ANSI/ASHRAE Standard 15-2007
(Supersedes ANSI/ASHRAE Standard 15-2004)
Includes ANSI/ASHRAE Addenda listed in Appendix J

ASHRAE STANDARD

Safety Standard for Refrigeration Systems

See Appendix J for approval dates by the ASHRAE Standards Committee, the ASHRAE Board of Directors, and the American National Standards Institute.

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American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
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FOREWORD

ANSI/ASHRAE Standard 15-2007 is the most recent edition of one of ASHRAE's oldest standards. This edition is a republication of ANSI/ASHRAE Standard 15-2004 with addenda b and c incorporated. Addendum b provided modifications to enhance the safety of pressure protection designed for relief internal to systems. Addendum c revised Informative Appendix F, which outlines a method for determining the required relief capacity for positive displacement compressors. Addendum c also expanded the list of refrigerants and the corresponding properties required for determining compressor relief capacity. In addition, it revised the relief-capacity determination method to more clearly demonstrate calculations for positive displacement compressors equipped with capacity modulation.

While Standard 15-2007 is generally written as a self-sufficient document, it does normatively reference several other standards (see Normative Appendix E). One of those standards is ANSI/ASHRAE Standard 34, Designation and Safety Classification of Refrigerants*, which prescribes the Refrigerant Classification System as well as refrigerant quantity limits that are vitally important in the context of this standard. Although changes to Standard 15 are closely coordinated with those to Standard 34, users of Standard 15 should also review the most recent version of Standard 34 and its associated addenda for the latest information related to refrigerant designations and safety classifications.*

Presently, Table 1 in Standard 15 shows the amount of refrigerant in a given space that, when exceeded, requires a machinery room. When a refrigerant is not classified in Standard 34 or its addenda or not shown in Table 1, it is the responsibility of the owner of a refrigerating system to make this judgment. For blends, Informative Appendix A is offered to aid in determining allowable concentrations.

This standard is directed toward the safety of persons and property on or near the premises where refrigeration facilities are located. It includes specifications for fabrication of tight systems but does not address the effects of refrigerant emissions on the environment. For information on the environmental effects of refrigerant emissions, see ASHRAE Guideline 3-1996, Reducing Emission of Halogenated Refrigerants in Refrigeration and Air-Conditioning Equipment and Systems*.*

While the user of this document should be familiar with the entire standard, its organization into the following sections allows faster location of information. The topics included in these sections are:

***General (Sections 1–6):** Purpose, Scope, Definitions, Occupancy Classification, Refrigerating System Classification, Refrigerant Classification, Precedence with Conflicting Requirements, Listed Equipment.*

***Restrictions (Sections 7–8):** Restrictions on Refrigerant Use, Installation Restrictions.*

***Design and Construction (Section 9):** Materials, System Design Pressure, Refrigerant-Containing Pressure Vessels, Pressure Relief Protection, Setting of Pressure-Relief Devices, Marking of Pressure-Relief Devices and Fusible Plugs, Pressure Vessel Protection, Positive Displacement Compressor Protection, Pressure-Limiting Devices, Refrigerant Piping, Valves, Fittings and Related Parts, Components Other than Pressure Vessels and Piping, Service Provisions, Fabrication, Factory Tests, and Nameplate.*

***Operation and Testing (Section 10):** Field Tests, General Requirements.*

The hazards of refrigerants are related to their physical and chemical characteristics as well as to the pressures and temperatures occurring in refrigerating and air-conditioning systems. Personal injury and property damage from inadequate precautions may occur from a number of origins, such as:

- *Rupture of a part or an explosion with risk from flying debris or from structural collapse.*
- *Release of refrigerant from a fracture, due to a leaking seal or incorrect operation.*
- *Fire resulting from or intensified by burning or deflagration of escaping refrigerant or lubricant.*

Personal injury resulting from the accidental release of refrigerants may also occur from:

- *Suffocation from heavier-than-air refrigerants in inadequately ventilated spaces.*
- *Narcotic and cardiac sensitization effects.*
- *Toxic effects of vapor or the decomposition products due to vapor contact with flames or hot surfaces.*
- *Corrosive attack on the eyes, skin, or other tissue.*
- *Freezing of tissue by contact with liquid.*

Care should be taken to avoid stagnant pockets of refrigerant vapors by proper location of ventilation inlet and exhaust openings (all commonly used refrigerants except ammonia [R-717] and water [R-718] are heavier than air). All machinery rooms are required to have detectors that will activate on alarm and mechanical ventilation at a value not greater than the corresponding TLV-TWV (or toxicity measure consistent therewith). Informative Appendix I provides guidance on integrating the requirements of this standard with occupational health and safety programs.

