37	1,669 6	0,803 3	0,867 9	122,31	40,79
liquid	30	0,089 1	1 351,6	235,96	236,03	1,124 9	0,910 8	1,231 1	608,9	-0,243 4
vapour			6,092	387,57	402,2	1,673 1	0,815 8	0,882 7	122,61	38,66
liquid	33,45[b]	0,101 3	1 342,4	240,22	240,29	1,138 9	0,916 2	1,238 3	596,6	-0,233 2
vapour			6,88	390,13	404,86	1,675 6	0,824 4	0,893	122,77	37,29
liquid	35	0,107 2	1 338,3	242,13	242,21	1,145 1	0,918 6	1,241 5	591,1	-0,228 4
vapour			7,258	391,28	406,05	1,676 8	0,828 2	0,897 6	122,83	36,7
liquid	40	0,128	1 324,8	248,36	248,45	1,165 2	0,926 3	1,252 1	573,3	-0,212 4
vapour			8,593	395	409,9	1,680 7	0,840 5	0,912 7	122,96	34,91
liquid	45	0,151 9	1 311	254,63	254,75	1,185	0,933 8	1,262 8	555,7	-0,195 1
vapour			10,117	398,74	413,75	1,684 8	0,852 8	0,928 1	123	33,28
liquid	50	0,179 1	1 297,1	260,95	261,09	1,204 8	0,941 3	1,273 7	538,1	-0,176 5
vapour			11,848	402,49	417,61	1,689 1	0,864 9	0,943 7	122,94	31,79
liquid	55	0,209 9	1 282,9	267,33	267,5	1,224 4	0,948 6	1,284 8	520,6	-0,156 2
vapour			13,808	406,25	421,45	1,693 5	0,877	0,959 7	122,77	30,45
liquid	60	0,244 7	1 268,4	273,76	273,95	1,243 8	0,955 9	1,296 2	503,1	-0,134 2
vapour			16,02	410,01	425,29	1,698 1	0,889	0,976 1	122,5	29,22
liquid	65	0,283 7	1 253,6	280,24	280,47	1,263 1	0,963	1,307 9	485,7	-0,110 1
vapour			18,508	413,78	429,11	1,702 7	0,900 9	0,992 9	122,12	28,12
liquid	70	0,327 4	1 238,5	286,78	287,05	1,282 3	0,970 1	1,320 1	468,3	-0,083 6
vapour			21,303	417,54	432,91	1,707 4	0,912 7	1,010 4	121,61	27,12
liquid	75	0,376	1 223	293,38	293,68	1,301 4	0,977 2	1,332 8	450,9	-0,054 3
vapour			24,433	421,3	436,68	1,712 2	0,924 5	1,028 5	120,98	26,23
liquid	80	0,429 9	1 207,1	300,03	300,38	1,320 4	0,984 2	1,346 1	433,4	-0,021 7
vapour			27,934	425,04	440,43	1,717	0,936 2	1,047 5	120,22	25,43
liquid	85	0,489 5	1 190,8	306,74	307,15	1,339 3	0,991 1	1,360 2	416	0,014 7
vapour			31,847	428,77	444,14	1,721 8	0,947 9	1,067 5	119,31	24,73
liquid	90	0,555 2	1 174,1	313,51	313,98	1,358 1	0,998	1,375 2	398,6	0,055 7
vapour			36,215	432,47	447,8	1,726 6	0,959 6	1,088 7	118,26	24,11
liquid	95	0,627 3	1 156,8	320,35	320,89	1,376 8	1,005	1,391 3	381,1	0,102 1
vapour			41,091	436,14	451,41	1,731 3	0,971 2	1,111 5	117,05	23,57
liquid	100	0,706 3	1 138,9	327,26	327,88	1,395 5	1,012	1,408 7	363,5	0,155 2
vapour			46,534	439,77	454,95	1,736	0,983	1,136 2	115,68	23,11
liquid	105	0,792 7	1 120,4	334,24	334,94	1,414 1	1,019	1,427 9	345,8	0,216 3
vapour			52,617	443,36	458,42	1,740 6	0,994 8	1,163 3	114,13	22,73

[b] Normal boiling point

* The values of C_v, C_p, and w at the critical point are not included as part of this document.

