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.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE Web site, http://www.ashrae.org, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada).

ISSN 1041-2336

Approved American National Standard
ANSI
www.ansi.org

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
1791 Tullie Circle NE, Atlanta, GA 30329
www.ashrae.org

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). *Consensus* is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as "substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution." Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

ASHRAE obtains consensus through participation of its national and international members, associated societies, and public review.

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Assistant Director of Technology for Standards and Special Projects of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard, or
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE's Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

CONTENTS

ANSI/ASHRAE Standard 15-2007
Safety Standard for Refrigeration Systems

NOTE

When addenda, interpretations, or errata to this standard have been approved, they can be downloaded free of charge from the ASHRAE Web site at http://www.ashrae.org.

1791 Tullie Circle NE
Atlanta, GA 30329
www.ashrae.org

(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

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 to escape within 30 minutes without escape-impairing symptoms or irreversible health effects.[1]

informative appendix: an appendix that is not part of the standard but is included for information only.

inside dimension: inside diameter, width, height, or cross-sectional diagonal.

internal gross volume: the volume as determined from internal dimensions of the container with no allowance for the volume of internal parts.

limited charge system: a system in which, with the compressor idle, the design pressure will not be exceeded when the refrigerant charge has completely evaporated.

liquid receiver: a vessel, permanently connected to a refrigerating system by inlet and outlet pipes, for storage of liquid refrigerant.

listed: equipment or materials included in a list published by an approved, nationally recognized testing laboratory, inspection agency, or other organization concerned with product evaluation that maintains periodic inspection of production of listed equipment or materials and whose listing states either that the equipment or material meets nationally recognized standards or has been tested and found suitable for use in a specified manner.

lithium bromide/water absorption system: an absorption system where water (R-718) is the refrigerant and lithium bromide (LiBr) is the absorbent.

lobby: a waiting room or large hallway serving as a waiting room.

lower flammability limit (LFL): the minimum concentration of the refrigerant that propagates a flame through a homogeneous mixture of refrigerant and air.

lowside: the portion of a refrigerating system that is subjected to approximate evaporator pressure.

machinery: the refrigerating equipment forming a part of the refrigerating system including, but not limited to, any or all of the following: compressor, condenser, liquid receiver, evaporator, and connecting piping.

machinery room: a space, meeting the requirements of Sections 8.11 and 8.12, that is designed to house compressors and pressure vessels.

manufacturer: the company or organization that evidences its responsibility by affixing its name, trademark, or trade name to refrigerating equipment.

means of egress: a continuous and unobstructed path of travel from any point in a building or structure to a public way.

mechanical joint: a gas-tight joint obtained by joining metal parts with a positive-holding mechanical construction such as flanged, screwed, or flared joints or compression fittings.

nonpositive displacement compressor: a compressor in which the increase in vapor pressure is attained without changing the internal volume of the compression chamber.

normative appendix: integral parts of the mandatory requirements of the standard, which, for reasons of convenience, are placed after all other normative elements.

occupancy: for class of occupancy, see Section 4.

occupied space: that portion of the premises accessible to or occupied by people, excluding machinery rooms.

pilot operated relief valve: a pressure-relief valve in which the major relieving device is combined with and is controlled by a self-actuated auxiliary pressure-relief valve.

piping: the pipe or tube used to convey fluid from one part of a refrigeration system to another. Piping includes pipe, flanges, bolting, gaskets, valves, fittings, pipe-supporting fixtures, structural attachments, and the pressure-containing parts of other components, such as expansion joints, strainers, filters, and devices that serve such purposes as mixing, separating, muffling, snubbing, distributing, metering, or controlling flow.

positive displacement compressor: a compressor in which the increase in pressure is attained by changing the internal volume of the compression chamber.

premises: a tract of land and the buildings thereon.

pressure-imposing element: any device or portion of the equipment used to increase refrigerant pressure.

pressure-limiting device: a pressure-responsive electronic or mechanical control designed to automatically stop the operation of the pressure-imposing element at a predetermined pressure.

pressure-relief device: a pressure-, not temperature-, actuated valve or rupture member designed to automatically relieve pressure in excess of its setting.

pressure-relief valve: a pressure-actuated valve held closed by a spring or other means and designed to automatically relieve pressure in excess of its setting.

pressure vessel: any refrigerant-containing receptacle in a refrigerating system. This does not include evaporators where each separate evaporator section does not exceed 0.5 ft^3 (0.014 m^3) of refrigerant-containing volume regardless of the maximum inside dimension. This also does not include evaporator coils, compressors, condenser coils, controls, headers, pumps, and piping.

pumpdown charge: the quantity of refrigerant stored at some point in the refrigeration system for operational, service, or standby purposes.

reclaimed refrigerants: refrigerants reprocessed to the same specifications as new refrigerants by any means, including distillation. Such refrigerants have been chemically analyzed to verify that those specifications have been met.

recovered refrigerants: refrigerants removed from a system in any condition without necessarily testing or processing them.

recycled refrigerants: refrigerants for which contaminants have been reduced by oil separation, removal of noncondensible gases, and single or multiple passes through filter driers or other devices that reduce moisture, acidity, and particulate matter.

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 change of state.

refrigerant detector: a device that is capable of sensing the presence of refrigerant vapor.

refrigerating system: a combination of interconnected parts forming a closed circuit in which refrigerant is circulated for the purpose of extracting, then rejecting, heat. (See Section 5 for classification of refrigerating systems by type.)

refrigerating system classification: refrigerating systems are classified according to the degree of probability, low or high, that leaked refrigerant from a failed connection, seal, or component could enter an occupied area. The distinction is based on the basic design or location of the components.

refrigerating system, direct: (see Section 5.1.1).

refrigerating system, indirect: (see Section 5.1.2).

rupture member: a device that will rupture and release refrigerant to relieve pressure.

saturation pressure: the pressure at which vapor and liquid exist in equilibrium at a given temperature.

sealed ammonia/water absorption system: an absorption system where ammonia (R-717) is the refrigerant and water is the absorbent and all refrigerant-containing parts are made permanently tight by welding or brazing.

secondary coolant: any liquid used for the transmission of heat, without vaporization.

self-contained system: a complete, factory-assembled and factory-tested system that is shipped in one or more sections and has no refrigerant-containing parts that are joined in the field by other than companion or block valves.

set pressure: the pressure at which a pressure-relief device or pressure control is set to operate.

shall (shall not): used when a provision is or is not mandatory.

soldered joint: a gas-tight joint formed by joining metal parts with alloys that melt at temperatures not exceeding 800°F (426.5°C) and above 400°F (204.5°C).

specified: explicitly stated in detail. Specified limits or prescriptions are mandatory.

stop valve: a device used to shut off the flow of refrigerant.

tenant: a person or organization having the legal right to occupy a premises.

three-way valve: a service valve for dual pressure-relief devices that allows using one device while isolating the other from the system, maintaining one valve in operation at all times.

TLV-TWA* (threshold limit value-time weighted average): the refrigerant concentration in air for a normal 8-hour workday and a 40-hour workweek to which repeated exposure, day after day, will not cause an adverse effect in most persons.

ultimate strength: the stress at which rupture occurs.

unit system: see *self-contained system*.

unprotected tubing: tubing that is unenclosed and therefore exposed to crushing, abrasion, puncture, or similar damage after installation.

zeotropic: refers to blends comprising multiple components of different volatility that, when used in refrigeration cycles, change volumetric composition and saturation temperatures as they evaporate (boil) or condense at constant pressure. The word is derived from the Greek words *zein* (to boil) and *tropos* (to change).

4. OCCUPANCY CLASSIFICATION

4.1 Locations of refrigerating systems are described by occupancy classifications that consider the ability of people to respond to potential exposure to refrigerant as follows.

4.1.1 *Institutional occupancy* is a premise or that portion of a premise from which, because they are disabled, debilitated, or confined, occupants cannot readily leave without the assistance of others. Institutional occupancies include, among others, hospitals, nursing homes, asylums, and spaces containing locked cells.

4.1.2 *Public assembly occupancy* is a premise or that portion of a premise where large numbers of people congregate and from which occupants cannot quickly vacate the space. Public assembly occupancies include, among others, auditoriums, ballrooms, classrooms, passenger depots, restaurants, and theaters.

4.1.3 *Residential occupancy* is a premise or that portion of a premise that provides the occupants with complete independent living facilities including permanent provisions for living, sleeping, eating, cooking, and sanitation. Residential occupancies include, among others, dormitories, hotels, multi-unit apartments, and private residences.

4.1.4 *Commercial occupancy* is a premise or that portion of a premise where people transact business, receive personal service, or purchase food and other goods. Commercial occupancies include, among others, office and professional buildings, markets (but not large mercantile occupancies), and work or storage areas that do not qualify as industrial occupancies.

4.1.5 *Large mercantile occupancy* is a premise or that portion of a premise where more than 100 persons congregate on levels above or below street level to purchase personal merchandise.

4.1.6 *Industrial occupancy* is a premise or that portion of a premise that is not open to the public, where access by

* TLV® is a registered trademark of the American Conference of Governmental Industrial Hygienists (ACGIH®).

authorized persons is controlled, and that is used to manufacture, process, or store goods such as chemicals, food, ice, meat, or petroleum.

4.1.7 *Mixed occupancy* occurs when two or more occupancies are located within the same building. When each occupancy is isolated from the rest of the building by tight walls, floors, and ceilings and by self-closing doors, the requirements for each occupancy shall apply to its portion of the building. When the various occupancies are not so isolated, the occupancy having the most stringent requirements shall be the governing occupancy.

4.2 Equipment, other than piping, located outside a building and within 20 ft (6.1 m) of any building opening shall be governed by the occupancy classification of the building.

Exception: Equipment located within 20 ft (6.1 m) of the building opening for the machinery room.

5. REFRIGERATING SYSTEM CLASSIFICATION

5.1 Refrigerating Systems. These systems are defined by the method employed for extracting or delivering heat as follows (see Figure 1).

5.1.1 A *direct system* is one in which the evaporator or condenser of the refrigerating system is in direct contact with the air or other substances to be cooled or heated.

5.1.2 An *indirect system* is one in which a secondary coolant cooled or heated by the refrigerating system is circulated to the air or other substance to be cooled or heated. Indirect systems are distinguished by the method of application given below.

5.1.2.1 An *indirect open spray system* is one in which a secondary coolant is in direct contact with the air or other substance to be cooled or heated.

5.1.2.2 A *double indirect open spray system* is one in which the secondary substance for an indirect open spray system (Section 5.1.2.1) is heated or cooled by the secondary coolant circulated from a second enclosure.

5.1.2.3 An *indirect closed system* is one in which a secondary coolant passes through a closed circuit in the air or other substance to be cooled or heated.

5.1.2.4 An *indirect, vented closed system* is one in which a secondary coolant passes through a closed circuit in the air or other substance to be cooled or heated, except that the evaporator or condenser is placed in an open or appropriately vented tank.

5.2 Refrigeration System Classification. For the purpose of applying Tables 1 and 2, a refrigerating system shall be classified according to the degree of probability that a leakage of refrigerant will enter an occupancy-classified area as follows.

5.2.1 High-Probability System. A high-probability system is any system in which the basic design, or the location of components, is such that a leakage of refrigerant from a failed connection, seal, or component will enter the occupied space. Typical high-probability systems are (a) direct systems or (b) indirect open spray systems in which the refrigerant is capable of producing pressure greater than the secondary coolant.

Paragraph	Designation	Cooling or Heating Source	Air or Substance to be Cooled or Heated
5.1.1	Direct system		
5.1.2.1	Indirect open spray system		
5.1.2.2	Double indirect open spray system		
5.1.2.3	Indirect closed system		
5.1.2.4	Indirect vented closed system		

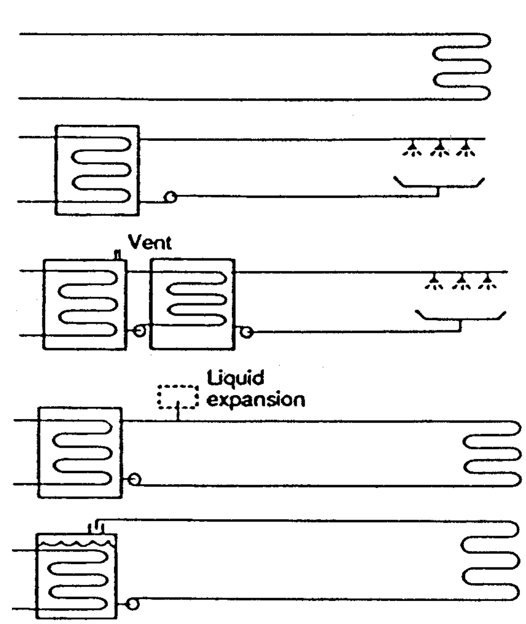

Figure 1 Refrigerating system designation.

TABLE 1 Refrigerant[a] and Amounts[b,c]

Refrigerant Number	Chemical Name	Chemical Formula	Quantity of Refrigerant per Occupied Space		
			Lb per 1000 ft^3 [a,d]	ppm by vol	g/m^3 [a,d]
Group A1					
R-11	Trichlorofluoromethane	CCl_3F	1.6	4,000	25
R-12	Dichlorodifluoromethane	CCl_2F_2	12	40,000	200
R-13	Chlorotrifluoromethane	$CClF_3$	18	67,000	290
R-13B1	Bromotrifluoromethane	$CBrF_3$	22	57,000	350
R-14	Tetrafluoromethane (Carbon tetrafluoride)	CF_4	15	67,000	240
R-22	Chlorodifluoromethane	$CHClF_2$	9.4	42,000	150
R-113	Trichlorotrifluoroethane	CCl_2FCClF_2	1.9	4,000	31
R-114	Dichlorotetrafluoroethane	$CClF_2CClF_2$	9.4	21,000	150
R-115	Chloropentafluoroethane	$CClF_2CF_3$	27	67,000	430
R-134a	1,1,1,2-Tetrafluoroethane	CH_2FCF_3	16	60,000	250
R-C318	Octafluorocyclobutane	C_4F_8	35	67,000	550
R-400	R-12 and R-114	$CCl_2F_2/C_2Cl_2F_4$	[e]	[e]	[e]
R-500	R-12/152a (73.8/26.2)	CCl_2F_2/CH_3CHF_2	12	47,000	200
R-502	R-22/115 (48.8/51.2)	$CHClF_2/CClF_2CF_3$	19	65,000	300
R-503	R-23/13 (40.1/59.9)	$CHF_3/CClF_3$	15	67,000	240
R-718	Water	H_2O	[f]	[f]	[f]
R-744	Carbon Dioxide	CO_2	5.7	50,000	91
Group A2					
R-142b	1-Chloro-1,1,-Difluoroethane	CH_3CClF_2	3.7	14,000	60
R-152a	1,1-Difluoroethane	CH_3CHF_2	1.2	7,000	20
Group A3					
R-170	Ethane	C_2H_6	0.50	6,400	8.0
R-290	Propane	C_3H_8	0.50	4,400	8.0
R-600	Butane	C_4H_{10}	0.51	3,400	8.2
R-600a	2-Methyl propane (Isobutane)	$CH(CH_3)_3$	0.51	3,400	8.2
R-1150	Ethene (Ethylene)	C_2H_4	0.38	5,200	6.0
R-1270	Propene (Propylene)	C_3H_6	0.37	3,400	5.9
Group B1					
R-123	2,2-Dichloro-1,1,1-Trifluoroethane	$CHCl_2CF_3$	0.40	1,000	6.3
R-764	Sulfur Dioxide	SO_2	0.016	100	0.26
Group B2					
R-40	Chloromethane (Methyl Chloride)	CH_3Cl	1.3	10,000	21
R-611	Methyl Formate	$HCOOCH_3$	0.78	5,000	12
R-717	Ammonia	NH_3	0.022	500	0.35

[a]The refrigerant safety groups in Table 1 are not part of ASHRAE Standard 15. The classifications shown are from ASHRAE Standard 34, which governs in the event of a difference.

[b]To be used only in conjunction with Section 7.

