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Technical Committee on Mechanical Refrigeration Code vi

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# B52-05

## ***Mechanical refrigeration code***

### **1 Scope**

#### **1.1 Purpose**

The purpose of this Standard is to minimize the risk of personal injury by providing minimum requirements for the design, construction, installation, inspection, and maintenance of the mechanical refrigeration systems specified in Clauses 1.2.1 and 1.2.2.

**Note:** *This Standard does not directly address protection of property and preservation of the environment.*

#### **1.2 Application**

##### **1.2.1**

Except as specified in Clause 1.2.3, this Standard applies to the design, construction, installation, inspection, and maintenance of every refrigeration system as provided for by the Act (as defined in Clause 3) and identified in this Standard.

##### **1.2.2**

This Standard applies to

- (a) all refrigeration systems installed subsequent to its adoption. This includes refrigeration systems installed in a new or existing premises. It also applies to all premises, including the machinery room if required, in which a refrigeration system is to be installed;
- (b) refrigeration systems that undergo a substitution of refrigerant in a premises defined in Item (a) above; and
- (c) those parts of a refrigeration system that are replaced in, or added to, systems installed prior to its adoption.

**Note:** *When adding or replacing parts (see Item (c)), consideration should be given to the premises requirements of Item (a).*

##### **1.2.3**

This Standard does not apply to the following:

- (a) the use of water or air as a refrigerant;
- (b) bulk-storage gas tanks not permanently connected to a refrigeration system;
- (c) refrigeration systems installed on railroad cars, motor vehicles, motor-drawn vehicles, aircraft, or ships; and
- (d) refrigeration systems used for air conditioning in private residences.

#### **1.3 Mandatory language**

In CSA Standards, “shall” is used to express a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard; “should” is used to express a recommendation or that which is advised but not required; and “may” is used to express an option or that which is permissible within the limits of the standard; and “can” is used to express possibility or capability. Notes accompanying clauses do not include requirements or alternative requirements; the purpose of a note accompanying a clause is to separate from the text explanatory or informative material. Notes to tables and figures are considered part of the table or figure and may be written as requirements. Legends to equations and figures are considered requirements. Annexes are designated normative (mandatory) or informative (non-mandatory) to define their application.

## 1.4 Units of measurement

The values given in SI (metric) units are the standard. The values given in parentheses are for information only. A list of conversion factors is provided in Annex D. Pressure, unless otherwise stated, is expressed in kilopascals above atmospheric pressure, i.e., gauge pressure.

## 2 Reference publications

This Standard refers to the following publications, and where such reference is made, it shall be to the edition listed below, including all amendments published thereto.

### **CSA (Canadian Standards Association)**

B51-03

*Boiler, pressure vessel, and pressure piping code*

CAN/CSA-B149.1-05

*Natural gas and propane installation code*

CAN/CSA-B149.2-05

*Propane storage and handling code*

C22.1-02

*Canadian electrical code, Part I*

C22.2 No. 63-93 (R2004)

*Household refrigerators and freezers*

C22.2 No. 92-1971 (R2004)

*Dehumidifiers*

C22.2 No. 117-1970 (R2002)

*Room air conditioners*

CAN/CSA-C22.2 No. 120-M91 (R2004)

*Refrigeration equipment*

C22.2 No. 128-95 (R1999)

*Vending machines*

CAN/CSA-C22.2 No. 236-95 (R2004)

*Heating and cooling equipment*

CAN/CSA-Z234.1-00

*Metric practice guide*

### **American Conference of Governmental Industrial Hygienists**

*Annual Manual of Threshold Limit Values*

### **ASHRAE (American Society of Heating, Refrigeration and Air-Conditioning Engineers)**

15-2004

*Safety Standard for Refrigeration Systems*

34-2004

*Designation and Safety Classification of Refrigerants*

**ASME (American Society of Mechanical Engineers)***Boiler and Pressure Vessel Code, 2004*

Section VIII — Pressure Vessels — Division 1

B31.5-2001

*Refrigeration Piping and Heat Transfer Components***ASTM International (American Society for Testing and Materials)**

B 88-03

*Standard Specification for Seamless Copper Water Tube*

B 280-03

*Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service*

D 93-02a

*Standard Test Methods for Flash-Point by Pensky-Martens Closed Cup Tester***National Research Council Canada***National Building Code of Canada, 2005*

### 3 Definitions and abbreviations

#### 3.1 Definitions

The following definitions apply in this Standard:

**Accepted** — acceptable to the regulatory authorities.

**Act** — the applicable provincial or territorial boiler and pressure vessel Act.

**Approved testing laboratory** — a testing laboratory, acceptable to the regulatory authorities, that provides uniform testing and examination procedures under established standards, is properly organized, equipped, and qualified for testing, and has an inspection service for follow-up inspections of the current production of listed equipment.