Table 61 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coeffi-cient
	°C	MPa	kg/m³	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
liquid	110	0,886 8	1 101,1	341,3	342,1	1,432 6	1,026 1	1,449 1	328	0,287 5
vapour			59,423	446,89	461,81	1,745 1	1,006 7	1,193 4	112,38	22,43
liquid	115	0,989 1	1 081	348,44	349,36	1,451 2	1,033 3	1,473 1	310	0,371 2
vapour			67,055	450,35	465,1	1,749 4	1,018 9	1,227 4	110,44	22,21
liquid	120	1,100 1	1 059,9	355,68	356,72	1,469 8	1,040 8	1,500 5	291,8	0,471 1
vapour			75,641	453,73	468,27	1,753 5	1,031 2	1,266 6	108,27	22,06
liquid	125	1,220 4	1 037,7	363,03	364,2	1,488 4	1,048 5	1,532 5	273,4	0,592 1
vapour			85,339	457	471,3	1,757 4	1,043 9	1,312 6	105,86	22
liquid	130	1,350 4	1 014,1	370,49	371,82	1,507 1	1,056 5	1,570 8	254,6	0,741 4
vapour			96,355	460,15	474,16	1,761	1,057	1,368	103,19	22,02
liquid	135	1,490 9	988,9	378,1	379,6	1,526	1,065 1	1,617 9	235,3	0,929 9
vapour			108,962	463,14	476,82	1,764 2	1,070 7	1,436 8	100,23	22,15
liquid	140	1,642 3	961,7	385,87	387,58	1,545	1,074 3	1,678	215,6	1,174 6
vapour			123,535	465,94	479,23	1,766 8	1,085 2	1,525 6	96,95	22,38
liquid	145	1,805 6	931,8	393,85	395,78	1,564 3	1,084 4	1,758 5	195,2	1,503 8
vapour			140,616	468,48	481,32	1,768 9	1,100 5	1,645 9	93,29	22,73
liquid	150	1,981 4	898,5	402,09	404,29	1,584 1	1,095 9	1,873 4	173,9	1,968 1
vapour			161,044	470,67	482,97	1,77	1,117 2	1,821 1	89,21	23,22
liquid	155	2,170 8	860,2	410,7	413,22	1,604 6	1,109 6	2,054 4	151,5	2,667 4
vapour			186,228	472,36	484,02	1,769 9	1,136 9	2,106 9	84,65	23,87
liquid	160	2,374 9	814,1	419,87	422,78	1,626 2	1,127	2,389 6	127,5	3,828 2
vapour			218,866	473,28	484,13	1,767 8	1,163 5	2,656 1	79,51	24,56
liquid	165	2,595 3	753,1	430,07	433,52	1,650 2	1,153	3,251 9	101,1	6,092 7
vapour			265,561	472,74	482,52	1,762	1,202 2	4,097 3	73,6	25,04
liquid	170	2,834 9	644,4	443,57	447,97	1,682 2	1,22	11,053 3	70,3	12,409 7
vapour			357,94	467,66	475,58	1,744 5	1,281 5	16,701 1	66,14	23,7
critical	171,35	2,903	499,4	455,8	461,61	1,712 7	*	*	*	19,180 3

[b] Normal boiling point

* The values of C_v, C_p, and w at the critical point are not included as part of this document.

5.19 R1234ze(E) — trans–1,3,3,3–tetrafluoropropene

5.19.1 Range of validity

T_{min} = 169,0 K, T_{max} = 420 K; p_{max} = 1 000 MPa; ρ_{max} = 13,25 mol/l (1 511 kg/m³)

5.19.2 Coefficients and exponents of the ideal-gas part (Formulae 3 to 5)

Coefficients and exponents of the ideal-gas part are listed in Table 62 and Table 63. Coefficients and exponents of the real-gas part are listed in Table 64 and Table 65.

Table 62 — Coefficients and exponents for k = 0

k	c_k
0	4,000

Table 63 — Coefficients and exponents for k = 1 up to 2

k	a_k	b_k
1	9,357 5	513
2	10,717	1 972

5.19.3 Coefficients and exponents of the real-gas part (Formula 2)

Parameters not listed are zero.

Table 64 — Coefficients and exponents for k = 1 up to 5

k	N_k	t_k	d_k
1	0,039 827 97	1	4
2	1,812 227	0,223	1
3	−2,537 512	0,755	1
4	−0,533 325 4	1,24	2
5	0,167 703 1	0,44	3

Table 65 — Coefficients and exponents for k = 6 up to 16

k	N_k	t_k	d_k	l_k	α_k	m_k	β_k	γ_k	ε_k
6	−1,323 801	2	1	2	1	1	0	1	0
7	−0,669 465 4	2,2	3	2	1	1	0	1	0
8	0,807 271 8	1,2	2	1	1	1	0	1	0
9	−0,774 022 9	1,5	2	2	1	1	0	1	0
10	−0,018 438 46	0,9	7	1	1	1	0	1	0
11	1,407 916	1,33	1	2	2	−1,00	−1,21	0,943	0,728
12	−0,423 708 2	1,75	1	2	2	−1,61	−1,37	0,642	0,87
13	−0,227 006 8	2,11	3	2	2	−1,24	−0,98	0,59	0,855
14	−0,805 213	1	3	2	2	−9,34	−171	1,2	0,79
15	0,009 943 18	1,5	2	2	2	−5,78	−47,4	1,33	1,3
16	−0,008 798 793	1	1	2	2	−3,08	−15,4	0,64	0,71

5.19.4 Reducing parameters, molar mass, and gas constant

T^* = 382,513 K, ρ^* = 4,29 mol/l, M = 114,041 6 g/mol, R = 8,314 462 1 J/(mol·K)

5.19.5 Reference state parameters

T_{ref} = 273,15 K, p_{ref} = 1,0 kPa, h_{ref} = 44 375,837 J/mol, s_{ref} = 237,138 3 J/(mol·K)

Property values along the liquid-vapour saturation boundary are listed in Table 66.