[c]The basis of the table quantities is a single event where a complete discharge of any refrigerant system into the occupied space occurs. The quantity of refrigerant is the most restrictive of a minimum oxygen concentration of 19.5% or as follows:

Group A1—	80% of the cardiac sensitization level for R-11, R-12, R-13B1, R-22, R-113, R-114, R-134a, R-500, and R-502. 100% of the IDLH (21) for R-744. Others are limited by levels where oxygen deprivation begins to occur.
Groups A2, A3—	Approximately 20% of LFL.
Group B1—	100% of IDLH for R-764, and 100% of the measure consistent with the IDLH for R-123.
Groups B2, B3—	100% of IDLH or 20% of LFL, whichever is lower.

[d]To correct for height, H (ft), above sea level, multiply these values by $(1 - 2.42 \times 10^{-5} \cdot H)$. To correct for height, h (m), above sea level, multiply these values by $(1 - 7.94 \times 10^{-5} \cdot h)$.

[e]The quantity of each component shall comply with the limits set in Table 1 for the pure compound, and the total volume % of all components shall be calculated per Appendix A (not to exceed 67,000 ppm by volume for any refrigerant blend).

[f]The quantity is unlimited when R-718 (water) is used as the refrigerant.

TABLE 2 Special Quantity Limits for Sealed Ammonia/Water Absorption and Self-Contained Systems

Type of Refrigeration System	Maximum lb (kg) for Various Occupancies			
	Institutional	Public/Large Mercantile	Residential	Commercial
Sealed Ammonia/Water Absorption System				
In public hallways or lobbies	0 (0)	0 (0)	3.3 (1.5)	3.3 (1.5)
In adjacent outdoor locations	0 (0)	0 (0)	22 (10)	22 (10)
In other than public hallways or lobbies	0 (0)	6.6 (3)	6.6 (3)	22 (10)
Unit Systems				
In other than public hallways or lobbies	0 (0)	0 (0)	6.6 (3)	22 (10)

5.2.2 Low-Probability System. A low-probability system is any system in which the basic design, or location of the components, is such that leakage of refrigerant from a failed connection, seal, or component cannot enter the occupied space. Typical low-probability systems are (a) indirect closed systems or (b) double indirect systems and (c) indirect open spray systems if the following condition is met:

In a low-probability indirect open spray system, the secondary coolant pressure shall remain greater than refrigerant pressure in all conditions of operation and standby. Operation conditions are defined in Section 9.2.1 and standby conditions are defined in Section 9.2.2.

5.3 Changing Refrigerant. A change in the type of refrigerant in a system shall not be made without the notification of the authority having jurisdiction, the user, and due observance of safety requirements. The refrigerant being considered shall be evaluated for suitability.

6. REFRIGERANT SAFETY CLASSIFICATION

6.1 Single-Compound Refrigerants. Single-compound refrigerants shall be classified into safety groups, based on toxicity and flammability, in accordance with *ANSI/ASHRAE Standard 34, Designation and Safety Classification of Refrigerants*.[1] The classifications indicated in Standard 34 shall be used for refrigerants that have them assigned. Other refrigerants shall be classified in accordance with the criteria in Standard 34; such classifications shall be submitted for approval to the authority having jurisdiction.

6.2 Blends. Refrigerant blends shall be classified following the worst-case of fractionation composition, determined in accordance with Standard 34.[1] For blends assigned only a single safety group in Standard 34, that classification shall be used.

7. RESTRICTIONS ON REFRIGERANT USE

7.1 General. The occupancy, refrigerating system, and refrigerant safety classifications cited in this section shall be determined in accordance with Sections 4, 5, and 6, respectively.

7.2 Refrigerant Quantity Limits. The quantity of refrigerant in each independent circuit of high probability systems shall not exceed the amounts shown in Table 1, except as provided in Sections 7.2.1 and 7.2.2, based on volumes determined in accordance with Section 7.3. For refrigerant blends not listed in Table 1, the amount of each component shall be limited in the same manner and the total of all components in each circuit shall not exceed the quantity that would equal 69,100 ppm by volume upon release to the volume determined by Section 7.3.

Exceptions:

a. Listed equipment containing not more than 6.6 lb (3 kg) of refrigerant, regardless of its refrigerant safety classification, is exempt from Section 7.2 provided the equipment is installed in accordance with the listing and with the manufacturer's installation instructions.
b. Listed equipment for use in laboratories with more than 100 ft^2 (9.3 m^2) of space per person, regardless of the refrigerant safety classification, is exempt from Section 7.2 provided that the equipment is installed in accordance with the listing and the manufacturer's installation instructions.

7.2.1 Institutional Occupancies. The amounts shown in Table 1 shall be reduced by 50% for all areas of institutional occupancies. Also, the total of all Group A2, B2, A3, and B3 refrigerants shall not exceed 550 lb (250 kg) in the occupied areas and machinery rooms of institutional occupancies.

7.2.2 Industrial Occupancies and Refrigerated Rooms. Section 7.3 does not apply in industrial occupancies and refrigerated rooms where the following seven conditions are met:

1. The space(s) containing the machinery is separated from other occupancies by tight construction with tight-fitting doors.
2. Access is restricted to authorized personnel.
3. The floor area per occupant is not less than 100 ft^2 (9.3 m^2).

Exception: The minimum floor area shall not apply where the space is provided with egress directly to the outdoors or into approved building exits.

4. Refrigerant detectors are installed with the sensing location and alarm level as required in refrigerating machinery rooms in accordance with Section 8.11.2.1.
5. Open flames and surfaces exceeding 800°F (426.7°C) are not permitted where any Group A2, B2, A3, or B3 refrigerant other than R-717, ammonia, is used.

6. All electrical equipment conforms to Class 1, Division 2, of NFPA 70 where the quantity of any Group A2, B2, A3, or B3 refrigerant other than R-717, ammonia, in an independent circuit would exceed 25% of the lower flammability limit (LFL) upon release to the space based on the volume determined by Section 7.3.
7. All refrigerant-containing parts in systems exceeding 100 HP (74.6 kW) compressor drive power, except evaporators used for refrigeration or dehumidification, condensers used for heating, control and pressure-relief valves for either, and connecting piping, are located either in a machinery room or outdoors.

7.3 Volume Calculations. The volume used to determine the refrigerant quantity limits for refrigerants in Section 7.2 shall be based on the volume of space to which refrigerant disperses in the event of a refrigerant leak.

7.3.1 Nonconnecting Spaces. Where a refrigerating system or a part thereof is located in one or more enclosed occupied spaces that do not connect through permanent openings or HVAC ducts, the volume of the smallest occupied space shall be used to determine the refrigerant quantity limit in the system. Where different stories and floor levels connect through an open atrium or mezzanine arrangement, the volume to be used in calculating the refrigerant quantity limit shall be determined by multiplying the floor area of the lowest space by 8.2 ft (2.5 m).

7.3.2 Ventilated Spaces. Where a refrigerating system or a part thereof is located within an air handler, an air distribution duct system, or in an occupied space served by a mechanical ventilation system, the entire air distribution system shall be analyzed to determine the worst case distribution of leaked refrigerant. The worst case or the smallest volume in which the leaked refrigerant disperses shall be used to determine the refrigerant quantity limit in the system, subject to the following criteria.

7.3.2.1 Closures. Closures in the air distribution system shall be considered. If one or more spaces of several arranged in parallel can be closed off from the source of the refrigerant leak, their volume(s) shall not be used in the calculation.

Exceptions: The following closure devices are not considered:

a. smoke dampers, fire dampers, and combination smoke/fire dampers that close only in an emergency not associated with a refrigerant leak, and
b. dampers, such as VAV boxes, that provide limited closure where air flow is not reduced below 10% of its maximum (with the fan running).

7.3.2.2 Plenums. The space above a suspended ceiling shall not be included in calculating the refrigerant quantity limit in the system unless such space is part of the air supply or return system.

7.3.2.3 Supply and Return Ducts. The volume of the supply and return ducts and plenums shall be included when calculating the refrigerant quantity limit in the system.

7.4 Location in a Machinery Room or Outdoors. All components containing refrigerant shall be located either in a machinery room or outdoors, where

a. the quantity of refrigerant needed exceeds the limits in Section 7.2 or
b. direct-fired absorption equipment, other than sealed absorption systems not exceeding the refrigerant quantity limits indicated in Table 2, is used.

7.4.1 Nonflammable Refrigerants. Machinery rooms required by Section 7.4 shall be constructed and maintained in accordance with Section 8.11 for Group A1 and B1 refrigerants.

7.4.2 Flammable Refrigerants. Machinery rooms required by Section 7.4 shall be constructed and maintained in accordance with Sections 8.11 and 8.12 for Group A2, B2, A3, and B3 refrigerants.

7.5 Additional Restrictions

7.5.1 All Occupancies. Sections 7.5.1.1 through 7.5.1.8 apply to all occupancies.

7.5.1.1 Flammable Refrigerants. The total of all Group A2, B2, A3, and B3 refrigerants other than R-717, ammonia, shall not exceed 1100 lb (500 kg) without approval by the authority having jurisdiction.

7.5.1.2 Corridors and Lobbies. Refrigerating systems installed in a public corridor or lobby shall be limited to either

a. unit systems containing not more than the quantities of Group A1 or B1 refrigerant indicated in Table 1 or
b. sealed absorption and unit systems having refrigerant quantities less than or equal to those indicated in Table 2.

7.5.1.3 Refrigerant Type and Purity. Refrigerants shall be of a type specified by the equipment manufacturer unless converted in accordance with Section 7.5.1.8. Refrigerants used in new equipment shall conform to ARI 700[2] in purity unless otherwise specified by the equipment manufacturer.

7.5.1.4 Recovered Refrigerants. Recovered refrigerants shall not be reused except in the system from which they were removed or as provided in Sections 7.5.1.5 or 7.5.1.6. When contamination is evident by discoloration, odor, acid test results, or system history, recovered refrigerants shall be reclaimed in accordance with Section 7.5.1.6 before reuse.

7.5.1.5 Recycled Refrigerants. Recycled refrigerants shall not be reused except in systems using the same refrigerant and lubricant designation and belonging to the same owner as the systems from which they were removed. When contamination is evident by discoloration, odor, acid test results, or system history, recycled refrigerants shall be reclaimed in accordance with Section 7.5.1.6.

Exception: Drying is not required in order to use recycled refrigerants where water is the refrigerant, or is used as an absorbent, or is a deliberate additive.

7.5.1.6 Reclaimed Refrigerants. Used refrigerants shall not be reused in a different owner's equipment unless tested and found to meet the requirements of ARI 700.[2] Contaminated refrigerants shall not be used unless reclaimed and found to meet the requirements of ARI 700.[2]

7.5.1.7 Mixing. Refrigerants, including refrigerant blends, with different designations in Standard 34[1] shall not be mixed in a system.

Exception: Addition of a second refrigerant is allowed where specified by the equipment manufacturer to improve oil return at low temperatures. The refrigerant and amount added shall follow the manufacturer's instructions.

7.5.1.8 Refrigerant or Lubricant Conversion. The type of refrigerant or lubricant in a system shall not be changed without evaluation for suitability, notification to the authority having jurisdiction and the user, due observance of safety requirements, and replacement or addition of signs and identification as required in Section 11.2.3.

7.5.2 Applications for Human Comfort. Group A2, A3, B1, B2, and B3 refrigerants shall not be used in high-probability systems for human comfort.

Exceptions:

a. This restriction does not apply to sealed absorption and unit systems having refrigerant quantities less than or equal to those indicated in Table 2.

b. This restriction does not apply to industrial occupancies.

7.5.3 Higher Flammability Refrigerants. Group A3 and B3 refrigerants shall not be used except where approved by the authority having jurisdiction.

Exceptions:

a. This restriction does not apply to laboratories with more than 100 ft^2 (9.3 m^2) of space per person.

b. This restriction does not apply to industrial occupancies.

8. INSTALLATION RESTRICTIONS

8.1 Foundations. Foundations and supports for condensing units or compressor units shall be of noncombustible construction and capable of supporting loads imposed by such units. Isolation materials such as rubber are permissible between the foundation and condensing or compressor units.

8.2 Guards. Moving machinery shall be guarded in accordance with approved safety standards.[3]

8.3 Safe Access. A clear and unobstructed approach and space shall be provided for inspection, service, and emergency shutdown of condensing units, compressor units, condensers, stop valves, and other serviceable components of refrigerating machinery. Permanent ladders, platforms, or portable access equipment shall be provided in accordance with the requirements of the authority having jurisdiction.

8.4 Water Connections. Water supply and discharge connections shall be made in accordance with the requirements of the authority having jurisdiction.

8.5 Electrical Safety. Electrical equipment and wiring shall be installed in accordance with the National Electrical Code[4] and the requirements of the authority having jurisdiction.

8.6 Gas Fuel Equipment. Gas fuel devices and equipment used with refrigerating systems shall be installed in accordance with approved safety standards and the requirements of the authority having jurisdiction.

8.7 Air Duct Installation. Air duct systems of air-conditioning equipment for human comfort using mechanical refrigeration shall be installed in accordance with approved safety standards, the requirements of the authority having jurisdiction, and the requirements of Section 8.11.7.

8.8 Refrigerant Parts in Air Duct. Joints and all refrigerant-containing parts of a refrigerating system located in an air duct carrying conditioned air to and from an occupied space shall be constructed to withstand a temperature of 700°F (371.1°C) without leakage into the airstream.

8.9 Refrigerant Pipe Joint Inspection. Refrigerant pipe joints erected on the premises shall be exposed to view for visual inspection prior to being covered or enclosed.

8.10 Location of Refrigerant Piping

8.10.1 Refrigerant piping crossing an open space that affords passageway in any building shall not be less than 7.25 ft (2.2 m) above the floor unless the piping is located against the ceiling of such space and is permitted by the authority having jurisdiction.

8.10.2 Passages shall not be obstructed by refrigerant piping. Refrigerant piping shall not be placed in any elevator, dumbwaiter, or other shaft containing a moving object or in any shaft that has openings to living quarters or to means of egress. Refrigerant piping shall not be installed in an enclosed public stairway, stair landing, or means of egress.

8.10.3 Refrigerant piping shall not penetrate floors, ceilings, or roofs.

Exceptions:

a. Penetrations connecting the basement and the first floor.

b. Penetrations connecting the top floor and a machinery penthouse or roof installation.

c. Penetrations connecting adjacent floors served by the refrigeration system.

d. Penetrations of a direct system where the refrigerant quantity does not exceed Table 1 quantity for the smallest occupied space through which the refrigerant piping passes.

e. In other than industrial occupancies and where the refrigerant quantity exceeds Table 1 quantity for the smallest occupied space, penetrations that connect separate pieces of equipment that are
   1. enclosed by an approved gas-tight, fire-resistive duct or shaft with openings to those floors served by the refrigerating system or
   2. located on the exterior wall of a building when vented to the outside or to the space served by the system and not used as an air shaft, closed court, or similar space.

8.10.4 Refrigerant piping installed in concrete floors shall be encased in pipe duct. Refrigerant piping shall be properly isolated and supported to prevent damaging vibration, stress, or corrosion.

8.11 Refrigerating Machinery Room, General Requirements. When a refrigerating system is located indoors and a machinery room is required by Section 7.4, the machinery room shall be in accordance with the following provisions.

8.11.1 Machinery rooms are not prohibited from housing other mechanical equipment unless specifically prohibited elsewhere in this standard. A machinery room shall be so dimensioned that parts are accessible with space for service, maintenance, and operations. There shall be clear head room of not less than 7.25 ft (2.2 m) below equipment situated over passageways.

8.11.2 Each refrigerating machinery room shall have a tight-fitting door or doors opening outward, self-closing if they open into the building, and adequate in number to ensure freedom for persons to escape in an emergency. With the exception of access doors and panels in air ducts and air-handling units conforming to Section 8.11.7, there shall be no openings that will permit passage of escaping refrigerant to other parts of the building.

8.11.2.1 Each refrigerating machinery room shall contain a detector, located in an area where refrigerant from a leak will concentrate, that actuates an alarm and mechanical ventilation in accordance with Section 8.11.4 at a value not greater than the corresponding TLV-TWA (or toxicity measure consistent therewith). The alarm shall annunciate visual and audible alarms inside the refrigerating machinery room and outside each entrance to the refrigerating machinery room. The alarms required in this section shall be of the manual reset type with the reset located inside the refrigerating machinery room.

