ASHRAE Guideline 6-1996

ASHRAE® GUIDELINE

Format for Information on Refrigerants

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(This foreword is not part of this guideline but is provided for information purposes only.)

FOREWORD

When a refrigerant was introduced many years ago (in the 1950s and earlier), the manufacturer only had to supply basic information on the thermodynamic properties of the material over a limited range of temperature and pressure. This was sufficient for potential users and system manufacturers to determine the equipment pressure requirements and compressor operating parameters, e.g., volumetric displacement, refrigerant flow (kg/ton [lb/ton]), and power requirements (kg/kWh [hp/ton]). At that time, the heat exchangers were almost universally based on a 5.6°C (10°F) approach, and the compressor was the most difficult part of the system to design and the most expensive (up to two-thirds of the cost of the total system). If the refrigerant showed promise economically on a thermodynamic basis, further data might have been provided on safety or use-related issues, such as flammability, toxicity, and compatibility with gaskets and other materials of construction. However, since the changes in the refrigeration industry were relatively evolutionary at that time, the rate and sequence of getting these data were considered of little importance. Also considered of secondary importance were the transport properties (viscosity and thermal conductivity).

Over the 20 years preceding the "ozone depletion issue," there were very few changes in refrigerants commonly used throughout the world, and refinements in data have mainly been to permit improved accuracy in related heat transfer and performance calculations. However, due to mandated phaseout of CFCs and HCFCs, it can be expected that not only lesser known and documented refrigerants but also completely new fluids and mixtures of fluids will be brought forth, with the developers of each making strong claims for their fluids. Also, with the improvements over the years in compressor manufacturing techniques and with the greater emphasis on energy efficiency (evaporators and condensers are now being designed with a less than 2.8°C [5°F] approach), we find the compressor/system cost ratio has dropped to about 1:3 and the heat exchanger/system cost ratio increased to more than 1:2. Furthermore, safety, health, and atmospheric pollution issues are much more important than earlier.

Due to the challenging task ahead of selecting and developing a new family of refrigerants and related hardware, there is a need to define required refrigerant property data and their accuracy, ranges of values, and recommended measurement methods as a cost-effective aid to apply these substitutes in a timely manner.

In interpreting paragraph 2.1 of the official scope of this guideline, it should be remembered that while all of the properties discussed are desirable, the development of a new refrigerant and its application normally occur in several phases. In the first phase (preliminary research), the information is mainly theoretical to see if the anticipated thermodynamic, health, and safety aspects make the fluid a viable candidate for further study. The next phase involves making small quantities in the laboratory to provide enough material to verify the anticipated theoretical properties and to determine the difficulty of producing the refrigerant in commercial quantities. If it still looks desirable, small "pilot plant" quantities are produced to provide samples to potential users for subsequent testing in laboratory systems (normally small unitary equipment). This is the stage where commercial feasibility is first considered. Of course, by this time, the federally mandated health and safety information will need to be determined as required by the current federal regulations, which may be less or more extensive than stated in this guideline. If the refrigerant is to be offered only for small, sealed unitary systems over limited ranges of operation, it could be "commercialized" with a limited set of properties and the understanding that unit testing is needed for each design; however, it would be desirable to provide the data listed so that calculations could be made for off-design conditions. If the refrigerant is to be "commercialized" for large or industrial system use, the full scope of data is desired.

In setting up paragraph 2.3 of the official scope of this guideline, the committee was optimistic that complete recommendations for each of the desired items could be fully defined and also that universally accepted means for evaluation could be recommended. However, at the present time, it is not possible to do this in all cases. As knowledge and acceptance of methods improve, future revisions of this guideline will be expanded to include that information. In using this guide, remember that the items mentioned are still desirable and should be obtained to the best of the ability of the investigator. In all cases, the estimated accuracy of the data supplied should be included along with the data.

Tribute to Willard R. Zahn

GPC-6P had its beginning in 1989 when ASHRAE Staff Liaison Jim L. Heldenbrand and SPC Liaison Carl N. Lawson were successful in recruiting Willard R. Zahn as the chair of a new committee to develop a "Guideline Format for Information on Refrigerants." Willard worked tirelessly in recruiting and motivating the members of the committee to develop GPC-6P from its inception in 1990 until 1995, when illness took him from us. He died 3 November 1995 in York, Pennsylvania, after a distinguished technical career of 45 years in industry for York Corporation and York International Corporation, with active participation in the American Chemical Society, American Institute of Chemical Engineers, National Society of Professional Engineers, Technical Societies Council of Southern Pennsylvania, and ASHRAE, where his latest award was as a Fellow. This guideline has been brought to fruition after six years of dedication by the committee, valuable public reviews followed by necessary modifications, and the skillful documentation of Willard R. Zahn, the original chair, Glenn C. Hourahan of ARI as secretary, and Dr. Robert G. Doerr of the Trane Company as vice-chair.

1. PURPOSE

The purposes of this guideline are:

(a) To recommend the types of information that should be available when a new refrigerant is commercialized. The goal is to facilitate availability of data needed by system designers and application engineers to select appropriate applications for new refrigerants.