Table 66 — R1234ze(E) — trans–1,3,3,3–tetrafluoropropene — 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	MPa	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
liquid	−104,15[a]	0,000 229	1 510,8	69,95	69,95	0,403	0,824 6	1,218	1 122	−0,391 7
vapour			0,018 56	299,8	312,12	1,836	0,553	0,626	118,06	89,18
liquid	−100,00	0,000 365	1 500,4	75	75	0,432 6	0,824 4	1,217 1	1 101,8	−0,390 1
vapour			0,028 95	302,12	314,73	1,817 1	0,564	0,637 1	119,35	84,27
liquid	−95,00	0,000 621	1 488	81,09	81,09	0,467 2	0,824 7	1,216 6	1 077,6	−0,387 9
vapour			0,047 83	304,96	317,94	1,796 7	0,576 9	0,65	120,88	78,85
liquid	−90,00	0,001 02	1 475,5	87,17	87,17	0,500 9	0,825 5	1,216 8	1 053,5	−0,385 1
vapour			0,076 4	307,86	321,2	1,778 7	0,589 3	0,662 6	122,38	73,89
liquid	−85,00	0,001 62	1 463,1	93,25	93,26	0,533 7	0,826 7	1,217 7	1 029,7	−0,381 8
vapour			0,118 3	310,82	324,52	1,762 8	0,601 3	0,674 8	123,85	69,34
liquid	−80,00	0,002 5	1 450,7	99,35	99,35	0,565 6	0,828 4	1,219 3	1 006	−0,378 0
vapour			0,178 1	313,83	327,88	1,748 8	0,612 9	0,686 7	125,29	65,14
liquid	−75,00	0,003 76	1 438,2	105,45	105,45	0,596 8	0,830 5	1,221 4	982,4	−0,373 7
vapour			0,261 4	316,89	331,29	1,736 5	0,624 2	0,698 3	126,68	61,27
liquid	−70,00	0,005 53	1 425,7	111,56	111,56	0,627 3	0,832 8	1,224 1	959,1	−0,368 8
vapour			0,374 9	319,99	334,73	1,725 8	0,635 2	0,709 7	128,04	57,68
liquid	−65,00	0,007 94	1 413,2	117,69	117,69	0,657 1	0,835 5	1,227 3	935,8	−0,363 3
vapour			0,526 2	323,13	338,21	1,716 5	0,645 9	0,720 9	129,34	54,35
liquid	−60,00	0,011 2	1 400,6	123,83	123,84	0,686 3	0,838 5	1,231 1	912,8	−0,357 2
vapour			0,724	326,31	341,72	1,708 5	0,656 4	0,732 1	130,58	51,27
liquid	−55,00	0,015 4	1 388	130	130,01	0,714 8	0,841 7	1,235 4	889,9	−0,350 5
vapour			0,979	329,51	345,25	1,701 5	0,666 8	0,743 3	131,77	48,4
liquid	−50,00	0,020 9	1 375,3	136,19	136,2	0,742 9	0,845 1	1,240 3	867,1	−0,343 1
vapour			1,303	332,75	348,81	1,695 6	0,677	0,754 5	132,89	45,75
liquid	−45,00	0,027 9	1 362,4	142,4	142,42	0,770 4	0,848 7	1,245 6	844,5	−0,334 9
vapour			1,707	336	352,37	1,690 7	0,687 1	0,765 8	133,94	43,29
liquid	−40,00	0,036 7	1 349,5	148,64	148,66	0,797 5	0,852 5	1,251 5	822	−0,325 9
vapour			2,206	339,28	355,94	1,686 5	0,697 2	0,777 4	134,9	41,01
liquid	−35,00	0,047 7	1 336,5	154,91	154,94	0,824 1	0,856 5	1,257 9	799,6	−0,316 1
vapour			2,814	342,57	359,51	1,683 1	0,707 2	0,789 1	135,79	38,9
liquid	−30,00	0,061 1	1 323,3	161,21	161,25	0,850 3	0,860 6	1,264 8	777,2	−0,305 3
vapour			3,549	345,87	363,09	1,680 3	0,717 3	0,801 2	136,58	36,94
liquid	−25,00	0,077 4	1 309,9	167,54	167,6	0,876 1	0,864 9	1,272 3	754,9	−0,293 5
vapour			4,428	349,18	366,65	1,678 2	0,727 4	0,813 6	137,27	35,14
liquid	−20,00	0,096 9	1 296,4	173,92	173,99	0,901 5	0,869 3	1,280 3	732,7	−0,280 6
vapour			5,47	352,49	370,2	1,676 6	0,737 6	0,826 5	137,87	33,47
liquid	−18,97[b]	0,101 3	1 293,6	175,23	175,31	0,906 7	0,870 2	1,282 1	728,1	−0,277 8
vapour			5,706	353,17	370,93	1,676 3	0,739 8	0,829 2	137,97	33,14
liquid	−15,00	0,120 1	1 282,7	180,33	180,42	0,926 6	0,873 9	1,288 9	710,5	−0,266 4
vapour			6,696	355,8	373,74	1,675 4	0,748	0,839 8	138,35	31,93

[a] Triple point.

[b] Normal boiling point.