Alarms set at other levels (such as IDLH) and automatic reset alarms are permitted in addition to those required by this section. The meaning of each alarm shall be clearly marked by signage near the annunciators.

Exceptions:

a. For ammonia, refer to 8.12 (h).
b. Detectors not required when only systems using R-718 (water) are located in the refrigerating machinery room.

8.11.3 Machinery rooms shall be vented to the outdoors, utilizing mechanical ventilation in accordance with Section 8.11.4 and 8.11.5.

8.11.4 Mechanical ventilation referred to in Section 8.11.3 shall be by one or more power-driven fans capable of exhausting air from the machinery room at least in the amount given in the formula in Section 8.11.5. To obtain a reduced airflow for normal ventilation, multiple fans or multispeed fans shall be used. Provision shall be made for inlet air to replace that being exhausted. Openings for inlet air shall be positioned to avoid recirculation. Air supply and exhaust ducts to the machinery room shall serve no other area. The discharge of the air shall be to the outdoors in such a manner as not to cause a nuisance or danger.

8.11.5 The mechanical ventilation required to exhaust an accumulation of refrigerant due to leaks or a rupture of the system shall be capable of removing air from the machinery room in not less than the following quantity:

$$Q = 100 \times G^{0.5} (Q = 70 \times G^{0.5})$$

where

Q = airflow, cfm (L/s)

G = mass of refrigerant in the largest system, any part of which is located in the machinery room, lb (kg)

A part of the refrigerating machinery room mechanical ventilation shall be

a. operated, when occupied, to supply at least 0.5 cfm/ft^2 (2.54 L/s/m^2) of machinery room area or 20 cfm (9.44 L/s) per person and
b. operable, when occupied at a volume required to not exceed the higher of a temperature rise of 18°F (10°C) above inlet air temperature or a maximum temperature of 122°F (50°C).

When a refrigerating system is located outdoors more than 20 ft (6.1 m) from building openings and is enclosed by a penthouse, lean-to, or other open structure, natural or mechanical ventilation shall be provided. The requirements for such natural ventilation are as follows:

c. The free-aperture cross section for the ventilation of a machinery room shall be at least

$$F = G^{0.5} (F = 0.138 G^{0.5}) \ ,$$

where

F = the free opening area, ft^2 (m^2) and

G = the mass of refrigerant in the largest system, any part of which is located in the machinery room, lb (kg).

d. Locations of the gravity ventilation openings shall be based on the relative density of the refrigerant to air.

8.11.6 No open flames that use combustion air from the machinery room shall be installed where any refrigerant is used. Combustion equipment shall not be installed in the same machinery room with refrigerant-containing equipment except under one of the following conditions:

a. combustion air is ducted from outside the machinery room and sealed in such a manner as to prevent any refrigerant leakage from entering the combustion chamber or
b. a refrigerant detector, conforming to Section 8.11.2.1, is employed to automatically shut down the combustion process in the event of refrigerant leakage.

Exceptions:

a. Machinery rooms where only carbon dioxide (R-744) or R-718 is the refrigerant.
b. Machinery rooms where only ammonia (R-717) is the refrigerant and internal combustion engines are used as the prime mover for the compressors.

8.11.7 There shall be no airflow to or from an occupied space through a machinery room unless the air is ducted and sealed in such a manner as to prevent any refrigerant leakage from entering the airstream. Access doors and panels in ductwork and air-handling units shall be gasketed and tight fitting.

8.11.8 Access. Access to the refrigerating machinery room shall be restricted to authorized personnel. Doors shall be clearly marked or permanent signs shall be posted at each entrance to indicate this restriction.

8.12 Machinery Room, Special Requirements. In cases specified in the rules of Section 7.4, a refrigerating machinery room shall meet the following special requirements in addition to those in Section 8.11:

a. There shall be no flame-producing device or continuously operating hot surface over 800°F (427°C) permanently installed in the room.
b. Doors communicating with the building shall be approved, self-closing, tight-fitting fire doors.
c. Walls, floor, and ceiling shall be tight and of noncombustible construction. Walls, floor, and ceiling separating the refrigerating machinery room from other occupied spaces shall be of at least one-hour fire-resistive construction.
d. The refrigerating machinery room shall have a door that opens directly to the outside air or through a vestibule equipped with self-closing, tight-fitting doors.
e. Exterior openings, if present, shall not be under any fire escape or any open stairway.
f. All pipes piercing the interior walls, ceiling, or floor of such rooms shall be tightly sealed to the walls, ceiling, or floor through which they pass.
g. When refrigerants of Groups A2, A3, B2, and B3 are used, the machinery room shall conform to Class 1, Division 2, of the *National Electrical Code*.[4] When refrigerant Groups A1 and B1 are used, the machinery room is not required to meet Class 1, Division 2, of the *National Electrical Code*.[4]

   Exception: When ammonia is used, the requirements of Class 1, Division 2, of the *National Electrical Code* shall not apply providing the requirements of Section 8.12(h) are met.

h. When ammonia is used, the machinery room is not required to meet Class 1, Division 2, of the *National Electrical Code*,[4] providing (1) the mechanical ventilation system in the machinery room is run continuously and failure of the mechanical ventilation system actuates an alarm or (2) the machinery room is equipped with a detector, conforming to Section 8.11.2.1, except the detector shall alarm at 1000 ppm.
i. Remote control of the mechanical equipment in the refrigerating machinery room shall be provided immediately outside the machinery room door solely for the purpose of shutting down the equipment in an emergency. Ventilation fans shall be on a separate electrical circuit and have a control switch located immediately outside the machinery room door.

8.13 Manual Emergency Discharge of Ammonia Refrigerant. When required by the authority having jurisdiction, manual emergency discharge or diffusion arrangements for ammonia refrigerants shall be provided. Appendix B contains information on emergency discharge of ammonia refrigerants.

8.14 Purge Discharge. The discharge from purge systems shall be governed by the same rules as pressure-relief devices and fusible plugs (see Section 9.7.8) and shall be piped in conjunction with these devices.

Exception: When R-718 (water) is the refrigerant.

9. DESIGN AND CONSTRUCTION OF EQUIPMENT AND SYSTEMS

9.1 Materials

9.1.1 Materials used in the construction and installation of refrigerating systems shall be suitable for conveying the refrigerant used. Materials shall not be used that will deteriorate because of the refrigerant, the lubricant, or their combination in the presence of air or moisture to a degree that poses a safety hazard.

9.1.2 Aluminum, zinc, magnesium, or their alloys shall not be used in contact with methyl chloride. Magnesium alloys shall not be used in contact with any halogenated refrigerants.

9.1.3 Copper and its alloys shall not be used in contact with ammonia except as a component of bronze alloys for bearings or other nonrefrigerant-containing uses.

9.1.4 Aluminum and its alloys are suitable for use in ammonia systems.

9.1.5 Piping material used in the discharge line of a pressure-relief device or fusible plug shall be the same as required for refrigerants.

Exception: When discharging to atmosphere, Type F buttweld pipe is allowed.

9.2 System Design Pressure

9.2.1 Design pressures shall not be less than pressure arising under maximum operating, standby, or shipping conditions. When selecting the design pressure, allowance shall be provided for setting pressure-limiting devices and pressure-relief devices to avoid nuisance shutdowns and loss of refrigerant. The *ASME Boiler and Pressure Vessel Code*,[5] Section VIII, Division I, Appendix M, contains information on the appropriate allowances for design pressure.

Refrigerating equipment shall be designed for a vacuum of 29.0 in. Hg (3.12 kPa). Design pressure for lithium bromide absorption systems shall not be less than 5 psig (34.7 kPa gage). Design pressure for mechanical refrigeration systems shall not be less than 15 psig (103.4 kPa gage) and, except as noted in Sections 9.2.2, 9.2.3, 9.2.4, and 9.2.5, shall not be less than the saturation pressure (gage) corresponding to the following temperatures:

a. Lowsides of all systems: 80°F (26.7°C).
b. Highsides of all water-cooled or evaporatively cooled systems: 30°F (16.7°C) higher than the summer 1% wet-bulb for the location as applicable or 15°F (8.3°C) higher than

the highest design leaving condensing water temperature for which the equipment is designed or 104°F (40°C), whichever is greatest.

c. Highsides of all air-cooled systems: 30°F (16.7°C) higher than the highest summer 1% design dry-bulb for the location but not lower than 122°F (50°C).

Note: See reference 13 for sources of information relating to summer 1% wet-bulb and summer 1% dry-bulb data for a specific location.

9.2.1.1 The design pressure selected shall exceed maximum pressures attained under any anticipated normal operating conditions, including conditions created by expected fouling of heat exchange surfaces.

9.2.1.2 Standby conditions are intended to include normal conditions that are capable of being attained when the system is not in operation (e.g., maintenance, shutdown, power failure). Selection of the design pressure for lowside components shall also consider pressure developed in the lowside of the system from equalization, or heating due to changes in ambient temperature, after the system has stopped.

9.2.1.3 The design pressure for both lowside and highside components that are shipped as part of a gas- or refrigerant-charged system shall be selected with consideration of internal pressures arising from exposure to maximum temperatures anticipated during the course of shipment.

9.2.2 The design pressure for either the highside or lowside need not exceed the critical pressure of the refrigerant unless such pressures are anticipated during operating, standby, or shipping conditions.

9.2.3 When part of a limited charge system is protected by a pressure-relief device, the design pressure of the part need not exceed the setting of the pressure-relief device.

9.2.4 When a compressor is used as a booster and discharges into the suction side of another compressor, the booster compressor shall be considered a part of the lowside.

9.2.5 Components connected to pressure vessels and subject to the same pressure as the pressure vessel shall have a design pressure no less than the pressure vessel.

9.3 Refrigerant-Containing Pressure Vessels

9.3.1 Inside Dimensions 6 Inches or Less. These vessels have an inside diameter, width, height, or cross-sectional diagonal not exceeding 6 in. (152 mm) with no limitation on length of vessel.

9.3.1.1 Pressure vessels having inside dimensions of 6 in. (152 mm) or less shall be

a. listed either individually or as part of an assembly by an approved, nationally recognized testing laboratory, or
b. marked directly on the vessel or on a nameplate attached to the vessel with a "U" or "UM" symbol signifying compliance with Section VIII of the *ASME Boiler and Pressure Vessel Code*,[5] or
c. when requested by the authority having jurisdiction, the manufacturer shall provide documentation to confirm that the vessel meets the design, fabrication, and testing requirements of Section VIII of the *ASME Boiler and Pressure Vessel Code*.[5]

Exception: Vessels having an internal or external design pressure of 15 psig (103.4 kPa gage) or less.

Pressure vessels having inside dimensions of 6 in. (152 mm) or less shall be protected by either a pressure-relief device or a fusible plug.

9.3.1.2 If a pressure-relief device is used to protect a pressure vessel having an inside dimension of 6 in. (152 mm) or less, the ultimate strength of the pressure vessel so protected shall be sufficient to withstand a pressure at least 3.0 times the design pressure.

9.3.1.3 If a fusible plug is used to protect a pressure vessel having an inside diameter of 6 in. (152 mm) or less, the ultimate strength of the pressure vessel so protected shall be sufficient to withstand a pressure 2.5 times the saturation pressure of the refrigerant used at the temperature stamped on the fusible plug or 2.5 times the critical pressure of the refrigerant used, whichever is less.

9.3.2 Inside Dimensions Greater than 6 Inches. Pressure vessels having an inside diameter exceeding 6 in. (152 mm) and having an internal or external design pressure greater than 15 psig (103.4 kPa gage) shall be directly marked, or marked on a nameplate, with a "U" or "UM" symbol signifying compliance with the rules of Section VIII of the *ASME Boiler and Pressure Vessel Code*.[5]

9.3.3 Pressure Vessels for 15 psig or Less. Pressure vessels having an internal or external design pressure of 15 psig (103.4 kPa gage) or less shall have an ultimate strength to withstand at least 3.0 times the design pressure and shall be tested with a pneumatic test pressure no less than 1.25 times the design pressure or a hydrostatic test pressure no less than 1.50 times the design pressure.

9.4 Pressure-Relief Protection

9.4.1 Refrigerating systems shall be protected by a pressure-relief device or other approved means to safely relieve pressure due to fire or other abnormal conditions.

9.4.2 Pressure vessels shall be protected in accordance with Section 9.7. Pressure-relief devices are acceptable if they bear either a nameplate or are directly marked with a "UV" or "VR" symbol signifying compliance with Section VIII of the *ASME Boiler and Pressure Vessel Code*.[5]

9.4.3 A pressure-relief device to relieve hydrostatic pressure to another part of the system shall be used on the portion of liquid-containing parts of the system that is capable of being isolated from the system during operation or service and that will be subjected to overpressure from hydrostatic expansion of the contained liquid due to temperature rise.

9.4.4 Evaporators located downstream, or upstream within 18 in. (460 mm), of a heating coil shall be fitted with a pressure-relief device discharging outside the building in accordance with the requirements of Section 9.7.8.

Exceptions:

a. Relief valves shall not be required on heating coils that are designed to produce a temperature that will result in the saturation pressure of the refrigerant being less than the design pressure.

b. A relief valve shall not be required on self-contained or unit systems if the volume of the lowside of the system, which is shut off by valves, is greater than the specific volume of the refrigerant at critical conditions of temperature and pressure, as determined by the following formula:

$$V_1/[W_1-(V_2-V_1)/V_{gt}] \text{ shall be greater than } V_{gc}$$

where

V_1 = lowside volume, ft^3 (m^3)
V_2 = total volume of system, ft^3 (m^3)
W_1 = total weight of refrigerant in system, lb (kg)
V_{gt} = specific volume of refrigerant vapor at 110°F (43.5°C), ft^3/lb (m^3/kg)
V_{gc} = specific volume at critical temperature and pressure, ft^3/lb (m^3/kg)

9.4.5 Pressure-relief devices shall be direct-pressure actuated or pilot-operated. Pilot-operated pressure-relief valves shall be self-actuated, and the main valve shall open automatically at the set pressure and, if some essential part of the pilot fails, shall discharge its full rated capacity.

9.4.6 Stop valves shall not be located between a pressure-relief device and parts of the system protected thereby. A three-way valve, used in conjunction with the dual relief valve requirements of Section 9.7.2.3, is not considered a stop valve.

9.4.7 When relief valves are connected to discharge to a common discharge header as described in Section 9.7.8.4, a full area stop valve is not prohibited from being installed in the discharge pipe between the relief valve and the common header. When such a stop valve is installed, a locking device shall be installed to ensure that the stop valve is locked in the open position. This discharge stop valve shall not be shut unless one of the following conditions exists:

a. a parallel relief valve is installed that protects the system or vessels, or
b. the system or vessels being protected have been depressurized and are vented to the atmosphere.

9.4.8 Pressure-relief devices shall be connected directly to the pressure vessel or other parts of the system protected thereby. These devices shall be connected above the liquid refrigerant level and installed so that they are accessible for inspection and repair and so that they cannot be readily rendered inoperative.

Exception: When fusible plugs are used on the highside, they shall be located either above or below the liquid refrigerant level.

9.4.9 The seats and discs of pressure-relief devices shall be constructed of suitable material to resist refrigerant corrosion or other chemical action caused by the refrigerant. Seats or discs of cast iron shall not be used. Seats and discs shall be limited in distortion, by pressure or other cause, to a set pressure change of not more than 5% in a span of five years.

9.5 Setting of Pressure-Relief Devices

9.5.1 Pressure-Relief Valve Setting. Pressure-relief valves shall start to function at a pressure not to exceed the design pressure of the parts of the system protected.

Exception: See Section 9.7.8.1 for relief valves that discharge into other parts of the system.

9.5.2 Rupture Member Setting. Rupture members used in lieu of, or in series with, a relief valve shall have a nominal rated rupture pressure not to exceed the design pressure of the parts of the system protected. The conditions of application shall conform to the requirements of paragraph UG-127 of Section VIII, Division 1, of the *ASME Boiler and Pressure Vessel Code.*[5] The size of rupture members installed ahead of relief valves shall not be less than the relief valve inlet.