The following short publishing history of this code traces the origins of these safety provisions. In 1919, the American Society of Refrigerating Engineers (ASRE) proposed a Tentative Code for the Regulation of Refrigerating Machines and Refrigerants. Over the next 11 years, representatives from the American Gas Association, American Institute of Electrical Engineers, American Institute of Refrigeration, American Chemical Society, American Society of Heating and Ventilation

Engineers, American Society of Mechanical Engineers, National Electrical Refrigerator Manufacturers Association, National Fire Protection Association, and ASRE met to expand the code to address all of the issues raised on the use of refrigeration equipment. The first Safety Code for Mechanical Refrigeration, recognized as American Standard B9 in October 1930, appeared in the first edition, 1932–1933, of the ASRE Refrigerating Handbook and Catalog*. ASRE revisions designated ASA B9 appeared in 1933 and 1939. ASRE revisions designated ASA B9.1 appeared in 1950, 1953, and 1958. After the formation of ASHRAE, editions appeared as ASA B9.1-1964, ANSI B9.1-1971, ANSI/ASHRAE Standard 15-1978, ANSI/ASHRAE Standard 15-1989, ANSI/ASHRAE Standard 15-1992, ANSI/ASHRAE Standard 15-1994, ANSI/ASHRAE Standard 15-2001, and ANSI/ASHRAE Standard 15-2004.*

1. PURPOSE

This standard specifies safe design, construction, installation, and operation of refrigeration systems.

2. SCOPE

2.1 This standard establishes safeguards for life, limb, health, and property and prescribes safety requirements.

2.2 This standard applies

a. to the design, construction, test, installation, operation, and inspection of mechanical and absorption refrigeration systems, including heat pump systems used in stationary applications,
b. to modifications including replacement of parts or components if they are not identical in function and capacity, and
c. to substitutions of refrigerant having a different designation.

3. DEFINITIONS

approved: acceptable to the authority having jurisdiction.

approved, nationally recognized laboratory: one that is acceptable to the authority having jurisdiction, which provides uniform testing and examination procedures and standards for meeting design, manufacturing, and factory testing requirements of this code; is organized, equipped, and qualified for testing; and has a follow-up inspection service of the current production of the listed products.

back pressure: the static pressure existing at the outlet of an operating pressure-relief device due to pressure in the discharge line.

balanced relief valve: a pressure-relief valve that incorporates means of minimizing the effect of back pressure on the operational characteristics of the valve (opening pressure, closing pressure, and relieving capacity).

blends: refrigerants consisting of mixtures of two or more different chemical compounds, often used individually as refrigerants for other applications.

brazed joint: a gas-tight joint obtained by the joining of metal parts with metallic mixtures or alloys that melt at temperatures above 1000°F (537°C) but less than the melting temperatures of the joined parts.

companion* or *block valves: pairs of mating stop valves that allow sections of a system to be joined before opening these valves or separated after closing them.

compressor: a machine used to compress refrigerant vapor.

compressor unit: a compressor with its prime mover and accessories.

condenser: that part of the refrigerating system where refrigerant is liquefied by the removal of heat.

condenser coil: a condenser constructed of pipe or tubing, not enclosed in a pressure vessel.

condensing unit: a combination of one or more power-driven compressors, condensers, liquid receivers (when required), and regularly furnished accessories.

containers, refrigerant: a cylinder for the transportation of refrigerant.

corridor: an enclosed passageway that limits travel to a single path.

critical pressure, critical temperature,* and *critical volume: a point on the saturation curve where the refrigerant liquid and vapor have identical volume, density, and enthalpy, and there is no latent heat.

design pressure: the maximum pressure for which a specific part of a refrigerating system is designed.

dual pressure-relief device: two pressure-relief devices mounted on a three-way valve that allows one device to remain active while the other is isolated.

duct: a tube or conduit used to convey or encase: (a) *air duct* is a tube or conduit used to convey air (air passages in self-contained systems are not air ducts); (b) *pipe duct* is a tube or conduit used to encase pipe or tubing.

evaporator: that part of the refrigerating system designed to vaporize liquid refrigerant to produce refrigeration.

evaporator coil: an evaporator constructed of pipe or tubing, not enclosed in a pressure vessel.

fusible plug: a plug containing an alloy that will melt at a specified temperature and relieve pressure.

header: a pipe or tube (extruded, cast, or fabricated) to which other pipes or tubes are connected.

heat pump: a refrigerating system used to transfer heat into a space or substance.

highside: those portions of the refrigerating system that are subject to approximate condensing pressure.

horsepower: the power delivered from the prime mover to the compressor of a refrigerating system.