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

Table 66 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
liquid	−10,00	0,147 4	1 268,7	186,78	186,9	0,951 3	0,878 6	1,298 1	688,3	−0,250 9
vapour			8,129	359,11	377,25	1,674 7	0,758 4	0,853 8	138,71	30,52
liquid	−5,00	0,179 4	1 254,6	193,28	193,42	0,975 8	0,883 5	1,307 9	666,2	−0,233 9
vapour			9,793	362,41	380,73	1,674 3	0,769	0,868 4	138,95	29,21
liquid	0	0,216 5	1 240,1	199,83	200	1	0,888 5	1,318 5	644,1	−0,215 2
vapour			11,714	365,69	384,18	1,674 3	0,779 7	0,883 7	139,06	28,02
liquid	5	0,259 3	1 225,4	206,42	206,63	1,023 9	0,893 8	1,329 8	622	−0,194 6
vapour			13,923	368,96	387,59	1,674 5	0,790 7	0,899 9	139,04	26,93
liquid	10	0,308 4	1 210,4	213,07	213,32	1,047 6	0,899 2	1,342	600	−0,171 8
vapour			16,45	372,21	390,96	1,675	0,801 8	0,917	138,87	25,93
liquid	15	0,364 2	1 195	219,77	220,08	1,071 1	0,904 9	1,355 3	578	−0,146 4
vapour			19,332	375,43	394,27	1,675 6	0,813 1	0,935 3	138,55	25,01
liquid	20	0,427 3	1 179,3	226,54	226,9	1,094 4	0,910 6	1,369 8	556	−0,118 1
vapour			22,607	378,62	397,53	1,676 5	0,824 7	0,954 8	138,08	24,19
liquid	25	0,498 5	1 163,1	233,37	233,8	1,117 5	0,916 4	1,385 6	534,1	−0,086 2
vapour			26,321	381,78	400,72	1,677 4	0,836 5	0,975 8	137,43	23,44
liquid	30	0,578 3	1 146,4	240,27	240,78	1,140 5	0,922 2	1,402 9	512,1	−0,050 1
vapour			30,523	384,89	403,83	1,678 4	0,848 5	0,998 6	136,61	22,76
liquid	35	0,667 4	1 129,3	247,25	247,84	1,163 4	0,928	1,422	490,1	−0,009 0
vapour			35,272	387,95	406,87	1,679 4	0,860 8	1,023 4	135,6	22,16
liquid	40	0,766 4	1 111,5	254,31	255	1,186 1	0,933 8	1,443 1	467,9	0,038 1
vapour			40,636	390,94	409,8	1,680 5	0,873 3	1,050 7	134,4	21,64
liquid	45	0,876 1	1 093,1	261,46	262,27	1,208 8	0,939 5	1,466 7	445,5	0,092 7
vapour			46,693	393,86	412,63	1,681 5	0,886 1	1,081 2	132,99	21,19
liquid	50	0,997 2	1 073,8	268,71	269,64	1,231 5	0,945 3	1,493 2	422,8	0,156 5
vapour			53,538	396,7	415,33	1,682 3	0,899 3	1,115 9	131,36	20,81
liquid	55	1,130 4	1 053,7	276,07	277,14	1,254 1	0,951 2	1,523 4	399,7	0,231 8
vapour			61,286	399,44	417,88	1,683	0,913 2	1,156	129,49	20,51
liquid	60	1,276 6	1 032,5	283,55	284,78	1,276 8	0,957 4	1,558 3	376,1	0,321 8
vapour			70,078	402,05	420,26	1,683 5	0,928	1,203 6	127,38	20,27
liquid	65	1,436 5	1 010,1	291,16	292,58	1,299 6	0,964 1	1,599 5	351,9	0,431
vapour			80,093	404,51	422,45	1,683 6	0,944	1,261 3	125	20,09
liquid	70	1,611	986,2	298,92	300,56	1,322 5	0,971 5	1,649 3	327,2	0,566
vapour			91,563	406,8	424,4	1,683 4	0,961 4	1,332 9	122,32	19,97
liquid	75	1,801	960,6	306,87	308,74	1,345 6	0,979 9	1,711 3	301,6	0,736 6
vapour			104,797	408,88	426,06	1,682 6	0,980 5	1,424 1	119,32	19,9
liquid	80	2,007 7	932,7	315,03	317,19	1,369 1	0,989 6	1,791 6	275,3	0,958 2
vapour			120,226	410,68	427,38	1,681 1	1,001 5	1,544 6	115,96	19,87
liquid	85	2,232 1	901,9	323,47	325,95	1,393	1,001 2	1,901 2	248	1,256 9
vapour			138,484	412,13	428,25	1,678 7	1,024 7	1,712 2	112,2	19,89
liquid	90	2,475 5	867,2	332,27	335,12	1,417 7	1,015 6	2,062 2	219,4	1,679 4

[a] Triple point.

[b] Normal boiling point.

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

Table 66 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
vapour			160,57	413,11	428,52	1,674 9	1,051	1,963 4	107,99	19,94
liquid	95	2,739 5	826,9	341,58	344,89	1,443 5	1,034 4	2,327 1	189,4	2,319 6
vapour			188,222	413,38	427,93	1,669 1	1,082	2,386 3	103,27	19,96
liquid	100	3,026	777,3	351,7	355,59	1,471 5	1,061 3	2,859 3	157,2	3,399 5
vapour			225,006	412,5	425,95	1,66	1,121 6	3,258 1	97,93	19,83
liquid	105	3,337 8	708,1	363,52	368,23	1,504	1,108 9	4,573 3	121,1	5,619 5
vapour			281,016	409,24	421,12	1,643 8	1,182	6,121 7	91,7	19,14
critical	109,36	3,634 9	489,2	388,11	395,54	1,574 4	*	*	*	0,000

[a] Triple point.

[b] Normal boiling point.