9.6 Marking of Relief Devices and Fusible Plugs

9.6.1 Pressure-relief valves for refrigerant-containing components shall be set and sealed by the manufacturer or an assembler as defined in Section VIII, Division 1, of the *ASME Boiler and Pressure Vessel Code.*[5] Each pressure-relief valve shall be marked by the manufacturer or assembler with the data required in Section VIII, Division 1, of the *ASME Boiler and Pressure Vessel Code.*[5]

Exception: Relief valves for systems with design pressures of 15 psig (103.4 kPa gage) or less shall be marked by the manufacturer with the pressure-setting capacity.

9.6.2 Each rupture member for refrigerant pressure vessels shall be marked with the data required in paragraph UG-129(e) of Section VIII, Division 1, of the *ASME Boiler and Pressure Vessel Code.*[5]

9.6.3 Fusible plugs shall be marked with the melting temperatures in Fahrenheit or Celsius.

9.7 Pressure Vessel Protection

9.7.1 Pressure vessels shall be provided with overpressure protection in accordance with rules in Section VIII, Division 1, of the *ASME Boiler and Pressure Vessel Code*.[5]

9.7.2 Pressure vessels containing liquid refrigerant and that are capable of being isolated by stop valves from other parts of a refrigerating system shall be provided with overpressure protection. Pressure-relief devices or fusible plugs shall be sized in accordance with Section 9.7.5.

9.7.2.1 Pressure vessels with an internal gross volume of 3 ft^3 (0.085 m^3) or less shall use one or more pressure-relief devices or a fusible plug.

9.7.2.2 Pressure vessels of more than 3 ft^3 (0.085 m^3) but less than 10 ft^3 (0.285 m^3) internal gross volume shall use one or more pressure-relief devices. Fusible plugs shall not be used.

9.7.2.3 Pressure vessels of 10 ft^3 (0.285 m^3) or more internal gross volume shall use one or more rupture member(s) or dual pressure-relief valves when discharging to the atmosphere. Dual pressure-relief valves shall be installed with a three-way valve to allow testing or repair. When dual relief valves are used, each valve must meet the requirements of Section 9.7.5.

Exception: A single relief valve is permitted on pressure vessels of 10 ft^3 (0.285 m^3) or more internal gross volume when all of the following conditions are met:

a. the relief valves are located on the lowside of the system,
b. the vessel is provided with shutoff valves designed to allow pumpdown of the refrigerant charge of the pressure vessel, and
c. other pressure vessels in the system are separately protected in accordance with Section 9.7.2.

9.7.3 For pressure-relief valves discharging into the lowside of the system, a single relief valve (not rupture member) of the required relieving capacity shall not be used on vessels of 10 ft^3 (0.283 m^3) or more internal gross volume except under the conditions permitted in Section 9.7.8.1.

9.7.4 Large vessels containing liquid refrigerant shall not be prohibited from using two or more pressure-relief devices or dual pressure-relief devices in parallel to obtain the required capacity.

9.7.5 The minimum required discharge capacity of the pressure-relief device or fusible plug for each pressure vessel shall be determined by the following:

$$C = fDL$$

where

C = minimum required discharge capacity of the relief device in pounds of air per minute, (kg/s)
D = outside diameter of vessel, ft (m)
L = length of vessel, ft (m)
f = factor dependent upon type of refrigerant

Note:

1. When combustible materials are used within 20 ft (6.1 m) of a pressure vessel, multiply the value of f by 2.5.
2. The formula is based on fire conditions. Other heat sources shall be calculated separately.

Refrigerant	Value of *f*
When used on the lowside of a limited-charge cascade system:	
R-23, R-170, R-744, R-1150, R-508A, R-508B	1.0 (0.082)
R-13, R-13B1, R-503	2.0 (0.163)
R-14	2.5 (0.203)
Other applications:	
R-718	0.2 (0.016)
R-717	0.5 (0.041)
R-11, R-32, R-113, R-123, R-142b, R-152a, R-290, R-600, R-600a, R-764	1.0 (0.082)
R-12, R-22, R-114, R-124, R-134a, R-401A, R-401B, R-401C, R-405A, R-406A, R-407C, R-407D, R-407E, R-409A, R-409B, R-411A, R-411B, R-411C, R-412A, R-414A, R-414B, R-500, R-1270	1.6 (0.131)
R-143a, R-402B, R-403A, R-407A, R-408A, R-413A	2.0 (0.163)
R-115, R-402A, R-403B, R-404A, R-407B, R-410A, R-410B, R-502, R-507A, R-509A	2.5 (0.203)

When one pressure-relief device or fusible plug is used to protect more than one pressure vessel, the required capacity shall be the sum of the capacities required for each pressure vessel.

9.7.6 The rated discharge capacity of a pressure-relief device expressed in pounds of air per minute (kilograms of air per second) shall be determined in accordance with paragraph UG-131, Section VIII, Division 1, of the *ASME Boiler and Pressure Vessel Code.*[5] All pipe and fittings between the pressure-relief valve and the parts of the system it protects shall have at least the area of the pressure-relief valve inlet area.

9.7.7 The rated discharge capacity of a rupture member or fusible plug discharging to the atmosphere under critical flow conditions in pounds of air per minute (kg/s) shall be determined by the following formulas:

$$C = 0.64 P_1 d^2 \qquad (C = 1.09 \times 10^{-6} P_1 d^2),$$

$$d = 1.25(C/P_1)^{0.5} \qquad (d = 958.7(C/P_1)^{0.5}),$$

where

C = rated discharge capacity in pounds of air per minute, (kg/s)
d = smallest of the internal diameter of the inlet pipe, retaining flanges, fusible plug, and rupture member, in. (mm)

where for rupture members,

$$P_1 = (\text{rated pressure psig[kPa gage]} \times 1.10) + 14.7(101.33)$$

where for fusible plugs

P_1 = absolute saturation pressure corresponding to the stamped temperature melting point of the fusible plug or the critical pressure of the refrigerant used, whichever is smaller, psia (kPa).

9.7.8 Pressure-relief devices and fusible plugs on any system containing a Group A3 or B3 refrigerant; on any system containing more than 6.6 lb (3 kg) of a Group A2, B1, or B2 refrigerant; and on any system containing more than 110 lb (50 kg) of a Group A1 refrigerant shall discharge to the atmosphere at a location not less than 15 ft (4.57 m) above the adjoining ground level and not less than 20 ft (6.1 m) from any window, ventilation opening, or exit in any building. The discharge shall be terminated in a manner that will prevent the discharged refrigerant from being sprayed directly on personnel in the vicinity and foreign material or debris from entering the discharge piping. Discharge piping connected to the discharge side of a fusible plug or rupture member shall have provisions to prevent plugging the pipe in the event the fusible plug or rupture member functions.

9.7.8.1 The application of pressure-relief valves that discharge from a higher pressure vessel into a lower pressure vessel of the system shall comply with (a) through (c) below:

a. The pressure-relief valve that protects the higher pressure vessel shall be selected to deliver capacity in accordance with Section 9.7.5 without exceeding the maximum allowable working pressure of the higher pressure vessel accounting for the change in mass flow capacity due to the elevated backpressure.

b. The capacity of the pressure-relief valve protecting the part of the system receiving a discharge from a pressure-relief valve protecting a higher pressure vessel shall be at least the sum of the capacity required in Section 9.7.5 plus the mass flow capacity of the pressure-relief valve discharging into that part of the system.
c. The design pressure of the body of the relief valve used on the higher pressure vessel shall be rated for operation at the design pressure of the higher pressure vessel in both pressure-containing areas of the valve.

9.7.8.2 Ammonia Discharge. Ammonia from pressure-relief valves shall be discharged into one or more of the following:

a. The atmosphere, per Section 9.7.8.
b. A tank containing one gallon of water for each pound of ammonia (8.3 liters of water for each kilogram of ammonia) that will be released in one hour from the largest relief device connected to the discharge pipe. The water shall be prevented from freezing. The discharge pipe from the pressure-relief device shall distribute ammonia in the bottom of the tank but no lower than 33 ft (10 m) below the maximum liquid level. The tank shall contain the volume of water and ammonia without overflowing.
c. Other treatment systems that meet the requirements of the authority having jurisdiction.

9.7.8.3 Optional Sulfur Dioxide Discharge. When sulfur dioxide is used, the discharge shall be into a tank of absorptive solution that shall be used for no other purpose except sulfur dioxide absorption. The absorptive solution shall be one gallon of standard dichromate solution (2.5 lb of sodium dichromate per gallon of water [300 grams of sodium dichromate per liter of water]) for each pound of sulfur dioxide in the system (8.3 liters of standard dichromate solution for each kilogram of sulfur dioxide in the system). Solutions made with caustic soda or soda ash shall not be used in place of sodium dichromate unless the quantity and strength have the equivalent sulfur-dioxide-absorbing power. The tank shall be constructed of not less than 1/8 in. (3.2 mm) or No. 11 US gage iron or steel. The tank shall have a hinged cover or, if of the enclosed type, shall have a vent hole at the top. All pipe connections shall be through the top of the tank only. The discharge pipe from the pressure-relief valve shall discharge the sulfur dioxide in the center of the tank near the bottom.

9.7.8.4 The size of the discharge pipe from a pressure-relief device or fusible plug shall not be less than the outlet size of the pressure-relief device or fusible plug. Where outlets of two or more relief devices or fusible plugs are connected to a common line or header, the effect of back pressure that will be developed when more than one relief device or fusible plug operates shall be considered. The sizing of the common discharge header downstream from each of the two or more relief devices or fusible plugs that are expected to operate simultaneously shall be based on the sum of their outlet areas with due allowance for the pressure drop in all downstream sections.

9.7.8.5 The maximum length of the discharge piping installed on the outlet of pressure-relief devices and fusible plugs discharging to the atmosphere shall be determined by the method in Appendix H. See Table 3 for the allowable flow capacity of various equivalent lengths of discharge piping for conventional safety relief valves.

9.8 Positive Displacement Compressor Protection. When equipped with a stop valve in the discharge connection, every positive displacement compressor shall be equipped with a pressure-relief device of adequate size and pressure setting, as specified by the compressor manufacturer, to prevent rupture of the compressor or to prevent the pressure from increasing to more than 10% above the maximum allowable working pressure of any other component located in the discharge line between the compressor and the stop valve or in accordance with Section 9.7.5, whichever is larger. The pressure-relief device shall discharge into the low-pressure side of the system or in accordance with Section 9.7.8.

The relief device(s) shall be sized based on compressor flow at the following conditions:

1. **High-Stage or Single-Stage Compressors:** Flow is to be calculated based on 50°F (10°C) saturated suction temperature at the compressor suction.
2. **Low-Stage or Booster Compressors:** For those compressors that are capable of running only when discharging to the suction of a high-stage compressor, flow is to be calculated based on the saturated suction temperature equal to the design operating intermediate temperature.

Exception for items 1 and 2: The discharge capacity of the relief device is allowed to be the minimum regulated flow rate of the compressor when the following conditions are met:

a. the compressor is equipped with capacity regulation,
b. capacity regulation actuates to minimum flow at 90% of the pressure-relief device setting, and
c. a pressure-limiting device is installed and set in accordance with the requirements of Section 9.9.

Appendix F describes one acceptable method of calculating the discharge capacity of positive displacement compressor relief devices.

9.9 Pressure-Limiting Devices

9.9.1 When Required. Pressure-limiting devices shall be provided on all systems operating above atmospheric pressure, except that a pressure-limiting device is not required on any factory-sealed system containing less than 22 lb (10 kg) of Group A1 refrigerant that has been listed by an approved, nationally recognized testing laboratory and is so identified.

9.9.2 Setting. When required by Section 9.9.1, the maximum setting to which a pressure-limiting device is capable of being readily set by use of the adjusting means provided shall not exceed the design pressure of the highside of a system that is not protected by a pressure-relief device or 90% of the setting of the pressure-relief device installed on the highside of a system. The pressure-limiting device shall stop the action of the pressure-imposing element at a pressure no higher than this maximum setting.

Exception: On systems using nonpositive displacement compressors, the maximum setting of the pressure-

TABLE 3 Pressure-Relief Valve Discharge Line Capacity (lb/min of air) of Various Discharge Line Lengths

Set, psig	Length, ft	Nominal Pipe Size, NPS/DN											Set, psig	Length, ft	Nominal Pipe Size, NPS/DN										
		0.5	0.75	1	1.25	1.5	2	2.5	3	4	5	6			0.5	0.75	1	1.25	1.5	2	2.5	3	4	5	6
		15	20	25	32	40	50	65	80	100	125	150			15	20	25	32	40	50	65	80	100	125	150
5	2	2.8	5.8	10.7	21.3	31.4	57.8	88.8	148.0	278.9	469	704	50	2	7.6	14.7	25.4	46.5	65.3	111.7	162.8	256	451	718	1045
5	3	2.3	4.8	9.0	18.1	26.8	49.9	77.3	130.4	249.8	426	647	50	3	6.8	13.2	23.2	43.4	61.4	106.3	156.1	248	439	704	1027
5	4	2.0	4.2	7.9	16.0	23.7	44.5	69.4	117.8	228.2	393	601	50	4	6.1	12.2	21.6	40.8	58.1	101.6	150.2	240	429	691	1011
5	5	1.8	3.8	7.1	14.4	21.5	40.6	63.5	108.3	211.4	367	564	50	5	5.7	11.3	20.2	38.6	55.2	97.4	144.9	233	419	678	996
5	6	1.7	3.5	6.6	13.3	19.8	37.5	58.9	100.8	197.8	346	533	50	6	5.3	10.6	19.1	36.7	52.8	93.8	140.1	226	410	666	981
5	8	1.5	3.0	5.7	11.6	17.4	33.1	52.0	89.5	177.0	312	484	50	8	4.7	9.5	17.3	33.6	48.7	87.5	131.8	215	393	644	953
5	10	1.3	2.7	5.1	10.5	15.7	29.9	47.1	81.3	161.7	286	446	50	10	4.3	8.7	15.9	31.2	45.5	82.4	124.8	205	378	624	927
5	15	1.1	2.2	4.2	8.6	12.9	24.7	39.2	67.9	135.9	243	380	50	15	3.6	7.4	13.6	26.9	39.6	72.7	113.3	185	347	582	872
5	20	0.9	1.9	3.7	7.5	11.3	21.6	34.2	59.4	119.5	214	337	50	20	3.1	6.5	12.0	24.0	35.5	65.8	101.4	170	323	547	825
5	25	0.8	1.7	3.3	6.7	10.1	19.4	30.8	53.5	107.9	194	306	50	25	2.8	5.9	10.9	21.9	32.4	60.5	93.8	158	303	517	785
5	30	0.8	1.6	3.0	6.2	9.3	17.8	28.2	49.1	99.1	179	282	50	30	2.6	5.4	10.0	20.3	30.1	56.3	87.6	148	286	492	750
5	40	0.7	1.4	2.6	5.3	8.0	15.4	24.5	42.8	86.5	156	247	50	40	2.3	4.7	8.8	17.8	26.6	50.1	78.3	133	260	451	692
5	60	0.5	1.1	2.1	4.4	6.6	12.6	20.1	35.1	71.2	129	205	50	60	1.9	3.9	7.3	14.8	22.1	42.0	66.0	113	224	393	608
5	100	0.4	0.9	1.7	3.4	5.1	9.8	15.6	27.3	55.6	101	160	50	100	1.4	3.0	5.7	11.6	17.4	33.3	52.6	91	182	323	504
5	160	0.3	0.7	1.3	2.7	4.0	7.8	12.4	21.7	44.1	80	127	50	160	1.1	2.4	4.5	9.3	13.9	26.7	42.3	73	148	265	416
5	250	0.3	0.6	1.0	2.1	3.2	6.2	9.9	17.4	35.3	64	102	50	250	0.9	1.9	3.6	7.5	11.2	21.5	34.2	59	120	217	342
15	2	4.6	9.3	16.7	32.0	46.0	81.6	121.8	196.5	355.2	577	849	75	2	9.1	17.2	29.4	53.3	74.3	126.0	182.7	286	501	795	1154
15	3	3.9	8.0	15.5	28.3	41.0	74.0	111.6	182.3	334.5	550	815	75	3	8.2	15.8	27.3	50.4	70.7	121.2	176.9	279	491	783	1140
15	4	3.5	7.1	13.0	25.6	37.4	68.1	103.6	170.8	317.1	526	784	75	4	7.5	14.6	25.7	47.8	67.6	116.9	171.6	272	482	772	1127
15	5	3.1	6.5	11.9	23.6	34.6	63.5	97.1	161.2	302.2	506	757	75	5	7.0	13.7	24.3	45.7	64.8	113.1	166.8	266	474	762	1114
15	6	2.9	6.0	11.0	22.0	32.3	59.7	91.7	153.1	289.2	487	732	75	6	6.5	13.0	23.1	43.7	62.4	109.6	162.3	260	466	751	1101
15	8	2.5	5.2	9.7	19.5	28.9	53.8	83.2	140.0	267.5	455	689	75	8	5.9	11.8	21.1	40.6	58.3	103.4	154.4	249	450	732	1077
15	10	2.3	4.7	8.8	17.8	26.3	49.3	76.7	129.7	250.1	429	683	75	10	5.4	10.8	19.6	38.0	54.9	98.2	147.5	240	437	714	1054
15	15	1.9	3.9	7.3	14.8	22.1	41.7	65.3	111.6	218.0	379	583	75	15	4.5	9.2	16.9	33.2	48.4	88.0	133.7	220	407	675	1004

Notes: SI Conversions; kPa = psig × 6.895, mm = in. × 25.4, kg/s = lb/min × 0.007559, m = ft × 0.3048.

