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Refrigerant properties

Propriétés des fluides frigorigènes

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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).

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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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.

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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.

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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.

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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;

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