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

5.20 R1234yf — 2,3,3,3-tetrafluoropropene

5.20.1 Range of validity

T_{min} = 122,77 K, T_{max} = 410 K; p_{max} = 30 MPa; ρ_{max} = 13,81 mol/l (1 575 kg/m^3)

5.20.2 Coefficients and exponents of the ideal-gas part (Formulae 3 to 5)

Coefficients and exponents of the ideal-gas part are listed in Table 67 and Table 68. Coefficients and exponents of the real-gas part are listed in Table 69 and Table 70.

Table 67 — Coefficients and exponents for k = 0

k	c_k
0	4,000

Table 68 — Coefficients and exponents for k = 1 up to 2

k	a_k	b_k
1	8,65	512
2	9,75	1 570
3	2,11	4 500

5.20.3 Coefficients and exponents of the real-gas part (Formula 2)

Parameters not listed are zero.

Table 69 — Coefficients and exponents for k = 1 up to 5

k	N_k	t_k	d_k
1	0,034 038 7	1	4
2	1,912 859	0,222	1
3	-2,198 472	0,61	1
4	-0,814 764 5	1,122	2
5	0,228 828 2	0,5	3

Table 70 — Coefficients and exponents for k = 6 up to 16

k	N_k	t_k	d_k	l_k	α_k	m_k	β_k	γ_k	ε_k
6	-1,654 36	2,14	1	2	1	1	0	1	0
7	-1,446 628	2,284	3	2	1	1	0	1	0
8	0,596 172 2	1,05	2	1	1	1	0	1	0
9	-0,614 820 9	2,33	2	2	1	1	0	1	0
10	-0,018 006 9	0,778	7	1	1	1	0	1	0
11	0,284 527 5	1	1	2	2	-28,1	-1 016	1,061	0,96
12	-0,305 080 9	2	1	2	2	-28	-1 000	1,062	0,96
13	2,198 935	1,236	1	2	2	-1,307	-1,16	1,3	0,853
14	-0,427 032 9	1,6	1	2	2	-1,96	-1,2	1,04	1,15
15	-0,401 558 1	1,85	1	2	2	-1,25	-1,26	1	1,3
16	0,117 958 7	0,7	1	2	2	-1	-1,6	1,14	1,5
17	-0,314 100 2	1,75	1	2	2	-2,2	-0,87	1,1	0,762

5.20.4 Reducing parameters, molar mass, and gas constant

T^* = 367,85 K, ρ^* = 4,18 mol/l, M = 114,041 6 g/mol, R = 8,314 462 618 J/(mol·K)

5.20.5 Reference state parameters

T_{ref} = 273,15 K, p_{ref} = 1,0 kPa, h_{ref} = 42 251,666 J/mol, s_{ref} = 232,282 1 J/(mol·K)

Property values along the liquid-vapour saturation boundary are listed in Table 71.

Table 71 — R1234yf - 2,3,3,3-tetrafluoropropene — 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	MPa	kg/m³	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
liquid	-150,38[a]	5,363×10⁻⁷	1 574,7	26,33	26,33	0,087 5	0,729 5	1,103 1	1 274,5	-0,456 7
vapour			5,991×10⁻⁵	260,66	269,61	2,069 1	0,393 8	0,466 7	102,99	266,05
liquid	-150	5,831×10⁻⁷	1 573,7	26,75	26,75	0,090 9	0,729 3	1,102 8	1 272,5	-0,456 8
vapour			6,495×10⁻⁵	260,81	269,79	2,064 4	0,395 1	0,468	103,13	263,78
liquid	-140	4,342×10⁻⁶	1 547,5	37,74	37,74	0,176 7	0,726 8	1,095 7	1 220,4	-0,458 2
vapour			4,473×10⁻⁴	264,92	274,63	1,955 9	0,427 6	0,500 6	106,59	212,9
liquid	-130	2,340×10⁻⁵	1 521,8	48,68	48,68	0,255 9	0,727 6	1,093 3	1 169	-0,456 8
vapour			2,242×10⁻⁴	269,36	279,79	1,870 4	0,459	0,531 9	109,97	175,09
liquid	-120	9,770×10⁻⁵	1 496,5	59,61	59,61	0,329 8	0,730 5	1,094 1	1 118,5	-0,453 1
vapour			8,752×10⁻⁴	274,09	285,26	1,803 1	0,489	0,561 9	113,26	145,85
liquid	-110	0,000 333	1 471,3	70,57	70,57	0,399 1	0,735 3	1,097 6	1 068,6	-0,447 1
vapour			0,027 98	279,11	291	1,750 2	0,517 4	0,590 6	116,45	122,47
liquid	-100	0,000 959	1 446,3	81,57	81,57	0,464 5	0,742	1,103 8	1 019,2	-0,438 8
vapour			0,076 1	284,4	297	1,708 7	0,544 6	0,618	119,52	103,39
liquid	-90	0,002 42	1 421,3	92,65	92,66	0,526 7	0,750 7	1,112 8	970,4	-0,427 9

[a] Triple point.

[b] Normal boiling point.

* The values of C_v, C_p, and w at the critical point are not included as part of this document.