IDLH (immediately dangerous to life or health): the maximum concentration from which unprotected persons are able

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FOREWORD

ANSI/ASHRAE Standard 34-2007 is the latest edition of Standard 34, which describes a shorthand way of naming refrigerants and assigns safety classifications based on toxicity and flammability data. The 2007 edition combines Standard 34-2004 and the 23 approved and published addenda to the 2004 edition, thereby providing an easy-to-use consolidated standard. More specific information on the contents of each addendum and its approval dates is included in an informative appendix at the end of this standard.

First published in 1978, Standard 34 is now updated on a regular basis using ASHRAE's continuous maintenance procedures. According to these procedures, Standard 34 is continuously revised—often several times a year—by addenda that are publicly reviewed, approved by ASHRAE and ANSI, and published on the ASHRAE Web site. Because the standard changes as new addenda are published, users are encouraged to sign up for the free Internet list server for the ASHRAE Standards Actions publication, which provides notice of all public reviews and approved and published addenda and errata. At the minimum, users should periodically review the ASHRAE Web site to ensure that they have all of the published addenda.

Among the key changes that were incorporated in the 2007 edition are the following:

- *Added thirteen refrigerants to Table 2 and three to Table 1.*
- *Added the requirement for refrigerant applications in electronic format in addition to the printed copies.*
- *Added a column to Tables 1 and 2 titled "Highly Toxic or Toxic Under Code Classification," with each refrigerant designated as highly toxic, toxic (as defined by the International Fire Code, Uniform Fire Code, and OSHA), or neither (for refrigerants less toxic than as defined above); also added definitions for these terms and updated the references.*
- *Removed the following four data requirements from the application instructions: freezing point or triple point for individual chemicals, vapor composition for the as-formulated saturated liquid composition at the normal boiling point and at 20°C for all blends, and the dew-point vapor pressure at 20°C and 60°C for zeotropic blends.*
- *Added guidance for the numbering of C4-C8 alkanes.*
- *Revised the refrigerant flammability classification and provided details on the required flammability and fractionation testing procedures.*
- *Added an informative appendix containing refrigerant data such as molecular mass and normal boiling point for the refrigerants listed. It also provides bubble points and dew points for azeotropic blends.*
- *Added a new section to the standard to specify the criteria to determine recommended RCLs in occupied spaces and added refrigerant concentration limit (RCL) values to Tables 1 and 2.*
- *Increased the oxygen deprivation limit (ODL) from 69,100 to 140,000 ppm for locations with altitudes at and below 1000 m (3300 ft) above sea level.*
- *Increased the cardiac sensitization default from 0 to 1000 ppm.*
- *Added an informative appendix containing toxicity and flammability data for single-compound refrigerants.*

Users of the standard are encouraged and invited to use the continuous maintenance procedure to suggest changes for further improvements. A form for submitting proposed changes to the standard is included at the back of this edition. The project committee for Standard 34 will take formal action on all proposals received.

1. PURPOSE

This standard is intended to establish a simple means of referring to common refrigerants instead of using the chemical name, formula, or trade name. It also establishes a uniform system for assigning reference numbers and safety classifications to refrigerants. The standard identifies requirements to apply for designations and safety classifications for refrigerants, including blends, in addenda or revisions to this standard.

2. SCOPE

This standard provides an unambiguous system for numbering refrigerants and assigning composition-designating prefixes for refrigerants. Safety classifications based on toxicity and flammability data are included. This standard does not imply endorsement or concurrence that individual refrigerant blends are suitable for any particular application.

3. DEFINITIONS OF TERMS

acute toxicity: the adverse health effect(s) from a single, short-term exposure, as might occur during an accidental release of refrigerants.

acute-toxicity exposure limit (ATEL): the refrigerant concentration limit determined in accordance with this standard and intended to reduce the risks of acute toxicity hazards in normally occupied, enclosed spaces. ATEL values are similar to the Immediately Dangerous to Life or Health (IDLH) concentrations set by the National Institute of Occupational Safety and Health (NIOSH). ATELs include explicit, additional components for cardiac sensitization and anesthetic effects, but they do not address flammability. The lowest of the ATEL, 50,000 ppm by volume, or 10% of the lower flammability limit, therefore, provides a conservative approximation to IDLH concentrations when needed for refrigerants without adopted IDLH values.

approximate lethal concentration (ALC): the concentration of a substance, a refrigerant in this standard, that was lethal to even a single test animal when tested by the same conditions as for an LC_{50} test.