TABLE 3 Pressure-Relief Valve Discharge Line Capacity (lb/min of air) of Various Discharge Line Lengths *(continued)*

Set, psig	Length, ft	Nominal Pipe Size, NPS/DN										
		0.5	0.75	1	1.25	1.5	2	2.5	3	4	5	6
		15	20	25	32	40	50	65	80	100	125	150
15	20	1.6	3.4	6.4	13.0	19.4	36.8	57.9	99.4	195.8	344	532
15	25	1.5	3.1	5.7	11.7	17.5	33.3	52.5	90.5	179.3	316	492
15	30	1.3	2.8	5.3	10.7	16.1	30.7	48.4	83.6	166.3	295	460
15	40	1.2	2.4	4.6	9.4	14.0	26.8	42.4	73.5	147.1	262	411
15	60	1.0	2.0	3.8	7.7	11.6	22.1	35.1	61.0	122.7	220	347
15	100	0.7	1.5	2.9	6.0	9.0	17.3	27.5	47.9	96.8	175	276
15	160	0.6	1.2	2.3	4.7	7.1	13.7	21.8	38.1	77.3	140	222
15	250	0.5	1.0	1.9	3.8	5.7	11.0	17.5	30.6	62.3	113	179
25	2	5.7	11.3	20.0	37.6	53.5	93.2	137.5	219.2	390.5	628	918
25	3	4.9	9.9	17.8	34.0	48.8	86.5	128.8	207.5	374.4	608	893
25	4	4.4	8.9	16.2	31.3	45.3	81.0	121.6	197.6	360.1	589	869
25	5	4.0	8.2	14.9	29.1	42.3	76.4	115.5	188.9	347.3	572	848
25	6	3.7	7.6	13.9	27.4	39.9	72.6	110.2	181.3	335.8	556	828
25	8	3.3	6.7	12.4	24.6	36.1	66.4	101.5	168.5	315.9	529	791
25	10	3.0	6.1	11.3	22.6	33.3	61.5	94.6	158.1	299.1	505	759
25	15	2.5	5.1	9.5	19.1	28.3	52.9	82.1	138.7	266.6	457	694
25	20	2.1	4.5	8.3	16.8	25.0	47.1	73.5	125.0	242.9	420	643
25	25	1.9	4.0	7.5	15.2	22.7	42.9	67.1	114.7	224.5	391	602
25	30	1.8	3.7	6.9	14.0	20.9	39.6	62.2	106.6	209.8	367	568
25	40	1.5	3.2	6.0	12.2	18.3	34.8	54.9	94.5	187.3	331	514
25	60	1.3	2.6	4.9	10.1	15.1	28.9	45.7	79.1	158.0	281	440
25	100	1.0	2.0	3.8	7.9	11.8	22.7	36.0	62.5	125.8	226	356
25	160	0.8	1.6	3.1	6.3	9.4	18.1	28.7	50.0	101.1	183	289
25	250	0.6	1.3	2.4	5.0	7.6	14.5	32.1	40.3	81.7	148	235

Set, psig	Length, ft	Nominal Pipe Size, NPS/DN										
		0.5	0.75	1	1.25	1.5	2	2.5	3	4	5	6
		15	20	25	32	40	50	65	80	100	125	150
75	20	4.0	8.2	15.1	29.9	43.8	80.5	123.1	204	383	641	960
75	25	3.6	7.4	13.7	27.4	40.3	74.6	114.8	192	363	612	921
75	30	3.3	6.8	12.7	25.4	37.6	69.8	107.9	181	345	587	887
75	40	2.9	6.0	11.2	22.5	33.4	62.5	97.2	164	317	544	828
75	60	2.4	5.0	9.3	16.8	28.0	52.9	82.8	141	276	481	739
75	100	1.9	3.9	7.3	14.8	22.2	42.2	66.5	115	227	401	623
75	160	1.5	3.1	5.8	11.9	17.8	34.0	53.8	93	186	332	520
75	250	1.2	2.5	4.7	9.6	14.4	27.5	43.6	76	153	274	432
100	2	10.3	19.4	32.9	59.3	82.2	138.8	200.8	314	547	868	1258
100	3	9.4	17.9	30.9	56.4	78.9	134.4	195.4	307	539	857	1246
100	4	8.7	16.8	29.2	54.0	75.9	130.3	190.4	301	531	847	1234
100	5	8.1	15.8	27.8	51.8	73.2	126.6	185.9	295	523	837	1222
100	6	7.6	15.0	26.5	49.9	70.8	123.2	181.7	289	515	828	1210
100	8	6.9	13.7	24.5	46.6	66.6	117.2	174.0	279	501	810	1188
100	10	6.3	12.7	22.8	43.9	63.1	112.0	167.2	270	488	793	1167
100	15	5.4	10.9	19.9	38.7	56.3	101.4	153.1	250	459	756	1120
100	20	4.7	9.7	17.8	35.1	51.3	93.4	142.1	234	435	723	1077
100	25	4.3	8.8	16.3	32.3	47.4	87.0	133.2	221	415	694	1039
100	30	4.0	8.2	15.1	30.1	44.3	81.8	125.8	210	397	668	1005
100	40	3.5	7.2	13.3	26.7	39.5	73.7	114.0	192	367	625	946
100	60	2.9	5.9	11.1	22.4	33.4	62.7	97.9	166	323	558	853
100	100	2.2	4.7	8.7	17.8	26.6	50.4	79.2	136	268	471	728
100	160	1.8	3.7	7.0	14.3	21.4	40.7	64.3	111	222	393	614
100	250	1.4	3.0	5.6	11.5	17.3	33.0	52.3	91	182	326	513

Notes: SI Conversions; kPa = psig × 6.895, mm = in. × 25.4, kg/s = lb/min × 0.007559, m = ft × 0.3048.

TABLE 3 Pressure-Relief Valve Discharge Line Capacity (lb/min of air) of Various Discharge Line Lengths *(continued)*

Set, psig	Length, ft	Nominal Pipe Size, NPS/DN 0.5 / 15	0.75 / 20	1 / 25	1.25 / 32	1.5 / 40	2 / 50	2.5 / 65	3 / 80	4 / 100	5 / 125	6 / 150
150	2	12.5	23.3	39.2	70.1	96.8	162.7	234.5	366	636	1006	1457
150	3	11.6	21.8	37.2	67.4	93.7	158.5	229.6	360	628	996	1446
150	4	10.8	20.6	35.5	64.9	90.8	154.7	225.1	354	621	987	1435
150	5	10.2	19.6	34.0	62.8	88.1	151.2	220.7	348	613	979	1425
150	6	9.6	18.7	32.7	60.8	85.7	147.8	216.6	343	606	970	1414
150	8	8.8	17.3	30.5	57.3	81.4	141.8	209.1	333	593	954	1394
150	10	8.1	16.1	28.7	54.4	77.7	136.5	202.3	324	581	938	1375
150	15	6.9	14.0	25.2	48.7	70.3	125.4	187.8	304	553	902	1330
150	20	6.2	12.5	22.8	44.5	64.6	116.6	176.0	288	529	870	1289
150	25	5.6	11.4	21.0	41.2	60.2	109.4	166.2	274	507	841	1251
150	30	5.2	10.6	19.5	38.6	56.5	103.4	157.9	261	488	815	1217
150	40	4.5	9.4	17.3	34.5	50.8	93.9	144.5	241	456	769	1156
150	60	3.8	7.8	14.5	29.2	43.3	80.8	125.4	212	407	696	1058
150	100	2.9	6.1	11.5	23.3	34.7	65.6	102.7	175	343	597	918
150	160	2.3	4.9	9.2	18.7	28.0	53.3	84.0	145	286	505	785
150	250	1.9	3.9	7.4	15.2	22.7	43.4	68.6	119	238	423	662
200	2	14.6	26.9	45.0	80.2	110.6	185.2	266.6	415	721	1139	1649
200	3	13.6	25.4	43.1	77.5	107.4	181.2	261.9	409	713	1130	1638
200	4	12.7	24.2	41.3	75.1	104.6	177.4	257.4	404	706	1121	1628
200	5	12.0	23.1	39.8	72.8	101.9	173.9	253.1	398	699	1113	1618
200	6	11.5	22.1	38.4	70.8	99.4	170.6	249.1	393	692	1105	1608
200	8	10.5	20.5	36.0	67.2	95.0	164.5	241.5	383	679	1089	1588
200	10	9.7	19.2	34.0	64.1	91.1	159.0	234.6	374	667	1073	1570
200	15	8.4	16.8	30.2	57.9	83.2	147.3	219.6	354	639	1038	1525
200	20	7.5	15.2	27.5	53.2	77.0	137.9	207.2	337	614	1005	1485

Set, psig	Length, ft	Nominal Pipe Size, NPS/DN 0.5 / 15	0.75 / 20	1 / 25	1.25 / 32	1.5 / 40	2 / 50	2.5 / 65	3 / 80	4 / 100	5 / 125	6 / 150
300	2	18.4	33.7	56.1	99.4	136.7	228.3	328	510	884	1395	2019
300	3	17.3	32.1	54.0	96.0	133.5	224.2	323	504	877	1386	2009
300	4	16.4	30.8	52.2	94.1	130.6	220.4	319	498	869	1378	1998
300	5	15.6	29.6	50.5	91.7	127.8	216.8	314	493	862	1369	1988
300	6	14.9	28.5	49.0	89.6	125.2	213.4	310	488	856	1361	1978
300	8	13.8	26.6	46.3	85.6	120.4	206.9	302	478	843	1345	1959
300	10	12.8	25.1	44.1	82.2	116.2	201.0	295	468	830	1330	1940
300	15	11.2	22.2	39.6	75.1	107.2	188.3	279	447	801	1293	1895
300	20	10.0	20.1	36.2	69.6	100.1	177.7	265	428	775	1260	1853
300	25	9.2	18.6	33.6	65.2	94.2	168.7	253	412	751	1229	1814
300	30	8.5	17.3	31.5	61.5	89.2	160.9	243	397	729	1200	1777
300	40	7.5	15.4	28.2	55.6	81.3	148.2	225	372	691	1148	1710
300	60	6.3	12.9	23.9	47.7	70.2	129.7	199	333	639	1061	1595
300	100	4.9	10.3	19.1	38.5	57.2	107.1	167	282	544	934	1422
300	160	3.9	8.2	15.4	31.3	46.6	88.1	138	236	463	807	1243
300	250	3.2	6.6	12.5	25.4	38.0	72.3	114	196	389	687	1068
350	2	20.3	37.0	61.4	108.6	149	249	358	556	963	1519	2199
350	3	19.1	35.3	59.3	105.8	146	245	353	550	956	1510	2189
350	4	18.1	33.9	57.4	103.3	143	241	348	544	949	1502	2178
350	5	17.3	32.7	55.7	100.9	140	237	344	539	941	1493	2168
350	6	16.6	31.5	54.1	98.6	137	234	340	534	935	1484	2158
350	8	15.3	29.6	51.3	94.5	132	227	331	523	921	1468	2139
350	10	14.4	28.0	48.9	90.9	128	221	324	514	908	1452	2120
350	15	12.5	24.8	44.1	83.5	119	208	307	492	879	1414	2075
350	20	11.3	22.6	40.5	77.6	111	196	293	473	852	1379	2032

Notes: SI Conversions; kPa = psig × 6.895, mm = in. × 25.4, kg/s = lb/min × 0.007559, m = ft × 0.3048.

TABLE 3 Pressure-Relief Valve Discharge Line Capacity (lb/min of air) of Various Discharge Line Lengths *(continued)*

Set, psig	Length, ft	Nominal Pipe Size, NPS/DN											Set, psig	Length, ft	Nominal Pipe Size, NPS/DN										
		0.5	0.75	1	1.25	1.5	2	2.5	3	4	5	6			0.5	0.75	1	1.25	1.5	2	2.5	3	4	5	6
		15	20	25	32	40	50	65	80	100	125	150			15	20	25	32	40	50	65	80	100	125	150
200	25	6.8	13.9	24.3	49.5	72.0	130.1	196.6	322	592	967	1447	350	25	10.3	20.8	37.6	72.8	105	187	280	455	827	1347	1992
200	30	6.3	12.9	23.6	46.5	67.9	123.4	187.6	309	572	949	1412	350	30	9.6	19.4	35.3	68.8	99	178	269	440	804	1317	1954
200	40	5.6	11.4	21.1	41.8	61.4	112.8	172.6	287	538	901	1349	350	40	8.5	17.3	31.7	62.4	91	163	250	413	764	1262	1885
200	60	4.6	9.6	17.7	35.5	52.5	97.7	151.1	254	484	823	1245	350	60	7.1	14.6	26.9	53.7	79	145	222	372	699	1170	1765
200	100	3.6	7.5	14.1	28.5	42.4	79.9	124.7	212	413	714	1094	350	100	5.6	11.6	21.6	43.5	64	120	186	316	607	1034	1582
200	160	2.9	6.0	11.3	23.0	34.4	65.2	102.5	176	347	610	944	350	160	4.5	9.3	17.4	35.4	52	99	155	266	519	897	1390
200	250	2.3	4.9	9.1	18.6	27.9	53.3	84.1	145	290	514	802	350	250	3.6	7.5	14.1	28.8	43	81	128	222	438	766	1200
250	2	16.5	30.4	50.7	89.9	123.8	207.0	297.7	463	803	1268	1836	400	2	22.0	40.2	66.6	117.7	161.7	269.6	387	601	1041	1642	2376
250	3	15.5	28.8	48.6	87.2	120.7	203.0	293.0	457	796	1260	1826	400	3	20.9	38.5	64.5	114.8	158.4	265.5	382	595	1034	1633	2366
250	4	14.6	27.5	46.9	84.7	117.8	199.3	288.5	452	789	1251	1815	400	4	19.8	37.0	62.5	112.2	155.3	261.5	378	589	1026	1625	2355
250	5	13.8	26.4	45.2	82.4	115.1	195.7	284.2	446	782	1243	1805	400	5	18.9	35.7	60.7	109.7	152.4	257.7	373	584	1019	1616	2345
250	6	13.2	25.4	43.8	80.3	112.5	192.3	280.2	441	775	1234	1795	400	6	18.2	34.5	59.1	107.4	149.6	254.1	369	578	1012	1608	2335
250	8	12.2	23.6	41.3	76.6	107.9	186.1	272.5	431	762	1219	1776	400	8	16.9	32.5	56.1	103.1	144.5	247.3	360	568	999	1591	2315
250	10	11.3	22.2	39.1	73.3	103.9	180.4	265.4	422	750	1203	1757	400	10	15.8	30.7	53.6	99.3	139.9	241.0	353	558	986	1575	2295
250	15	9.8	19.6	35.0	66.7	95.4	168.2	249.8	401	721	1167	1713	400	15	13.9	27.4	48.5	91.5	130.1	227.1	335	535	955	1537	2249
250	20	8.8	17.7	31.9	61.5	88.7	158.1	236.7	383	696	1135	1672	400	20	12.5	24.9	44.6	85.2	122.0	215.4	320	515	927	1502	2205
250	25	8.0	16.3	29.5	57.5	83.3	149.7	225.5	368	673	1104	1634	400	25	11.4	23.0	41.6	80.1	115.3	205.4	307	497	902	1469	2164
250	30	7.4	15.1	27.6	54.1	78.7	142.5	215.7	354	652	1076	1598	400	30	10.6	21.5	39.0	75.8	109.6	196.6	296	481	878	1438	2125
250	40	6.5	13.4	24.7	48.8	71.5	130.7	199.5	330	616	1026	1533	400	40	9.4	19.2	35.1	68.9	100.4	182.0	276	453	836	1382	2052
250	60	5.4	11.3	20.9	41.7	61.5	114.0	175.6	294	558	944	1423	400	60	7.9	16.2	26.9	59.4	87.2	160.4	246	409	767	1286	1927
250	100	4.3	8.9	16.6	33.6	49.9	93.7	145.9	248	479	826	1261	400	100	6.2	12.9	24.0	48.3	71.5	133.4	207	349	669	1143	1734
250	160	3.4	7.1	13.4	27.2	40.6	76.8	120.5	207	406	710	1096	400	160	5.0	10.4	19.4	39.3	58.5	110.3	173	294	574	996	1529
250	250	2.7	5.8	10.8	22.1	33.0	62.9	99.2	171	340	602	937	400	250	4.0	8.4	15.7	32.0	47.9	90.9	143	246	468	854	1324

Notes: SI Conversions; kPa = psig × 6.895, mm = in. × 25.4, kg/s = lb/min × 0.007559, m = ft × 0.3048.

limiting device is not required to be less than the design pressure of the highside of the system provided the pressure-relief device is (1) located in the lowside and (2) subject to lowside pressure and (3) there is a permanent (unvalved) relief path between the highside and the lowside of the system.