**Back pressure** — the static pressure at the outlet of an operating pressure-relief device due to pressure in the discharge line.

**Blends** — refrigerants consisting of mixtures of two or more chemical compounds.

**Brazed joint** — a gas-tight joint obtained by joining metal parts with alloys that melt at temperatures higher than 427 °C (800°F) but lower than the melting temperatures of the joined parts.

**Brine** — a secondary coolant that is a solution of a salt and water.

**Companion or block valves** — pairs of mating stop valves that valve off sections of refrigeration systems and are arranged in such a way that the sections can be joined before the valves are opened or can be separated after they are closed.

**Compressor** — a machine, with or without accessories, for compressing a specific refrigerant vapour.

**Compressor unit** — a combination of one or more compressors with their associated prime movers.

**Condenser** — that part of a refrigeration system designed to liquefy refrigerant vapour by removing heat.

**Condenser coil** — a condenser constructed of pipe or tubing, other than a shell-and-tube or shell-and-coil type.

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

**Container** — a cylinder for transporting refrigerant.

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

**Critically charged system** — a refrigeration system whose refrigerant charge is limited in such a way that if the entire charge is located in the evaporator(s), it is not possible for liquid refrigerant to be entrained in the compressor suction line.

**Design pressure** — the maximum allowable working pressure, expressed in kilopascals (pounds per square inch gauge) for which a specific part of a refrigeration system is designed.

**Diffuser** — a device used to dilute and disperse the discharge of a refrigerant gas.

**Direct system** — a system in which the evaporator or condenser of the refrigeration system is in direct contact with air or other substances to be cooled or heated.

**Double direct system** — a system in which an evaporative refrigerant is used in a secondary circuit to condense or cool a refrigerant in a primary circuit. For the purposes of this Standard, each system enclosing a separate body of an evaporative refrigerant is considered a separate direct system.

**Double indirect open spray system** — a system in which a secondary coolant that is cooled or heated by a refrigeration system is circulated to the air or other substance to be cooled or heated.

**Duct** — a tube or conduit used for the conveying or encasing purposes described in the following definitions:

**Air duct** — a tube or conduit used for conveying air.

**Note:** *The air passages of self-contained systems are not considered to be air ducts.*

**Pipe duct or tubing** — a tube or conduit used for encasing pipe.

**Evaporator** — that part of a refrigeration system designed to produce refrigeration by vaporizing.

**Evaporator coil** — an evaporator, constructed of pipe or tubing, that is not enclosed in a pressure vessel.

**Exit** — a confined passageway immediately adjacent to and including the door through which people leave a building.

**Note:** *An exit can also be used for entering a building.*

**Factory test** — a pressure test performed at a manufacturing facility by a manufacturer to prove refrigeration system integrity.

**Field test** — a pressure test performed in the field to prove refrigeration system integrity.

**Fitting** — an appurtenance attached to a pressure vessel or to piping, including such items as valves, gauges, and controlling devices, and which can include other pressure-retaining components installed in a piping system within the scope of CSA B51 and the Act.

**Hallway** — a corridor for the passage of people.

**Header** — a pipe or tube (extruded, cast, or fabricated) to which a number of other pipes or tubes are connected.

**Heat pump** — a refrigeration system used to transfer heat into a space or substance.

**High side** — those portions of a refrigeration system that are subject to condensing pressure.

**Immediately dangerous to life or health (IDLH)** — the maximum concentration of a substance from which one can escape within 30 min without any escape-impairing symptoms or irreversible health effects.

**Indirect closed system** — see Clause 4.3.1.3, Item (c).

**Indirect open spray system** — see Clause 4.3.1.3, Item (a).

**Indirect system** — see Clause 4.3.1.3.

**Indirect vented closed system** — see Clause 4.3.1.3, Item (d).

**Internal gross volume** — the volume of the container as determined from its internal dimensions, 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 that is designed for storage of a liquid refrigerant and that is permanently connected to a system by inlet and outlet pipes.