Table 71 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m^3	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
vapour			0,181 4	289,92	303,23	1,676 5	0,570 8	0,644 7	122,46	87,66
liquid	-80	0,005 43	1 396,1	103,84	103,84	0,586 2	0,761 2	1,124 6	922,1	-0,414 4
vapour			0,388	295,64	309,65	1,651 7	0,596 1	0,671 1	125,23	74,65
liquid	-70	0,011 1	1 370,8	115,15	115,16	0,643 3	0,773 2	1,139	874,4	-0,398 2
vapour			0,758	301,55	316,23	1,633 1	0,621 1	0,697 6	127,78	63,9
liquid	-60	0,021	1 345,1	126,62	126,64	0,698 4	0,786 5	1,155 7	827,3	-0,378 9
vapour			1,375	307,61	322,92	1,619 3	0,645 9	0,724 7	130,06	55,05
liquid	-50	0,037 2	1 318,9	138,27	138,29	0,751 8	0,800 7	1,174 5	780,8	-0,356 3
vapour			2,341	313,79	329,7	1,609 5	0,670 9	0,752 7	132,04	47,77
liquid	-40	0,062 2	1 292,1	150,1	150,15	0,803 7	0,815 4	1,195 3	734,9	-0,33
vapour			3,781	320,07	336,52	1,603	0,696 1	0,782 1	133,66	41,81
liquid	-35	0,078 9	1 278,5	156,1	156,16	0,829 2	0,823	1,206 4	712,1	-0,315 2
vapour			4,725	323,23	339,93	1,600 8	0,708 8	0,797 5	134,31	39,25
liquid	-30	0,098 9	1 264,7	162,15	162,23	0,854 3	0,830 6	1,218	689,5	-0,299 3
vapour			5,843	326,41	343,34	1,599 2	0,721 6	0,813 3	134,86	36,93
liquid	-29,46[b]	0,101 3	1 263,1	162,81	162,89	0,857	0,831 5	1,219 3	687,1	-0,297 5
vapour			5,976	326,76	343,71	1,599	0,723	0,815	134,91	36,7
liquid	-25	0,122 8	1 250,6	168,26	168,36	0,879 2	0,838 4	1,230 1	667	-0,282
vapour			7,16	329,6	346,75	1,598 1	0,734 5	0,829 6	135,28	34,85
liquid	-20	0,150 9	1 236,3	174,43	174,55	0,903 8	0,846 2	1,242 7	644,7	-0,263 2
vapour			8,698	332,8	350,14	1,597 4	0,747 5	0,846 6	135,59	32,96
liquid	-15	0,183 7	1 221,7	180,66	180,81	0,928 2	0,854	1,255 9	622,4	-0,242 7
vapour			10,485	336	353,52	1,597 2	0,760 7	0,864 1	135,76	31,27
liquid	-10	0,221 8	1 206,8	186,95	187,13	0,952 3	0,862	1,269 8	600,2	-0,220 3
vapour			12,548	339,2	356,87	1,597 3	0,773 9	0,882 5	135,79	29,74
liquid	-5	0,265 7	1 191,7	193,31	193,53	0,976 2	0,87	1,284 3	578,2	-0,195 7
vapour			14,92	342,39	360,19	1,597 8	0,787 2	0,901 6	135,68	28,36
liquid	0	0,315 9	1 176,1	199,73	200	1	0,878	1,299 6	556,2	-0,168 6
vapour			17,634	345,57	363,48	1,598 5	0,800 6	0,921 7	135,42	27,13
liquid	5	0,373	1 160,2	206,23	206,55	1,023 6	0,886 2	1,315 8	534,2	-0,138 5
vapour			20,73	348,74	366,73	1,599 5	0,814 2	0,943	134,99	26,03
liquid	10	0,437 6	1 143,8	212,8	213,18	1,047	0,894 4	1,333 1	512,3	-0,104 9
vapour			24,25	351,88	369,93	1,600 6	0,827 9	0,965 5	134,39	25,05
liquid	15	0,510 4	1 127	219,45	219,9	1,070 3	0,902 7	1,351 6	490,3	-0,067 2
vapour			28,245	355	373,06	1,601 9	0,841 7	0,989 7	133,62	24,17
liquid	20	0,591 8	1 109,7	226,18	226,71	1,093 5	0,911 1	1,371 7	468,4	-0,024 5
vapour			32,769	358,07	376,14	1,603 2	0,855 7	1,015 7	132,65	23,4
liquid	25	0,682 7	1 091,7	233	233,63	1,116 6	0,919 6	1,393 6	446,4	0,024 2
vapour			37,89	361,11	379,13	1,604 6	0,869 8	1,044	131,49	22,72
liquid	30	0,783 6	1 073,1	239,92	240,65	1,139 6	0,928 2	1,417 7	424,3	0,080 3
vapour			43,683	364,09	382,03	1,606	0,884 1	1,075 2	130,11	22,14

[a] Triple point.

[b] Normal boiling point.

* The values of C_v, C_p, and w at the critical point are not included as part of this document.