9.9.3 Connection. Pressure-limiting devices shall be connected between the pressure-imposing element and any stop valve on the discharge side. There shall be no intervening stop valves in the line leading to the pressure-limiting device.

9.10 Refrigerant Piping, Valves, Fittings, and Related Parts

9.10.1 Refrigerant piping, valves, fittings, and related parts having a maximum internal or external design pressure greater than 15 psig (103.4 kPa gage) shall be listed either individually or as part of an assembly or a system by an approved, nationally recognized laboratory or shall comply with *ASME B31.5*[6] where applicable.

9.10.2 Refrigerant Parts in Air Duct. Joints and all refrigerant-containing parts of a refrigerating system located in an air duct carrying conditioned air to and from an occupied space shall be constructed to withstand a temperature of 700°F (371.1°C) without leaking into the airstream.

9.11 Components Other Than Pressure Vessels and Piping

9.11.1 Every pressure-containing component of a refrigerating system, other than pressure vessels, piping, pressure gages, and control mechanisms, shall be listed either individually or as part of a complete refrigerating system or a sub assembly by an approved, nationally recognized testing laboratory or shall be designed, constructed, and assembled to have an ultimate strength sufficient to withstand three times the design pressure for which it is rated.

Exception: Water-side components exempted from the rules of Section VIII of the *ASME Boiler and Pressure Vessel Code*[5] shall be designed, constructed, and assembled to have an ultimate strength sufficient to withstand 150 psig (1034 kPa) or two times the design pressure for which it is rated, whichever is greater.

9.11.2 Liquid-level-gage glass columns shall have automatic closing shut-off valves. All such glass columns shall be protected against external damage and properly supported.

Exception: Liquid-level-gage glasses of the bull's-eye type.

9.11.3 When a pressure gage is permanently installed on the highside of a refrigerating system, its dial shall be graduated to at least 1.2 times the design pressure.

9.11.4 Liquid receivers, if used, or parts of a system designed to receive the refrigerant charge during pumpdown shall have sufficient capacity to receive the pumpdown charge. The liquid shall not occupy more than 90% of the volume when the temperature of the refrigerant is 90°F (32°C).

Note: The receiver volume is not required to contain the total system charge but is required to contain the amount being transferred. If the environmental temperature is expected to rise above 122°F (50°C), the designer shall account for the specific expansion characteristics of the refrigerant.

9.12 Service Provisions

9.12.1 All serviceable components of refrigerating systems shall be provided with safe access.

9.12.2 Condensing units or compressor units with enclosures shall be provided with safe access without the need to climb over or remove any obstacles, or the use of portable access equipment.

9.12.3 All systems shall have provisions to handle the refrigerant charge for service purposes. When required, there shall be liquid and vapor transfer valves, a transfer compressor or pump, and refrigerant storage tanks or appropriate valved connections for removal by a reclaim, recycle, or recovery device.

9.12.4 Systems containing more than 6.6 lb (3 kg) of refrigerant shall have stop valves installed at the following locations:

a. the suction inlet of each compressor, compressor unit, or condensing unit;
b. the discharge of each compressor, compressor unit, or condensing unit; and
c. the outlet of each liquid receiver.

Exceptions: Systems that have a refrigerant pumpout function capable of storing the entire refrigerant charge, or are equipped with the provisions for pumpout of the refrigerant, or self-contained systems.

9.12.5 Systems containing more than 110 lb (50 kg) of refrigerant shall have stop valves installed at the following locations:

a. the suction inlet of each compressor, compressor unit, or condensing unit
b. the discharge outlet of each compressor, compressor unit, or condensing unit
c. the inlet of each liquid receiver, except for self-contained systems or where the receiver is an integral part of the condenser or condensing unit
d. the outlet of each liquid receiver
e. the inlet and outlet of condensers when more than one condenser is used in parallel in the system

Exceptions: Systems that have a refrigerant pumpout function capable of storing the entire refrigerant charge, or are equipped with the provisions for pumpout of the refrigerant, or self-contained systems.

9.12.6 Stop valves shall be suitably labeled if the components to and from which the valve regulates flow are not in view at the valve location. Valves or piping adjacent to the valves shall be identified in accordance with *ANSI A13.1*.[11] When numbers are used to label the valves, there shall be a key to the numbers located within sight of the valves with letters at least 0.5 in. (12.7 mm) high.

9.13 Fabrication

9.13.1 The following are requirements for unprotected refrigerant-containing copper pipe or tubing:

a. Copper tubing used for refrigerant piping shall conform to one of the following ASTM specifications: *B88*[7] types K or L or *B280*.[8] Where *ASTM B68*[9] and *B75*[10] tubing is used, the tube wall thickness shall meet or exceed the requirements of *ASTM B280*[8] for the given outside diameter.

b. Copper tube shall be connected by brazed joints, soldered joints, or compression fittings.

c. For groups A2, A3, B1, B2, and B3 refrigerants, protective metal enclosures shall be provided for annealed copper tube erected on the premises.

Exception: No enclosures shall be required for connections between a condensing unit and the nearest protected riser if such connections are not longer than 6.6 ft (2 m) in length.

9.13.2 Joints on refrigerant-containing copper tube that are made by the addition of filler metal shall be brazed.

Exception: A1 refrigerants.

9.14 Factory Tests

9.14.1 All refrigerant-containing parts or unit systems shall be tested and proved tight by the manufacturer at not less than the design pressure for which they are rated. Pressure vessels shall be tested in accordance with Section 9.3.

9.14.1.1 Testing Procedure. Tests shall be performed with dry nitrogen or another nonflammable, nonreactive, dried gas. Oxygen, air, or mixtures containing them shall not be used. The means used to build up the test pressure shall have either a pressure-limiting device or a pressure-reducing device and a gage on the outlet side. The pressure-relief device shall be set above the test pressure but low enough to prevent permanent deformation of the system's components.

Exceptions:

a. Mixtures of dry nitrogen, inert gases, nonflammable refrigerants allowed for factory tests.

b. Mixtures of dry nitrogen, inert gases, or a combination of them with flammable refrigerants in concentrations not exceeding the lesser of a refrigerant weight fraction (mass fraction) of 5% or 25% of the LFL are allowed for factory tests.

c. Compressed air without added refrigerant is allowed for factory tests provided the system is subsequently evacuated to less than 1000 microns (132 Pa) before charging with refrigerant. The required evacuation level is atmospheric pressure for systems using R-718 (water) or R-744 (carbon dioxide) as the refrigerant.

9.14.2 The test pressure applied to the highside of each factory-assembled refrigerating system shall be at least equal to the design pressure of the highside. The test pressure applied to the lowside of each factory-assembled refrigerating system shall be at least equal to the design pressure of the lowside.

The pressure test on the complete unit shall not be conducted at the lowside design pressure per Section 9.2 unless the final assembly connections are made per *ASME B31.5*.[6] In this case, parts shall be individually tested by either the unit manufacturer or the manufacturer of the part at not less than the highside design pressure.

9.14.3 Units with a design pressure of 15 psig (103.4 kPa gage) or less shall be tested at a pressure not less than 1.33 times the design pressure and shall be proved leak-tight at not less than the lowside design pressure.

9.15 Nameplate. Each unit system and each separate condensing unit, compressor, or compressor unit sold for field assembly in a refrigerating system shall carry a nameplate marked with the manufacturer's name, nationally registered trademark or trade name, identification number, the design pressures, and the refrigerant for which it is designed. The refrigerant shall be designated by the refrigerant number (R number) as shown in Table 1. If the refrigerant is not listed in Table 1, the refrigerant shall be designated in accordance with Standard 34.[1]

10. OPERATION AND TESTING

10.1 Field Tests

10.1.1 Every refrigerant-containing part of every system that is erected on the premises, except compressors, condensers, evaporators, safety devices, pressure gages, control mechanisms, and systems that are factory-tested, shall be tested and proved tight after complete installation and before operation. The highside and lowside of each system shall be tested and proved tight at not less than the lower of the design pressure or the setting of the pressure-relief device protecting the highside or lowside of the system, respectively.

10.1.2 Testing Procedure. Tests shall be performed with dry nitrogen or another nonflammable, nonreactive, dried gas. Oxygen, air, or mixtures containing them shall not be used. The means used to build up the test pressure shall have either a pressure-limiting device or a pressure-reducing device and a gage on the outlet side. The pressure-relief device shall be set above the test pressure but low enough to prevent permanent deformation of the system's components.

Exceptions:

a. Mixtures of dry nitrogen, inert gases, or a combination of them with nonflammable refrigerants in concentrations of a refrigerant weight fraction (mass fraction) not exceeding 5% are allowed for tests.

b. Mixtures of dry nitrogen, inert gases, or a combination of them with flammable refrigerants in concentrations not exceeding the lesser of a refrigerant weight fraction (mass fraction) of 5% or 25% of the LFL are allowed for tests.

c. Compressed air without added refrigerant is allowed for tests provided the system is subsequently evacuated to less than 1000 microns (132 Pa) before charging with refrigerant. The required evacuation level is atmospheric pressure for systems using R-718 (water) or R-744 (carbon dioxide) as the refrigerant.

d. Systems erected on the premises using Group A1 refrigerant and with copper tubing not exceeding 0.62 in. (16 mm) outside diameter shall be tested by means of the refrigerant charged into the system at the saturated vapor pressure of the refrigerant at 68°F (20°C) minimum.

10.2 Declaration. A dated declaration of test shall be provided for all systems containing 55 lb (25 kg) or more of refrigerant. The declaration shall give the name of the refrigerant and the field test pressure applied to the highside and the lowside of the system. The declaration of test shall be signed by the installer and, if an inspector is present at the tests, the inspector shall also sign the declaration. When requested, copies of this declaration shall be furnished to the authority having jurisdiction.

11. GENERAL REQUIREMENTS

11.1 General Restrictions—Safeguards. Means shall be taken to adequately safeguard piping, controls, and other refrigerating equipment to minimize possible accidental damage or rupture by external sources.

11.2 Signs and Identification

11.2.1 Installation Identification. Each refrigerating system erected on the premises shall be provided with a legible permanent sign, securely attached and easily accessible, indicating

a. the name and address of the installer,
b. the refrigerant number and amount of refrigerant,
c. the lubricant identity and amount, and
d. the field test pressure applied.

11.2.2 Controls and Piping Identification. Systems containing more than 110 lb (50 kg) of refrigerant shall be provided with durable signs having letters not less than 0.5 in. (12.7 mm) in height designating:

a. Valves or switches for controlling the refrigerant flow, the ventilation, and the refrigeration compressor(s).
b. The kind of refrigerant or secondary coolant contained in exposed piping outside the machinery room. Valves or piping adjacent to valves shall be identified[12] in accordance with *ANSI A13.1, Scheme for Identification of Piping Systems*.[11]

11.2.3 Changes in Refrigerant or Lubricant. When the kind of refrigerant or lubricant is changed as provided in Section 7.5.1.8, the signs required by Sections 11.2.1 and 11.2.2 shall be replaced, or added if not present, to identify the refrigerant and lubricant used.

11.2.4 Each entrance to a refrigerating machinery room shall be provided with a legible permanent sign, securely attached and easily accessible, reading "Machinery Room – Authorized Personnel Only." The sign shall further communicate that entry is forbidden except by those personnel trained in the emergency procedures required by Section 11.7 when the refrigerant alarm, required by Section 8.11.2.1, has been activated.

11.3 Charging, Withdrawal, and Disposition of Refrigerants. No service containers shall be left connected to a system except while charging or withdrawing refrigerant. Refrigerants withdrawn from refrigerating systems shall be transferred to approved containers only. Except for discharge of pressure-relief devices and fusible plugs, incidental releases due to leaks, purging of noncondensibles, draining oil, and other routine operating or maintenance procedures, no refrigerant shall be discharged to the atmosphere or to locations such as a sewer, river, stream, or lake.

11.4 Containers. Containers used for refrigerants withdrawn from a refrigerating system shall be as prescribed in the pertinent regulations of the Department of Transportation and shall be carefully weighed each time they are used for this purpose, and containers shall not be filled in excess of the permissible filling weight.

11.5 Storing Refrigerant. The total amount of refrigerant stored in a machinery room in all containers not provided with relief valves and piping in accordance with Section 9.7 shall not exceed 330 lb (150 kg). Refrigerant shall be stored in approved storage containers. Additional quantities of refrigerant shall be stored in an approved storage facility.

11.6 Maintenance. Refrigerating systems shall be maintained by the user in a clean condition, free from accumulations of oily dirt, waste, and other debris, and shall be kept accessible at all times.

11.6.1 Stop Valves. Stop valves connecting refrigerant-containing parts to atmosphere during shipping, testing, operating, servicing, or standby conditions shall be capped, plugged, blanked, or locked closed when not in use.

11.6.2 Calibration of Pressure-Measuring Equipment. Pressure-measuring equipment shall be checked for accuracy and calibrated prior to test and immediately after every occasion of unusually high (full-scale) pressure, either by comparison with master gages or a dead-weight pressure gage tester, over the operating range of the equipment.

11.6.3 Periodic Tests. Detector(s), alarm(s), and mechanical ventilating systems shall be tested in accordance with manufacturers' specifications and the requirements of the jurisdiction having authority.

11.7 Responsibility for Operation and Emergency Shutdown. It shall be the duty of the person in charge of the premises on which a refrigerating system containing more than 55 lb (25 kg) of refrigerant is installed to provide a schematic drawing or panel giving directions for the operation of the system at a location that is convenient to the operators of the equipment.

Emergency shutdown procedures, including precautions to be observed in case of a breakdown or leak, shall be displayed on a conspicuous card located as near as possible to the refrigerant compressor. These precautions shall address

a. instructions for shutting down the system in case of emergency;
b. the name, address, and day and night telephone numbers for obtaining service; and
c. the names, addresses, and telephone numbers of all corporate, local, state, and federal agencies to be contacted as required in the event of a reportable incident.

When a refrigerating machinery room is used, the emergency procedures shall be posted outside the room, immediately adjacent to each door.

The emergency procedures shall forbid entry into the refrigerating machinery room when the refrigerant alarm required by Section 8.11.2.1 has been activated except by persons provided with the appropriate respiratory and other protective equipment and trained in accordance with jurisdictional requirements.