**Listed equipment** — equipment that has been tested and is identified as acceptable by an approved testing laboratory.

**Lobby** — a waiting room or a large hallway serving as a waiting room.

**Low side** — those portions of a refrigeration system that are subject to evaporating pressure.

**Lower flammability limit (LFL)** — the minimum concentration of a refrigerant that is capable of propagating a flame through a homogeneous mixture of refrigerant and air.

**Machinery** — the refrigeration equipment in a refrigeration system, including (as applicable) a compressor, a condenser, a liquid receiver, connecting piping, and an evaporator.

**Machinery room** — a room in which a refrigeration system is permanently installed and operated. This does not include a cold-storage room in which evaporators are located, a refrigerator box, an air-cooled space, or any other enclosed space subject to Clause 6.2.

**Note:** A machinery room can have equipment such as a boiler or air receiver in addition to a refrigeration system (see Clause 6.2.1). A machinery room is sometimes referred to by the industry as a mechanical room. Any subdivided portion of a machinery room is not to be considered a machinery room unless it meets all of the applicable requirements of this Standard. It is not the intent of this definition to classify the space in which a self-contained system is located as a machinery room.

**Class T machinery room** — a machinery room subject to specific restrictions and requirements (see Clause 6.3).

**Manufacturer** — a refrigeration equipment company or organization that affixes its name or nationally registered trademark or trade name to its refrigeration equipment.

**Non-positive displacement compressor** — a compressor in which vapour pressure is increased without changing the internal volume of the compression chamber.

**Occupancy** — a location governed by this Standard in which refrigeration systems may be placed (see Clause 4.2).

**Occupied space** — that portion of a premises accessible to or occupied by people, excluding the machinery room.

**Open flame** — any flame with which refrigerant can come into direct contact if there is a refrigerant leak.

**Owner** — one or more persons, including lessees, who have permanent or temporary power and authority of ownership.

**Piping** — the pipe or tube mains for interconnecting the various parts of a refrigeration system. Piping includes the following:

- (a) pipe;
- (b) flanges;
- (c) bolting;
- (d) gaskets;
- (e) valves;
- (f) fittings;
- (g) the pressure-containing parts of other components such as expansion joints, strainers, and devices that perform functions such as mixing, separating, snubbing, distributing, metering, or controlling flow;
- (h) pipe-supporting fixtures; and
- (i) structural attachments.

**Positive displacement compressor** — a compressor in which vapour pressure is increased by changing the internal volume of the compression chamber.

**Premises** — a tract of land and its buildings.

**Pressure-imposing element** — a device or portion of equipment used to increase refrigerant pressure.

**Pressure-limiting device** — a pressure-responsive mechanism designed to automatically stop the operation of the pressure-imposing element at a predetermined pressure.

**Pressure-relief devices** —

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

**Dual pressure-relief device** — a device in which two pressure-relief devices are mounted on a three-way valve to allow one device to remain active while the other is isolated.

**Fusible plug** — a device containing an alloy that will melt at a specified temperature to relieve pressure.

**Pilot-operated relief valve** — a pressure-relief valve in which a major relieving device is combined with and controlled by a self-actuated auxiliary pressure-relief valve.

**Pressure-relief device** — a pressure-actuated valve or rupture member designed to automatically relieve pressure exceeding its setting.

**Note:** *This definition excludes temperature-actuated valves.*

**Pressure-relief valve** — a pressure-actuated valve held closed by a spring or other means and designed to automatically relieve pressure exceeding its setting.

**Rupture member** — a device that will rupture at a predetermined pressure.

**Pressure vessel** — a closed vessel for containing, storing, distributing, transferring, distilling, processing, or otherwise handling a gas, vapour, or liquid exceeding the service and size limits defined in CSA B51.

**Pumpdown charge** — the quantity of refrigerant stored at some point in the refrigeration system for operational service or standby purposes.

**Receiver** — see **Liquid receiver**.

**Refrigerant** — a fluid that absorbs heat at a low temperature and pressure, with a change of state, and rejects it at a higher temperature and pressure.

**Refrigeration system** — a combination of interconnected parts forming a closed circuit in which refrigerant is circulated for the purpose of extracting and then rejecting heat. (See Clause 4.3.1 for a classification of refrigeration systems by type.)

**Saturation pressure** — the pressure, at a given temperature, at which vapour and liquid can exist in equilibrium.

**Sealed system** — a unit system in which all refrigerant-containing parts are made permanently tight by welding or brazing.

