ANSI/ASHRAE Standard 41.9-2011
(Supersedes ANSI/ASHRAE Standard 41.9-2000 [RA 2006])

ASHRAE STANDARD

Standard Methods for Volatile-Refrigerant Mass Flow Measurements Using Calorimeters

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CONTENTS

ANSI/ASHRAE Standard 41.9-2011, Standard Methods for Volatile-Refrigerant Mass Flow Measurements Using Calorimeters

NOTE

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FOREWORD

Originally published in 1989, ASHRAE Standard 41.9 was thoroughly revised in 2000, was reaffirmed in 2006, and has been updated and improved in this edition. The 2000 edition of the standard expanded its scope to include zeotropic refrigerant blends, reorganized the test methods according to calorimeter types for ease of use, and added information and illustrative examples regarding measurement uncertainty calculations. This revision of the standard updates the 2006 edition by citing the most recent reference sources, by making procedural revisions to the lubricant circulation rate measurement in Section 11, and by other revisions to bring this standard into compliance with ASHRAE's mandatory language requirement. Various minor changes make it more usable and easier to read.

1. PURPOSE

This standard provides recommended practices for measuring the mass flow rate of volatile refrigerants using calorimeters.

2. SCOPE

2.1 This standard applies to the measurement of the flow of a volatile refrigerant in the following cases:

a. where the entire flow stream of the volatile refrigerant enters the calorimeter as a subcooled liquid and leaves as a superheated vapor (evaporator-type), and
b. where the entire flow stream of the volatile refrigerant enters the calorimeter as a superheated vapor and leaves as a subcooled liquid (condenser-type).

2.2 This standard applies to all of the refrigerants listed in ANSI/ASHRAE Standard 34, *Designation and Safety Classification of Refrigerants*.[1]

3. DEFINITIONS

The following definitions apply to the terms used in this standard. Additional definitions are given in *ASHRAE Terminology of Heating, Ventilation, Air Conditioning, & Refrigeration*.[2]

azeotropic refrigerant: an azeotropic blend contains two or more refrigerants whose equilibrium vapor-phase and liquid-phase compositions are the same at a given pressure. The temperature of an azeotropic refrigerant remains constant as it evaporates or condenses at constant pressure (compare to *zeotropic refrigerant*).

bubble-point temperature: a liquid-vapor equilibrium point for a volatile pure liquid or 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 the minimum temperature required for a vapor bubble to form in the liquid.

calorimeter: a thermally insulated apparatus containing a heat exchanger that determines the mass flow rate of a volatile refrigerant by measuring the heat input/output that will result in a known enthalpy change for the volatile refrigerant.

dew-point temperature: a vapor-liquid equilibrium point for a volatile pure liquid or 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 the maximum temperature required for a liquid drop to form in the vapor.

enthalpy (heat content): a thermodynamic quantity equal to the sum of the internal energy of a system plus the product of the pressure-volume work done on the system.

error: the difference between the true value of the quantity measured and the observed value. All errors in experimental data can be classified as one of two types: systematic (fixed) errors or random (precision) errors. The terms *accuracy* and *precision* are often used to distinguish between *systematic* and *random* errors. A measurement with small systematic errors is said to be unbiased. A measurement with small random errors is said to have high precision. A measurement that is unbiased and precise is said to be accurate.

fixed error: same as *systematic error.*

fractionation: a change in composition of a refrigerant blend by preferential evaporation of the more volatile component(s) or condensation of the less volatile component(s).

glide: the absolute value of the difference between the starting and ending temperatures of a phase-change process (condensation or evaporation) for a zeotropic refrigerant exclusive of any liquid subcooling or vapor superheating.

lubricant circulation rate: the ratio of the mass of lubricant circulating through a refrigerant system to the total mass of refrigerant and lubricant flowing through the system at a specified set of operating conditions.

near-azeotropic: a zeotropic refrigerant blend with a temperature glide sufficiently small that it may be disregarded without consequential error in analysis for a given application.

nonazeotropic: a synonym for *zeotropic*, which is the preferred term.

precision error: same as *random error.*

random error: an error that causes readings to take random values on either side of a mean value. The random error is quantified based on how well an instrument can reproduce subsequent readings for an unchanging input. Random errors cannot be corrected through calibration.