(b) To guide ASHRAE research projects in upgrading data on current refrigerants.

2. SCOPE

2.1 This guideline lists the information that is desired and is recommended as the minimum information necessary for reasonable commercial application.

2.2 The scope of this guideline covers six main subjects:

(a) basic chemical data;
(b) thermodynamic data at saturation and in the superheat region;
(c) thermophysical data as a function of temperature;
(d) safety, health, and environmental information;
(e) materials compatibility data; and
(f) refrigerant lubricant, miscibility, and solubility data.

2.3 Information on the desired format (tables, graphs, equations, etc.) is included as appropriate. Desired accuracy and methods to be used in obtaining the data are given or reference is made to applicable standards.

3. DEFINITIONS

azeotropic: refer to *ANSI/ASHRAE Standard 34-1992*.[1]

bubble-point temperature**:** a liquid-vapor equilibrium point for a multi-component mixture of miscible, volatile pure component liquids, in the absence of noncondensables, where the temperature of the mixture at a defined pressure is sufficiently elevated to force the first vapor bubble to form in the liquid.

blends: refer to *ANSI/ASHRAE Standard 34-1992*.[1]

compounds: refer to *ANSI/ASHRAE Standard 34-1992*.[1]

critical state (critical point): state of a substance at which the corresponding physical properties (pressure, volume, temperature) of liquid and gas are identical.

dew-point temperature: a vapor-liquid equilibrium point for a multi-component mixture of miscible pure component vapors, in the absence of noncondensables, where the temperature of the mixture at a defined pressure is sufficiently lowered to force the first drop of liquid to form from the vapor.

glide: refer to *ANSI/ASHRAE Standard 34-1992*.[1]

global warming potential (GWP): an index developed to provide a simplified means of describing the relative ability of each greenhouse gas emission to affect radiative forcing, over its lifetime in the atmosphere, and thereby the global climate. Radiative forcing reflects the factors that affect the balance between the energy absorbed by the earth and the energy emitted by it in the form of longwave infrared radiation. The GWP is defined on a mass basis relative to carbon dioxide. The GWP for a compound must be calculated up to a particular integrated time horizon, for example, 20, 100, or 500 years. The time horizon most widely accepted is 100 years.

halocarbon global warming potential (HGWP): an index representing the steady-state 500 year global warming potential (GWP) defined on a mass basis relative to R-11 (a CFC). Because R-11 has a finite lifetime in the atmosphere, the HGWP can be calculated explicitly and is a single number.[2]

near azeotropic: refer to *ANSI/ASHRAE Standard 34-1992*.[1]

nonazeotropic: refer to *ANSI/ASHRAE Standard 34-1992*.[1]

ozone depletion potential (ODP): a numerical quantity describing the extent of ozone depletion calculated to arise from the release to the atmosphere of 1 kilogram of a compound relative to the ozone depletion calculated to arise from a similar release of R-11. The calculation is an integration of all known potential effects on ozone over the whole time that traces of the compounds could remain in the atmosphere.[2]

pressure volume temperature (PVT): relationship of pressure, volume, and temperature as fundamental thermodynamic properties of a fluid in a single-phase region.

radiative forcing: represents the net amount of infrared radiation that is trapped by gases in the atmosphere. The radiative forcing of a gas depends on the efficiency with which it traps infrared radiation and its concentration in the atmosphere. Atmospheric concentration depends on emission rates and the atmospheric lifetime of the gas.

refrigerant: the fluid used for heat transfer in a refrigerating system; the refrigerant absorbs heat and transfers it at a higher temperature and a higher pressure, usually with a phase change.

temperature glide—see ***glide***.

thermodynamic property data: those data needed to calculate the equilibrium relations among pressure, volume, and temperature along with the enthalpy and entropy of the fluid in the liquid and vapor states.

thermophysical property data: those data needed to calculate heat transfer and fluid flow characteristics of the fluid. Thermophysical properties include both thermodynamic (equilibrium) and transport properties.

threshold limit values (TLVs): refer to *ANSI/ASHRAE Standard 34-1992*.[1]

threshold limit value-time-weighted average (TLV-TWA): refer to *ANSI/ASHRAE Standard 34-1992*.[1]

toxicity: refer to *ANSI/ASHRAE Standard 34-1992*.[1]

transport property data: properties that describe the capability of a fluid to transfer heat and momentum, typically thermal conductivity and dynamic or kinematic viscosity.

zeotropic: refer to *ANSI/ASHRAE Standard 34-1992*.[1]

4. BASIC CHEMICAL DATA

Note: The number of significant figures for all properties should correspond to the uncertainty of the data.[3]

4.1 Compound Chemical Identification

All refrigerants shall be identified by their numbers as determined from *ANSI/ASHRAE Standard 34-1992*.[1]

4.2 Molecular Formula

For a single refrigerant, the molecular formula shall be identified using symbols for the chemical elements and small whole numbers representing the mole ratios of the elements composing the molecule (preferably subscripted). For example, Refrigerant 22 is identified as $CHClF_2$. Where an element