Table 71 *(continued)*

	Temp.	Pressure	Density	Internal energy	Enthalpy	Entropy	C_v	C_p	Sound speed	J-T coefficient
	°C	MPa	kg/m³	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
liquid	35	0,895 3	1 053,8	246,93	247,78	1,162 7	0,937	1,444 7	402	0,145 5
vapour			50,241	367	384,82	1,607 4	0,898 7	1,109 9	128,5	21,64
liquid	40	1,018 5	1 033,6	254,06	255,05	1,185 7	0,946 1	1,475 1	379,6	0,222 4
vapour			57,674	369,82	387,48	1,608 6	0,913 5	1,149 3	126,65	21,22
liquid	45	1,153 9	1 012,3	261,32	262,46	1,208 7	0,955 3	1,510 1	356,9	0,314
vapour			66,121	372,55	390	1,609 6	0,928 7	1,194 8	124,55	20,89
liquid	50	1,302 3	989,9	268,71	270,02	1,231 8	0,964 9	1,551 1	333,9	0,425 1
vapour			75,754	375,15	392,34	1,610 4	0,944 3	1,248 5	122,16	20,63
liquid	55	1,464 7	966,1	276,25	277,77	1,255 1	0,974 8	1,600 1	310,5	0,562 2
vapour			86,799	377,6	394,48	1,610 8	0,960 4	1,313 5	119,48	20,45
liquid	60	1,641 8	940,6	283,98	285,73	1,278 6	0,985 3	1,660 3	286,6	0,735 1
vapour			99,553	379,86	396,35	1,610 7	0,977 1	1,394 7	116,46	20,36
liquid	65	1,834 7	912,9	291,93	293,94	1,302 5	0,996 4	1,737 2	262,1	0,959 1
vapour			114,432	381,87	397,9	1,609 9	0,994 6	1,500 5	113,1	20,34
liquid	70	2,044 5	882,5	300,14	302,45	1,326 8	1,008 5	1,839 9	236,9	1,259 7
vapour			132,04	383,56	399,04	1,608 3	1,013 2	1,645 9	109,33	20,39
liquid	75	2,272 2	848,4	308,68	311,36	1,351 8	1,022	1,987 4	210,7	1,682 4
vapour			153,322	384,81	399,63	1,605 3	1,033 3	1,861 1	105,13	20,51
liquid	80	2,519 5	809,1	317,69	320,8	1,377 9	1,037 5	2,223 6	183,3	2,317 8
vapour			179,914	385,43	399,43	1,600 5	1,055 5	2,217 9	100,41	20,67
liquid	85	2,788 1	761,3	327,42	331,08	1,405 8	1,056 5	2,684 1	153,9	3,379 5
vapour			215,174	385	397,96	1,592 5	1,081 8	2,941	95,08	20,78
liquid	90	3,080 8	695,9	338,61	343,04	1,437 8	1,084 4	4,113 1	121	5,549 1
vapour			268,811	382,38	393,84	1,577 7	1,120 6	5,287 7	88,89	20,45
critical	94,70	3,384 4	476,7	362,83	369,93	1,509 9	*	*	*	0

[a] Triple point.

[b] Normal boiling point.

* The values of C_v, C_p, and w at the critical point are not included as part of this document.

5.21 R1233zd(E) — trans-1-chloro-3,3,3-trifluoropropene

5.21.1 Range of validity

T_{min} = 195,15 K, T_{max} = 550 K; p_{max} = 100 MPa; ρ_{max} = 11,395 mol/l (1 487 kg/m³)

5.21.2 Coefficients and exponents of the ideal-gas part (Formulae 3 to 5)

Coefficients and exponents of the ideal-gas part are listed in Table 72 and Table 73. Coefficients and exponents of the real-gas part are listed in Table 74 and Table 75.

Table 72 — Coefficients and exponents for k = 0

k	c_k
0	4,000

Table 73 — Coefficients and exponents for k = 1 up to 2

k	a_k	b_k
1	7,097 4	2 870
2	13,7	761

5.21.3 Coefficients and exponents of the real-gas part (Formula 2)

Parameters not listed are zero.

Table 74 — Coefficients and exponents for k = 1 up to 5

k	N_k	t_k	d_k
1	0,043 942 57	1	4
2	1,062 919	0,182	1
3	-1,287 914	0,865	1
4	-0,808 861 9	1,092 4	2
5	0,237 242 7	0,49	3

Table 75 — Coefficients and exponents for k = 6 up to 18

k	N_k	t_k	d_k	l_k	α_k	m_k	β_k	γ_k	ε_k
6	-1,940 3	1,958	1	2	1	1	0	1	0
7	-2,831 967	2,05	3	2	1	1	0	1	0
8	0,373 421	0,658	2	1	1	1	0	1	0
9	-1,515 798	2,051	2	2	1	1	0	1	0
10	-0,027 556 27	0,862	7	1	1	1	0	1	0
11	4,240 23	1,852	1	2	2	-1,532	-0,291 2	1,717 1	0,883 4
12	-0,031 526 71	1,92	2	2	2	-0,635	-0,624 5	0,63	1,386
13	-1,366 494	1,936	3	2	2	-1,405 6	-0,669	0,785 2	0,519 6
14	2,647 143	1,515	1	2	2	-1,451	-0,579 8	2,251	1,133
15	-2,325 463	2,668	1	2	2	-1,395	-0,464 3	1,821	0,978 8
16	-0,254 152 1	1,755	1	2	2	-2,259	-2,449	2,074	1,166
17	0,133 083 443	0,526	1	2	2	-24,3	-1 061,4	1,079 7	0,924 4
18	-0,156 921 74	2,98	1	2	2	-23,6	-917,8	1,084	0,937 2

5.21.4 Reducing parameters, molar mass, and gas constant

T^* = 438,86 K, ρ^* = 3,704 mol/l, M = 130,496 2 g/mol, R = 8,314 462 618 J/(mol·K)

5.21.5 Reference state parameters

T_{ref} = 273,15 K, p_{ref} = 1,0 kPa, h_{ref} = 52 752,273 J/mol, s_{ref} = 260,149 7 J/(mol·K)

Property values along the liquid-vapour saturation boundary are listed in Table 76.