12. PRECEDENCE WITH CONFLICTING REQUIREMENTS

Where there is a conflict between this standard and local building, electrical, fire, mechanical, or other adopted codes, their provisions shall take precedence unless otherwise stated in those codes. No provision in this standard shall be deemed to restrict the authority of local building, electrical, fire, mechanical, or other officials from approving plans, performing inspections, allowing use of alternative methods and/or materials, or otherwise enforcing adopted codes.

13. LISTED EQUIPMENT

Equipment listed by an approved, nationally recognized testing laboratory and identified, as part of the listing, as being in conformance with this standard is deemed to meet the design, construction of equipment, and factory test requirement sections of this standard for the refrigerant or refrigerants for which the equipment was designed.

(This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

INFORMATIVE APPENDIX A CALCULATIONS OF THE MAXIMUM ALLOWABLE CONCENTRATION (C_M) OF A BLEND

A1. FOR 100 LB OF BLEND, DETERMINE THE IDEAL GAS VOLUMES OCCUPIED BY EACH COMPONENT AND BY THE BLEND AT 70°F AND 1 ATM

$387\ W_1/(MW_1) = V_1 \quad V_T = V_1 + V_2 \ldots V_i$

$387\ W_2/(MW_2) = V_2$

—

—

—

$387\ W_i/(MW_i) = V_i$

W_i = weight (lb) of component i in 100 lb of blend

MW_i = molecular weight of component i

V_i = volume (ft^3) of component i in 100 lb of blend at 70°F and 1 atm pressure

V_T = volume (ft^3) of the blend at 70°F and 1 atm pressure

A2. DETERMINE THE DILUTION VOLUME REQUIRED FOR THE 100 LB OF BLEND AND EACH COMPONENT THEREIN

$V_1/LV_1 = DV_1$

—

—

—

$V_i/LV_i = DV_i$

$V_T/LV_{max} = DV_T$

LV_i = (limiting volume percent from Table 1)/100

DV_i = dilution volume required for weight (W_i) of component i

LV_{max} = the highest value of LV_i

A3. DETERMINE THE MAXIMUM ALLOWABLE CONCENTRATION (C_m) OF A BLEND

C_m = (100 lb/DV_{max})1000

C_m = the maximum allowable concentration of blend lb/1000 ft^3 (multiply this value by 0.016 to obtain D_m in kg/m^3)

DV_{max} = the largest of the values DV_1, DV_2, DV_i, DV_T

(This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

INFORMATIVE APPENDIX B GUIDELINES FOR EMERGENCY DISCHARGE OF REFRIGERANTS WHEN REQUIRED BY LOCAL CODES

B1. INTRODUCTION

a. Every precaution should be taken to prevent the accidental or deliberate discharge of refrigerants to the atmosphere, to the sewer, or into local lakes and rivers.
b. Nevertheless, this appendix is provided to aid the design engineer where local codes require manual emergency discharge systems for refrigerants.
c. It is permissible to use any departures suggested herein from provisions in the mandatory parts of this standard when granted by the authority having jurisdiction.

B2. EMERGENCY DISCHARGE LINES

An emergency discharge pipeline, independent of any other lines, shall be connected above the liquid refrigerant level on the high-pressure side and, when required by local codes, on the low-pressure side of the system. The lines shall be pitched so as to drain to the system. These lines shall extend into an emergency refrigerant control box. This box shall be locked and identified with a permanent label reading “Emergency Refrigerant Control Box” with the name of the refrigerant in the system.

B3. STOP VALVES

A readily accessible stop valve and a suitable pressure gage shall be installed on the discharge pipe within the emergency refrigerant control box. The gage shall be located ahead of the stop valve, and the valve shall have the same capacity as the discharge pipe it serves. A permanent label shall be attached to the valve reading “High-Pressure Refrigerant Discharge Valve” or “Low-Pressure Refrigerant Discharge Valve” as appropriate.

B4. SIZING VALVES AND LINES

Determine the size of the discharge line and the stop valve from the required capacity per Section 9.7.5 and the length per Section 9.7.8.5.

B5. HIGH- TO LOW-PRESSURE VALVE

When both highside and lowside emergency discharge valves are located in a common box, a stop valve connecting them on the system side of the emergency discharge stop valves shall be provided in the box. The stop valve and line shall be the same size as the higher pressure line. This valve shall be labeled “High- to Low-Pressure Control Valve.”

B6. DIFFUSER

The discharge line (B4) shall be vented to the atmosphere through a diffuser fitted to its upper extremity. The diffuser shall provide for mixing the refrigerant with air and shall have a rain cap or means to prevent water from easily entering the vent pipe.

B7. SIZING HEADERS AND DIFFUSERS

When more than one relief valve or emergency discharge line is connected to a common header or riser for discharge to the atmosphere, a diffuser shall be installed on the common riser. The area of the header or riser and the diffuser inlet shall be equal to the sum of the areas of all of the relief valve vent lines and emergency discharge lines feeding it.

B8. LOCATION OF DIFFUSER

The diffuser shall be located per Section 9.7.8 for discharge to the atmosphere.

B9. PROVIDE DRIP LEGS

Adequately sized drip pockets for collecting moisture shall be installed on every emergency line beyond the emergency valve exposed to the atmosphere.

B10. AMMONIA DIFFUSION SYSTEMS

Ammonia may be released from refrigerating systems to the atmosphere in the event of an emergency. If this is done by employees of the refrigerated facility, it may be subject to the reporting requirements of the Emergency Planning and Community Right-to-Know Act of 1986. In locations where atmospheric release may be hazardous due to the proximity of people or other premises, the diffuser shall be equipped with an automatic burner for reducing the discharge to nitrogen and water, or such emergency system shall discharge into a storage tank (per Section 9.7.8.2) or into a water mixer (B15) and retention tank (B13) or basin (B14).

B11. AMMONIA DISCHARGE LINES

For emergency discharge line connections to the system, the stop valves and control box shall be as described above.

B12. AMMONIA FLARES

Systems for reducing the ammonia to nitrogen and water by burning shall be approved by the jurisdictional authority.

B13. WATER TANKS

Water tanks shall be as specified in Section 9.7.8.2.

B14. BASINS

Retention basins shall meet the requirements as set forth by the fire chief in the local jurisdiction.

B15. AMMONIA-WATER MIXERS

Ammonia-water mixers shall have the following components:

a. Connection to a permanent water supply with a capacity as in (c).
b. A fire department inlet hose connection to the diffuser adjacent to the Emergency Refrigeration Control Box.
c. An engineered ammonia-water mixing chamber, sized to provide 2 gpm of water per lb/min of ammonia (17 L/s water per kg/s ammonia). The ammonia flow can be estimated at 77% of the equivalent airflow calculated for the discharge line from Sections 9.7.5 and 9.7.8.5.
d. Connection to an approved storage tank, basin, or drainage system by means of welded or flanged piping.
e. Necessary control valves, check valves, and fittings.

B16. DESIGN RESPONSIBILITY

The design of the manual emergency discharging system and the components that comprise it, such as the diffusers for mixing refrigerants with air or water, as well as the design of tanks and holding basins, is the responsibility of the engineer.

(This is a normative appendix and is part of this standard.)

NORMATIVE APPENDIX C
REFRIGERANT CLASSIFICATION SCHEME

Refrigerants are classified by Standard 34[1] in a classification scheme illustrated in the following matrix:

Safety Group

Increasing Flammability ↑		
Higher Flammability	A3	B3
Lower Flammability	A2	B2
No Flame Propogation	A1	B1
	Lower Toxicity	Higher Toxicity

Increasing Toxicity →

(This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

INFORMATIVE APPENDIX D INFORMATIVE REFERENCES

This appendix contains full citations for informative references only. Full citations for normative references are listed in Appendix E. References in this standard are numbered in the order in which they appear in the document, so the numbers for the normative references are shown for the convenience of the user.

1. Not an informative reference.
2. Not an informative reference.
3. Not an informative reference.
4. Not an informative reference.
5. Not an informative reference.
6. Not an informative reference.
7. Not an informative reference.
8. Not an informative reference.
9. Not an informative reference.
10. Not an informative reference.
11. Not an informative reference.
12. *IIAR Bulletin 114-1991, Guidelines for Identification of Ammonia Refrigeration Piping and System Components*, International Institute of Ammonia Refrigeration, 1110 North Glebe Road, Suite 250, Arlington, VA 22201.
13. *2005 ASHRAE Handbook—Fundamentals*, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta, GA 30329.

(This is a normative appendix and is part of this standard.)

NORMATIVE APPENDIX E NORMATIVE REFERENCES

This appendix contains full citations for normative references. Full citations for references that are solely informative are included in Appendix D. Note that in some locations within the standard, normative references are also used as informative references. References in this standard are numbered in the order in which they appear in the document, so the numbers for the informative references are shown for the convenience of the user.

1. *ANSI/ASHRAE Standard 34-2001, Designation and Safety Classification of Refrigerants*, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta, GA 30329.
2. *ARI 700-1999, Specifications for Flourocarbon Refrigerants* and *ARI Standard 700c-1999, Appendix C to ARI Standard 700—Analytical Procedures for ARI Standard 700-99*, Air-Conditioning and Refrigeration Institute, 4100 North Fairfax Drive, Arlington, VA 22203.
3. *UL 1995-1995 Heating and Cooling Equipment*, Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062.
4. *NFPA 70-2002, National Electrical Code®,* National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02269-9101.
5. *ANSI/ASME Boiler and Pressure Vessel Code*, Section VIII, Rules for Construction of Pressure Vessels, Division 1, 2001, American Society of Mechanical Engineers (ASME), 3 Park Avenue, New York, NY 10016-5990.

   Note: Reference 5 is mandatory for designers, manufacturers, and producers of refrigeration equipment. For all other users, this reference is informative.
6. *ANSI//ASME B31.5-2001, Refrigeration Piping and Heat Transfer Components*, American Society of Mechanical Engineers (ASME), 3 Park Avenue, New York, NY 10016-5990.

   Note: Reference 6 is mandatory for designers, manufacturers, and producers of refrigeration equipment. For all other users, this reference is informative.
7. *ANSI/ASTM B88-99e1, Standard Specification for Seamless Copper Water Tube*, American Society for Testing and Materials (ASTM), 100 Barr Harbor Drive, West Conshohocken, PA 19428.
8. *ANSI/ASTM B280-99e1, Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service*, American Society for Testing and Materials (ASTM),100 Barr Harbor Drive, West Conshohocken, PA 19428.
9. *ANSI/ASTM B68-99, Standard Specification for Seamless Copper Tube, Bright Annealed*, American Society for Testing and Materials (ASTM), 100 Barr Harbor Drive, West Conshohocken, PA 19428.
10. *ANSI/ASTM B75-99, Standard Specification for Seamless Copper Tube*, American Society for Testing and Materials (ASTM), 100 Barr Harbor Drive, West Conshohocken, PA 19428.
11. *ANSI/ASME A13.1-1996, Scheme for the Identification of Piping Systems*, American Society of Mechanical Engineers (ASME), 3 Park Avenue, New York, NY 10016-5990.
12. Not a normative reference.
13. Not a normative reference.

(This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

INFORMATIVE APPENDIX F METHOD FOR CALCULATING DISCHARGE CAPACITY OF POSITIVE DISPLACEMENT COMPRESSOR PRESSURE-RELIEF DEVICE

The following calculation method provides the required discharge capacity of the compressor pressure-relief device in Section 9.8:*

$$W_r = \frac{Q \cdot PL \cdot \eta_v}{v_g} \quad \text{(F-1)}$$

where

W_r = mass flow of refrigerant, lb_m/min (kg/s)

Q = swept volume flow rate of compressor, ft^3/min (m^3/s)

PL = fraction of compressor capacity at minimum regulated flow

η_v = volumetric efficiency (assume 0.9 unless actual volumetric efficiency at relieving pressure is known)

v_g = specific volume of refrigerant vapor as specified in Section 9.8, ft^3/lb_m (m^3/kg)

Next, find the relieving capacity in mass flow of air, W_a, for an ASME-rated (Reference 5 in Appendix E) pressure-relief device:

$$W_a = W_r \cdot r_w \quad \text{(F-2)}$$

$$r_w = \frac{C_a}{C_r}\sqrt{\frac{T_r}{T_a}}\sqrt{\frac{M_a}{M_r}} \quad \text{(F-2a)}$$

where

r_w = refrigerant-to-standard-air-mass-flow conversion factor

M_r = molar mass of refrigerant (see table below)

M_a = molar mass of air = 28.97

T_a = absolute temperature of the air = 520 R (289 K)

C_a = constant for air = 356

C_r = constant for refrigerant (as determined from Equation F-2b)

T_r = absolute temperature of refrigerant = 510 R (283 K)

* Section 9.8 permits the discharge capacity of the relief device to be the minimum regulated flow rate of the compressor when the following conditions are met: (a) the compressor is equipped with capacity regulation, (b) capacity regulation actuates to minimum flow at 90% of the pressure-relief device setting, and (c) the pressure-limiting device is installed and set in accordance with the requirements of Section 9.9.

$$C_r = 520\sqrt{k\left(\frac{2}{k+1}\right)^{\frac{k+1}{k-1}}} \quad \text{(F-2b)}$$

where

k = ratio of specific heats (C_p/C_v)

C_p = constant-pressure specific heat of refrigerant at a refrigerant quality of 1 at 50°F (10°C)

C_v = constant-volume specific heat of refrigerant at a refrigerant quality of 1 at 50°F (10°C)

Constants for several refrigerants are listed in the following table.

Refrigerant	k*	Molar Mass†	C_r	r_w
R-11	1.137	137.4	330.7	0.49
R-12	1.205	120.9	337.7	0.51
R-13	2.053	104.5	403.6	0.46
R-22	1.319	86.5	348.8	0.59
R-23	2.742	70.0	439.3	0.52
R-113	1.081	187.4	324.7	0.43
R-114	1.094	170.9	326.1	0.45
R-123	1.104	152.9	327.1	0.47
R-134a	1.196	102.0	336.8	0.56
R-236fa	1.101	152.0	326.8	0.47
R-245fa	1.107	134.0	327.5	0.50
R-290	1.235	44.1	340.8	0.84
R-404A	1.279	97.6	345.0	0.56
R-407C	1.270	86.2	344.1	0.59
R-410A	1.434	72.6	359.0	0.62
R-500	1.236	99.3	340.8	0.56
R-502	1.264	111.6	343.6	0.52
R-507A	1.284	98.9	345.5	0.55
R-600	1.122	58.1	329.2	0.76
R-717	1.422	17.0	358.0	1.28
R-718	1.328	18.0	349.6	1.28
R-744	2.690	44.0	437.0	0.65

* Source: *NIST Refprop, Standard Reference Database 23*, Version 7, 2002.
† Source: *IUPAC Atomic Weights*, 2003.

Example: Determine the flow capacity of a relief device for an ammonia (R-717) screw compressor with a swept volume, Q, of 1,665 ft^3/min (0.7858 m^3/s). The compressor is equipped with capacity control that is actuated at 90% of the pressure relief device set pressure to its minimum regulated flow of 10%.

$$Q = 1{,}665\ ft^3/min\ (0.7858\ m^3/s)$$

$$\eta_v = 0.90, \text{ assumed}$$

$$PL = 0.1$$

$$v_g = 3.2997\ ft^3/lb_m\ (0.206\ m^3/kg)$$

$$W_r = \frac{1665\frac{\text{ft}^3}{\text{min}} \cdot 0.1 \cdot 0.9}{3.2997\frac{\text{ft}^3}{\text{lb}_\text{m}}} = 45.4\frac{\text{lb}_\text{m}}{\text{min}} \qquad \text{(see F-1)}$$

$$\left[W_r = \frac{0.7858\frac{\text{m}^3}{\text{s}} \cdot 0.1 \cdot 0.9}{0.206\frac{\text{m}^3}{\text{kg}}} = 0.343\frac{\text{kg}}{\text{s}}\right]$$

$$W_a = W_r \cdot r_w = 45.4 \cdot 1.28 = 58.1\frac{\text{lb}_\text{m}}{\text{min}} \text{ of air} \qquad \text{(see F-2)}$$

$$\left[W_a = W_r \cdot r_w = 0.343 \cdot 1.28 = 0.439\frac{\text{kg}}{\text{s}} \text{ of air}\right]$$

Converting to standard cubic feet per minute (SCFM), where V_a = specific volume of air = 13.1 ft^3/lb$_\text{m}$ (0.818 m^3/kg) for dry air at 60°F (15.6°C),

$$\text{SCFM} = 13.1(58.1) = 761 \text{ ft}^3/\text{min}$$

$$[\text{SCFM} = 0.818(0.439) = 0.359 \text{ m}^3/\text{s}].$$

APPENDIX G—RESERVED FOR FUTURE USE

(This is a normative appendix and is part of this standard.)