anesthetic effect: loss of the ability to perceive pain and other sensory stimulation.

azeotropic: an azeotropic blend is one containing two or more refrigerants whose equilibrium vapor and liquid phase compositions are the same at a given pressure. At this pressure, the slope of the temperature vs. composition curve equals zero, which mathematically is expressed as $(dt/dx)_p = 0$, which, in turn, implies the occurrence of a maximum, minimum, or saddle point temperature. Azeotropic blends exhibit some segregation of components at other conditions. The extent of the segregation depends on the particular azeotrope and the application.

azeotropic temperature: the temperature at which the liquid and vapor phases of a blend have the same mole fraction of each component at equilibrium for a specified pressure.

blends: refrigerants consisting of mixtures of two or more different chemical compounds, often used individually as refrigerants for other applications.

cardiac sensitization: an acute effect in which the heart is rendered more sensitive to the body's own catecholamine compounds or administered drugs, such as epinephrine, possibly resulting in irregular heart beat (cardiac arrhythmia), which could be fatal.

ceiling: an exposure level, permissible exposure level-ceiling (PEL-C), or threshold limit value-ceiling (TLV-C), that should not be exceeded during any part of the day.

central nervous system (CNS) effect: treatment-related depression, distraction, stimulation, or other behavioral modification suggesting temporary or permanent changes to control by the brain.

chronic toxicity: adverse health effect(s) from long-term, repeated exposures. This information is used, in part, to establish a TLV-TWA, PEL, or consistent indices.

committee: as used in the standard, refers to ASHRAE Standing Standards Project Committee (SSPC) 34.

compounds: substances formed by the chemical combination of two or more elements in definite proportions by mass.

critical point: the location on a plot of thermodynamic properties at which the liquid and vapor states of a substance meet and become indistinguishable. The temperature, density, and composition of the substance are the same for the liquid and vapor phases at this point. The density, pressure, specific volume, and temperature at the critical point are referred to as the *critical density*, *critical pressure*, *critical volume*, and *critical temperature*, respectively.

cyclic compound: an organic compound that contains three or more atoms arranged in a ring structure.

EC_{50} (effective concentration 50%): the concentration of a material, a refrigerant in this standard, that has caused a biological effect to 50% of test animals.

elevated temperature flame limit (ETFL): the minimum concentration of refrigerant that is capable of propagating a flame through a homogeneous mixture of the refrigerant and air using test equipment and procedures specified in Section B1.1 (in Normative Appendix B) at 101.3 kPa (14.7 psia) and either 60.0°C (140°F) or 100°C (212°F). It is normally expressed as a refrigerant percentage by volume. When tested at 60.0°C, it is called the $ETFL_{60}$. When tested at 100°C, it is called the $ETFL_{100}$.

flame propagation: any combustion that moves upward and outward from the point of ignition as defined in Section B1.8 in Normative Appendix B.

flammable concentration limit (FCL): the refrigerant concentration limit, in air, determined in accordance with this standard and intended to reduce the risk of fire or explosion in normally occupied, enclosed spaces.

fractionation: a change in composition of a 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 by a refrigerant within a component of a refrigerating system, exclusive of any subcooling or superheating. This term usually describes condensation or evaporation of a zeotrope.

halocarbon: as used in this standard, a hydrocarbon derivative containing one or more of the halogens bromine, chlorine, or fluorine; hydrogen also may be present.

heat of combustion (HOC): the heat released when a substance is combusted, determined as the difference in the enthalpy between the reactants (refrigerant[s] and air) and their products after combustion as defined in Section 6.1.3.5. The heat or enthalpy of combustion is often expressed as energy per mass (e.g., kJ/kg or Btu/lb).

highly toxic: A material that produces a lethal dose or lethal concentration that falls within any of the following categories:[12,13,14]

1. A chemical that has a median lethal dose (LD_{50}) of 50 milligrams or less per kilogram of body weight when administered orally to albino rats weighing between 200 and 300 grams each.
2. A chemical that has a median lethal dose (LD_{50}) of 200 milligrams or less per kilogram of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between 2 and 3 kilograms each.
3. A chemical that has a median lethal concentration (LC_{50}) in air of 200 parts per million by volume or less of gas or vapor, or 2 milligrams per liter or less of mist, fume, or dust, when administered by continuous inhalation for one hour (or less if death occurs within one hour) to albino rats weighing between 200 and 300 grams each.

hydrocarbon: a compound containing only the elements hydrogen and carbon.

isomer: one of a group of compounds having the same chemical composition with differing molecular structures. Examples include R-123 and R-123a, both of which contain one hydrogen atom and two carbon, three flourine, and two chlorine atoms; both chlorine atoms are bonded to the same carbon atom in R-123 ($CHCl_2CF_3$), but one is bonded to each in

R-123a ($CHClFCClF_2$). The methane series of refrigerants cannot form isomers because the single-carbon nucleus does not enable structural variations.