Table 76 — R1233zd(E) — 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	MPa	kg/m³	kJ/kg	kJ/kg	kJ/(kg·K)	kJ/(kg·K)	kJ/(kg·K)	m/s	K/MPa
liquid	-78,00[a]	0,000 286	1 487	116,62	116,62	0,641 9	0,695 7	1,006 3	1 111,7	-0,490 3
vapour			0,022 99	341,96	354,39	1,860 3	0,471 3	0,535 1	118,77	116,29
liquid	-70	0,000 603	1 470,8	124,72	124,72	0,682 6	0,703 6	1,018 5	1 078,5	-0,479 2
vapour			0,046 66	345,81	358,74	1,834 6	0,494 7	0,558 7	120,8	102,3
liquid	-60	0,001 4	1 450,2	134,98	134,98	0,731 9	0,713 9	1,033 9	1 036,9	-0,464 7
vapour			0,103 2	350,87	364,43	1,808 4	0,523 1	0,587 3	123,28	87,68
liquid	-50	0,002 97	1 429,5	145,4	145,4	0,779 7	0,724 9	1,049 6	995,1	-0,449 5
vapour			0,209 3	356,19	370,37	1,787 8	0,550 5	0,615 1	125,68	75,65
liquid	-40	0,005 83	1 408,5	155,97	155,98	0,826	0,736 5	1,065 8	953,4	-0,433 3
vapour			0,394 1	361,75	376,53	1,772	0,576 8	0,642 1	127,96	65,73
liquid	-35	0,007 96	1 397,9	161,32	161,33	0,848 7	0,742 6	1,074	932,6	-0,424 7
vapour			0,527 8	364,6	379,68	1,765 6	0,589 6	0,655 2	129,05	61,44
liquid	-30	0,010 7	1 387,3	166,71	166,72	0,871 1	0,748 8	1,082 4	911,9	-0,415 9
vapour			0,697	367,51	382,88	1,760 1	0,602 1	0,668 3	130,1	57,53
liquid	-25	0,014 2	1 376,5	172,15	172,16	0,893 2	0,755 1	1,091	891,2	-0,406 6
vapour			0,907	370,47	386,13	1,755 5	0,614 4	0,681 1	131,11	53,98
liquid	-20	0,018 6	1 365,7	177,62	177,63	0,915 1	0,761 5	1,099 7	870,6	-0,397
vapour			1,166	373,47	389,41	1,751 6	0,626 4	0,693 9	132,07	50,74
liquid	-15	0,024	1 354,7	183,14	183,16	0,936 7	0,768 1	1,108 5	850,1	-0,386 9
vapour			1,482	376,51	392,72	1,748 4	0,638 3	0,706 5	132,98	47,8
liquid	-10	0,030 7	1 343,7	188,7	188,73	0,958	0,774 7	1,117 5	829,7	-0,376 4
vapour			1,862	379,59	396,06	1,745 9	0,649 9	0,719	133,84	45,12
liquid	-5	0,038 8	1 332,6	194,31	194,34	0,979 1	0,781 4	1,126 7	809,5	-0,365 3
vapour			2,317	382,7	399,43	1,744	0,661 2	0,731 5	134,63	42,67
liquid	0	0,048 5	1 321,3	199,96	200	1	0,788 1	1,136 1	789,3	-0,353 7
vapour			2,857	385,84	402,82	1,742 5	0,672 4	0,743 9	135,36	40,44
liquid	5	0,060 1	1 309,9	205,66	205,71	1,020 7	0,794 8	1,145 7	769,3	-0,341 5
vapour			3,491	389,01	406,23	1,741 6	0,683 5	0,756 4	136,02	38,41
liquid	10	0,073 8	1 298,4	211,41	211,47	1,041 2	0,801 6	1,155 4	749,3	-0,328 5
vapour			4,232	392,21	409,65	1,741 1	0,694 3	0,768 8	136,61	36,56
liquid	15	0,089 9	1 286,7	217,2	217,27	1,061 4	0,808 3	1,165 4	729,5	-0,314 8
vapour			5,091	395,42	413,08	1,741	0,705	0,781 3	137,12	34,87
liquid	18,13[b]	0,101 3	1 279,4	220,86	220,94	1,074 1	0,812 5	1,171 8	717,1	-0,305 7
vapour			5,695	397,44	415,23	1,741 1	0,711 6	0,789 2	137,4	33,89
liquid	20	0,108 7	1 274,9	223,05	223,13	1,081 6	0,815 1	1,175 6	709,8	-0,300 2
vapour			6,082	398,65	416,52	1,741 2	0,715 5	0,793 9	137,55	33,33
liquid	25	0,130 3	1 262,9	228,94	229,05	1,101 5	0,821 8	1,186	690,1	-0,284 6
vapour			7,219	401,9	419,95	1,741 8	0,725 9	0,806 6	137,89	31,92
liquid	30	0,155 3	1 250,8	234,89	235,01	1,121 3	0,828 5	1,196 8	670,6	-0,268
vapour			8,517	405,16	423,39	1,742 7	0,736 2	0,819 5	138,14	30,64
liquid	35	0,183 7	1 238,4	240,88	241,03	1,140 9	0,835 2	1,207 8	651,1	-0,250 1

[a] Triple point

[b] Normal boiling point

* The values of C_v, C_p, and w at the critical point are not included as part of this document.