NORMATIVE APPENDIX H ALLOWABLE EQUIVALENT LENGTH OF DISCHARGE PIPING

The design back pressure due to flow in the discharge piping at the outlet of pressure-relief devices and fusible plugs, discharging to atmosphere, shall be limited by the allowable equivalent length of piping determined by Equations H-1 or H-2. See Table 3 for the flow capacity of various equivalent lengths of discharge piping for conventional relief valves.

$$L = \frac{0.2146 d^5 (P_0^2 - P_2^2)}{f C_r^2} - \frac{d^* \ln(P_0/P_2)}{6f} \qquad \text{(H-1)}$$

$$\left[L = \frac{7.4381 \times 10^{-15} d^5 (P_0^2 - P_2^2)}{f C_r^2} - \frac{d^* \ln(P_0/P_2)}{500f}\right] \qquad \text{(H-2)}$$

where

L	=	equivalent length of discharge piping, ft (m)
C_r	=	rated capacity as stamped on the relief device in lb/min (kg/s), or in SCFM multiplied by 0.0764, or as calculated in 9.7.7 for a rupture member or fusible plug, or as adjusted for reduced capacity due to piping as specified by the manufacturer of the device, or as adjusted for reduced capacity due to piping as estimated by an approved method
f	=	Moody friction factor in fully turbulent flow (see typical values below)
d	=	inside diameter of pipe or tube, in (mm)
ln	=	natural logarithm
P_2	=	absolute pressure at outlet of discharge piping, psi (kPa)
P_0	=	allowed back pressure (absolute) at the outlet of pressure relief device, psi (kPa)

For the allowed back pressure (P_0), use the percent of set pressure specified by the manufacturer, or, when the allowed back pressure is not specified, use the following values, where P is the set pressure:

- for conventional relief valves, 15% of set pressure, $P_0 = (0.15\ P)$ + atmospheric pressure.
- for balanced relief valves, 25% of set pressure, $P_0 = (0.25\ P)$ + atmospheric pressure.
- for rupture members, fusible plugs, and pilot operated relief valves, 50% of set pressure, $P_0 = (0.50\ P)$ + atmospheric pressure.

Note: For fusible plugs, P is the saturated absolute pressure for the stamped temperature melting point of the fusible plug or the critical pressure of the refrigerant used, whichever is smaller, psi (kPa), and atmospheric pressure is at the elevation of the installation above sea level. A default value is the atmospheric pressure at sea level, 14.7 psi (101.325 kPa).

Typical Moody friction factors (f) for fully turbulent flow:

Tubing OD (in.)	DN	ID (in.)	f	Piping NPS	DN	ID (in.)	f
3/8	8	0.315	0.0136	1/2	15	0.622	0.0259
1/2	10	0.430	0.0128	3/4	20	0.824	0.0240
5/8	13	0.545	0.0122	1	25	1.049	0.0225
3/4	16	0.666	0.0117	1 1/4	32	1.380	0.0209
7/8	20	0.785	0.0114	1 1/2	40	1.610	0.0202
1 1/8	25	1.025	0.0108	2	50	2.067	0.0190
1 3/8	32	1.265	0.0104	2 1/2	65	2.469	0.0182
1 5/8	40	1.505	0.0101	3	80	3.068	0.0173
				4	100	4.026	0.0163
				5	125	5.047	0.0155
				6	150	6.065	0.0149

(This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

INFORMATIVE APPENDIX I EMERGENCIES IN REFRIGERATING MACHINERY ROOMS

This standard specifies refrigerating machinery rooms under some conditions to reduce risks from large refrigerating systems and large amounts of refrigerant. One purpose of the requirements is to warn of emergencies in the refrigerating machinery room. The refrigerant detector required by Section 8.11.2.1 triggers alarms inside and outside the refrigerating machinery room; signage warns refrigeration technicians and bystanders not to enter when the alarm has activated.

This appendix provides guidance on integrating the minimum emergency warning and training requirements of this standard with measures often taken in occupational health and safety programs.

The requirements in the standard provide minimum protection to help prevent injury from refrigerating machinery room accidents. Minimal conformance to the standard's specifications does not necessarily facilitate the convenient handling of incidents in the room. For example, if only the minimum protective steps are taken, refrigeration technicians may not reenter the machinery room after an alarm has sounded (to silence the alarm and repair any damage) without calling on the services of emergency responders (generally the local hazardous materials team). Many other approaches are possible, especially in facilities that prepare sophisticated emergency response plans.

I1. ALARM LEVELS

A refrigerant level above the TLV-TWA activates the alarms required by Section 8.11.2.1. If personnel working in the refrigerating machinery room are not provided with and trained to use respiratory protection equipment appropriate for the refrigerant (such as canister respirators or self-contained breathing apparatus), they must leave the room immediately. Presence of refrigerant above the TLV-TWA does not by itself signal an emergency; many routine service operations can create such levels. Local or national regulations often prescribe that steps be taken to protect the health and safety of personnel working in the machinery room when refrigerant concentrations rise above the TLV-TWA.

In a more sophisticated facility, with appropriate training and other measures specified by local regulations, refrigeration technicians might use this alarm as a signal to don respiratory protection. Evacuation of the machinery room may not be necessary, although warning bystanders not to enter still is. Selection of the proper respiratory protection for the particular situation may require additional information (e.g., whether or not the refrigerant concentration is above the IDLH level).

Note that donning respiratory protection is a last-resort option under most industrial hygiene regimens; it is preferable to provide engineering controls to reduce refrigerant concentrations to tolerable levels. The refrigerant detector required by Section 8.11.2.1 activates the machinery room ventilation automatically. In many cases, this may be entirely adequate to reduce the concentration, and respiratory protection may not be needed. (An alarm silence switch is useful for situations where personnel are to remain working in the room.)

I2. ALTERNATE REFRIGERANT LEVEL MEASUREMENTS

The required alarms signal only that refrigerant was detected at concentrations above the TLV-TWA. Some facilities may find it useful to have multiple levels of alarms or to provide an instrument that indicates the actual refrigerant level (digital readout in parts per million refrigerant). Selecting proper respiratory protection for technicians or other responders, as mentioned above, is one reason. This is perfectly acceptable, provided that the additional alarms or indicators are clearly distinguished from the main alarm. Bystanders should not be confused by the alarm arrangements.

The main alarm must still be *manual-reset only*. It is unwise to rely on automatic detectors to announce that an event is over. A technician could not distinguish between an alarm that reset when the refrigerant concentration dropped (e.g., because ventilation fans controlled the incident) and one that reset because the refrigerant detector was damaged. In the latter case, anyone entering the refrigerating machinery room might be entering a hazardous area. Alarms or indicators intended to communicate current conditions inside the refrigeration machinery room may, of course, be automatically resetting.

I3. REENTRY INTO REFRIGERATING MACHINERY ROOMS

Reentering an area during an emergency requires sophisticated equipment and training; many national and local regulations govern such activities. Prepositioning emergency response equipment (e.g., self-contained breathing apparatus) should be done only by arrangement with emergency responders, and any prepositioned equipment should be clearly labeled for use by trained personnel only. Doing otherwise invites unauthorized use (or vandalism) by untrained personnel, with dangerous consequences.

Facilities should note, however, that the alarms required in this standard annunciate not that an emergency is occurring but that an abnormal situation is occurring. It may be acceptable for trained personnel to enter the refrigerating machinery room to investigate the situation, repair minor leaks, reset alarms tripped in error, etc. Any personnel required to enter should be provided with appropriate personal protective equipment (especially respiratory protection, if needed) and should be trained to recognize an emergency situation requiring professional emergency response.

I4. EXAMPLE EMERGENCY PROCEDURES

As an example (and there are many other possibilities), consider a facility that wishes to use its own technicians to handle minor problems in the refrigerating machinery room. The facility takes the following steps:

1. Provides the refrigerant alarm required by Section 8.11.2.1, along with signage warning "Authorized Personnel Only. Stay Out When Refrigerant Alarm Sounds; Call Facilities Management Immediately." This alarm triggers at the TLV-TWA.
2. Provides a digital readout of the current refrigerant detector reading outside the refrigerating machinery room. A sign distinguishes the current-reading indicator from the alarm-activation indicator required by Section 8.11.2.1.
3. Provides the refrigeration technicians with appropriate respiratory protection suitable for use in an atmosphere containing refrigerant in concentrations below the IDLH, in accordance with all applicable national and local regulations.
4. Defines as "incidental" any refrigerant release that is not producing levels above the IDLH in the machinery room. (The ventilating system will render many potential releases incidental.)
5. Trains the technicians to leave the refrigerating machinery room when the refrigerant alarm sounds. After donning appropriate respiratory protection (if necessary), they may reenter the machinery room to close valves, fix leaks, shut off alarms, etc., *if and only if* the current refrigerant level is below the IDLH. That is, technicians may reenter the room if the refrigerant release is incidental. If the level exceeds the IDLH or the problem seems uncontrolled in the sense that it may unpredictably worsen or require a team of technicians to fix, they are to leave and call for emergency responders.
6. Coordinates emergency procedures with the local emergency response agencies in advance.

None of these steps contradicts the requirements of the standard, but the additional procedures significantly aid the facility's efforts to handle minor maintenance problems safely.

(This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

INFORMATIVE APPENDIX J
ADDENDA DESCRIPTION INFORMATION

ANSI/ASHRAE Standard 15-2007 incorporates ANSI/ASHRAE Standard 15-2004 and Addenda b and c to ANSI/ASHRAE Standard 15-2004. Table J-1 lists each addendum and describes the way in which the standard is affected by the change. It also lists the ASHRAE and ANSI approval dates for the addenda.

TABLE J-1 Addenda to ANSI/ASHRAE Standard 15-2004

Addendum	Section(s) Affected	Description of Changes*	ASHRAE Standards Approval	ASHRAE Board of Directors Approval	ANSI Approval
15b	9.7.8.1	Modified requirements to enhance the safety of pressure relief internal to systems.	1/21/06	1/26/06	1/27/06
15c	Informative Appendix F	Expanded list of refrigerants and properties needed for relief-capacity determination for positive displacement compressors. Also revised the method of relief-capacity determination to more clearly illustrate capacity determination for compressors equipped with capacity modulation.	6/24/06	6/29/06	3/3/07

* These descriptions may not be complete and are provided for information only.

NOTE

When addenda, interpretations, or errata to this standard have been approved, they can be downloaded free of charge from the ASHRAE Web site at http://www.ashrae.org.

NOTICE

INSTRUCTIONS FOR SUBMITTING A PROPOSED CHANGE TO THIS STANDARD UNDER CONTINUOUS MAINTENANCE

This standard is maintained under continuous maintenance procedures by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. SSPC consideration will be given to proposed changes at the Annual Meeting (normally June) if proposed changes are received by the Manager of Standards (MOS) no later than December 31. Proposals received after December 31 shall be considered by the SSPC no later than at the Annual Meeting of the following year.

Proposed changes must be submitted to the MOS in the latest published format available from the MOS. However, the MOS may accept proposed changes in an earlier published format if the MOS concludes that the differences are immaterial to the proposed change submittal. If the MOS concludes that a current form must be utilized, the proposer may be given up to 20 additional days to resubmit the proposed changes in the current format.

ELECTRONIC PREPARATION/SUBMISSION OF FORM FOR PROPOSING CHANGES

An electronic version of each change, which must comply with the instructions in the Notice and the Form, is the preferred form of submittal to ASHRAE Headquarters at the address shown below. The electronic format facilitates both paper-based and computer-based processing. Submittal in paper form is acceptable. The following instructions apply to change proposals submitted in electronic form.

Use the appropriate file format for your word processor and save the file in either a recent version of Microsoft Word (preferred) or another commonly used word-processing program. Please save each change proposal file with a different name (for example, "prop01.doc," "prop02.doc," etc.). If supplemental background documents to support changes submitted are included, it is preferred that they also be in electronic form as word-processed or scanned documents.

ASHRAE will accept the following as equivalent to the signature required on the change submittal form to convey non-exclusive copyright:

Files attached to an e-mail:	Electronic signature on change submittal form (as a picture; *.tif, or *.wpg).
Files on a CD:	Electronic signature on change submittal form (as a picture; *.tif, or *.wpg) or a letter with submitter's signature accompanying the CD or sent by facsimile (single letter may cover all of proponent's proposed changes).

Submit an e-mail or a CD containing the change proposal files to:
Manager of Standards
ASHRAE
1791 Tullie Circle, NE
Atlanta, GA 30329-2305
E-mail: change.proposal@ashrae.org
(Alternatively, mail paper versions to ASHRAE address or fax to 404-321-5478.)

The form and instructions for electronic submittal may be obtained from the Standards section of ASHRAE's Home Page, www.ashrae.org, or by contacting a Standards Secretary, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305.
Phone: 404-636-8400. Fax: 404-321-5478. E-mail: standards.section@ashrae.org.

FORM FOR SUBMITTAL OF PROPOSED CHANGE TO AN ASHRAE STANDARD UNDER CONTINUOUS MAINTENANCE

NOTE: Use a separate form for each comment. Submittals (Microsoft Word preferred) may be attached to e-mail (preferred), submitted on a CD, or submitted in paper by mail or fax to ASHRAE, Manager of Standards, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: change.proposal@ashrae.org. Fax: +1-404/321-5478.

1. Submitter:

Affiliation:

Address: City: State: Zip: Country:

Telephone: Fax: E-Mail:

I hereby grant the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) the non-exclusive royalty rights, including non-exclusive rights in copyright, in my proposals. I understand that I acquire no rights in publication of the standard in which my proposals in this or other analogous form is used. I hereby attest that I have the authority and am empowered to grant this copyright release.

Submitter's signature: ____ Date: ____________________________

All electronic submittals must have the following statement completed:

I *(insert name)*____, through this electronic signature, hereby grant the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) the non-exclusive royalty rights, including non-exclusive rights in copyright, in my proposals. I understand that I acquire no rights in publication of the standard in which my proposals in this or other analogous form is used. I hereby attest that I have the authority and am empowered to grant this copyright release.

2. Number and year of standard:

3. Page number and clause (section), subclause, or paragraph number:

4. I propose to: *(check one)*

[ ] Change to read as follows
[ ] Delete and substitute as follows
[ ] Add new text as follows
[ ] Delete without substitution

Use underscores to show material to be added (added) and strike through material to be deleted (~~deleted~~). Use additional pages if needed.

5. Proposed change:

6. Reason and substantiation:

7. Will the proposed change increase the cost of engineering or construction? If yes, provide a brief explanation as to why the increase is justified.

[ ] Check if additional pages are attached. Number of additional pages: _______

[ ] Check if attachments or referenced materials cited in this proposal accompany this proposed change. Please verify that all attachments and references are relevant, current, and clearly labeled to avoid processing and review delays. *Please list your attachments here:*

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ERRATA SHEET FOR FIRST PRINTING
ANSI/ASHRAE STANDARD 15-2007,
Safety Standard for Refrigeration Systems

June 11, 2007

The corrections listed in this errata sheet apply to the first printing of ANSI/ASHRAE Standard 15-2007. The outside back cover marking identifying the first printing is "86017 PC 4/07".

Page	**Erratum**
8	**Section 7.2.2 Industrial Occupancies and Refrigerated Rooms.** Change the first sentence of Section 7.2.2 to read as follows: *(Additions are shown in underline and deletions in ~~strikethrough~~.)* "Section 7.2 ~~7.3~~ does not apply in industrial occupancies and refrigerated rooms where the following seven conditions are met:"