LC_{50}: a measure of acute inhalation toxicity representing a lethal concentration for 50% of exposed test animals for a specified time interval and species of animal.

lower flammability limit (LFL): the minimum concentration of a substance, a refrigerant in this standard, that is capable of propagating a flame through a homogeneous mixture of the substance and air under specified test conditions.

lowest observed effect level (LOEL): the concentration of a material, a refrigerant in this standard, that has caused any observed effect to even one test animal.

maximum temperature glide: the difference between the saturated liquid temperature (bubble point) and the saturated vapor temperature (dew point) for the "as formulated" blend composition at constant pressure. For a given pressure, the evaporator temperature glide in a direct expansion system will typically be 70% to 80% of the maximum temperature glide, as the refrigerant blend entering the evaporator is a mixture of liquid and vapor, and not at the saturated liquid temperature of the "as formulated" blend composition.

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

nominal formulation: the bulk manufactured composition of the refrigerant, which includes the gas and liquid phases. For the purpose of this standard, when a container is 80% or more liquid filled, the liquid composition may be considered the nominal composition.

no-observed-effect level (NOEL): the highest concentration of a material, a refrigerant in this standard, at which no effect has been observed in even one test animal.

nonazeotropic: a synonym for *zeotropic*, the latter being the preferred descriptor. Both *non* and *a* are negation prefixes, the latter from Latin, and therefore cancel one another (i.e., not-not-zeotropic, hence zeotropic). The double negative results from antecedent interest in, and the need to make a distinction with, azeotropic mixtures.

oxygen deprivation limit (ODL): the concentration of a refrigerant or other gas that results in insufficient oxygen for normal breathing.

ppm: parts per million.

permissible exposure level (PEL): the time-weighted average concentration (set by the US Occupational Safety and Health Administration [OSHA]) for a normal 8-hour work day and a 40-hour work week to which nearly all workers can be repeatedly exposed without adverse effect. Chemical manufacturers publish similar recommendations (e.g., acceptable exposure level, AEL; industrial exposure limit, IEL; or occupational exposure limit, OEL, depending on the company), generally for substances for which PEL has not been established.

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. Substances added to provide other functions, such as lubrication, leak detection, absorption, or drying, are not refrigerants.

refrigerant concentration limit (RCL): the refrigerant concentration limit, in air, determined in accordance with this standard and intended to reduce the risks of acute toxicity, asphyxiation, and flammability hazards in normally occupied, enclosed spaces.

relative molecular mass: the ratio of the mass of a molecule to 1/12 of that of carbon-12. The relative molecular mass is numerically equivalent to the molecular weight expressed in g/mol, but it is dimensionless.

saturated: an organic (carbon-containing) compound in which each carbon atom is joined to four other atoms; all of the chemical bonds in a saturated compound are single.

short-term exposure limit (STEL): typically a 15-minute time-weighted average (TWA) exposure that should not be exceeded at any time during a work day.

temperature glide: see *glide*.

threshold limit values (TLVs): refer to airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects. Because of the wide variation in individual susceptibility, however, a small percentage of workers may experience discomfort from some substances at concentrations at or below the threshold limit; a smaller percentage may be affected more seriously by aggravation of a pre-existing condition or by development of an occupational illness. Smoking of tobacco is harmful for several reasons. Smoking may act to enhance the biological effects of chemicals encountered in the workplace and may reduce the body's defense mechanisms against toxic substances.

Individuals may also be hypersusceptible or otherwise unusually responsive to some industrial chemicals because of genetic factors, age, personal habits (smoking, use of alcohol or other drugs), medication, or previous exposure. Such workers may not be adequately protected from adverse health effects from certain chemicals at concentrations at or below the threshold limits. An occupational physician should evaluate the extent to which such workers require additional protection.

TLVs are based on the best available information from industrial experience, from experimental human and animal studies, and, when possible, from a combination of the three. The basis on which the values are established may differ from substance to substance; protection against impairment of health may be a guiding factor for some, whereas reasonable freedom from irritation, narcosis, nuisance, or other forms of stress may form the basis for others.[1] (This definition reprinted by permission of ACGIH.)

threshold limit value–time-weighted average (TLV-TWA): the time-weighted average concentration for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.[1] (This definition reprinted by permission of ACGIH.)