**Secondary coolant** — any liquid or slurry used for the transmission of heat without a change of state to vapour.

**Self-contained system** — a complete factory-made and factory-tested system, in a suitable frame or enclosure, that is fabricated and shipped in one or more sections and does not have any refrigerant-containing parts connected in the field other than by companion or block valves.

**Soldered joint** — a gas-tight joint formed by joining metal parts with alloys that melt at temperatures above 204 °C (400°F) but not exceeding 427 °C (800°F).

**Stop valve** — a device to shut off the flow of refrigerant.

**Tenant** — a person or organization with the legal right to occupy premises.

**Tight-fitting door** — a door that is sealed in a way that prevents the free flow of escaping refrigerant from one space to another.

**Three-way valve** — a service valve for dual pressure-relief devices that allows use of one device while the other is isolated from the system, thereby keeping one valve operating.

**Threshold limit value<sup>®</sup>/time-weighted average (TLV<sup>®</sup>/TWA)** — the refrigerant concentration in air during a normal 8 h workday and 40 h workweek, to which nearly all workers can be exposed every day without adverse effect.

**Note:** TLV<sup>®</sup> is a registered trademark of the American Conference of Governmental Industrial Hygienists, Inc. (ACGIH).

**Unit system** — see **Self-contained system**.

**Unprotected tubing** — tubing that, because it is not protected by an enclosure or placement in a suitable location, is exposed to potential crushing, abrasion, puncture, or similar mechanical damage under installed conditions.

**Welded joint** — a gas-tight joint obtained by joining metal parts in the plastic or molten state.

**Zeotropic** — the characterization given to blends comprising multiple components of different volatilities that, when used in refrigeration cycles, change volumetric composition and saturation temperatures as they evaporate (boil) or condense at constant pressure.

### 3.2 Abbreviations

IDLH — immediately dangerous to life or health

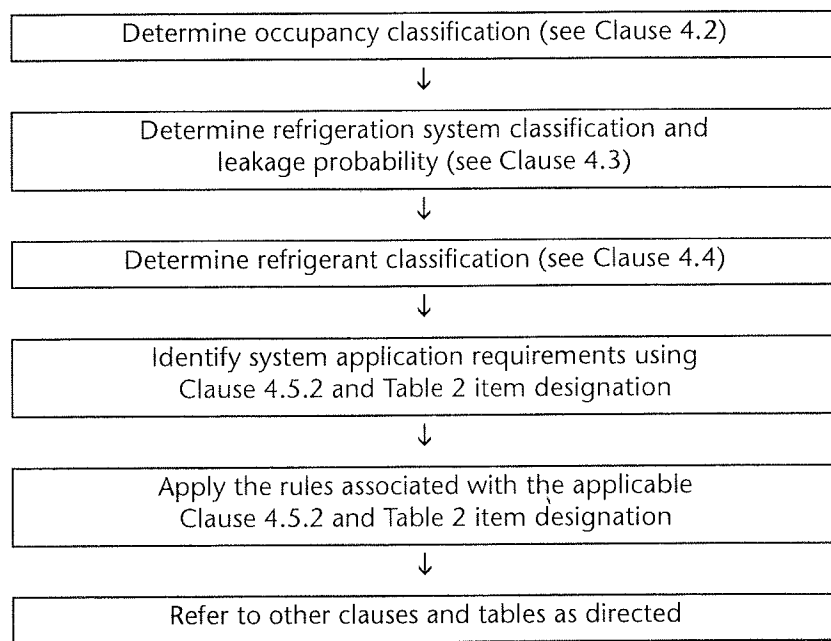
LFL — lower flammability limit

TLV<sup>®</sup>/TWA — threshold limit value/time-weighted average

## 4 System selection and application requirements

### 4.1 Application procedure

The system requirements determined by the occupancy, system, and refrigerant classifications can be identified by following the flow diagram in Figure 1. The requirements that are independent of these classifications are specified in Clauses 5 to 8.



**Figure 1**  
**Flow diagram for identification of systems requirements**  
(See Clause 4.1.)

### 4.2 Classification by occupancy

#### 4.2.1 General

Refrigeration system locations are classified under occupancy classifications that take into consideration the ability of people to respond to potential exposure to refrigerant (see Clauses 4.2.2 to 4.2.8).

#### 4.2.2 Institutional occupancy

The institutional occupancy classification shall apply to that portion of a premises in which persons are confined to receive medical care or treatment, or in which persons are held or detained by reason of public or civic duty. Institutional occupancies include hospitals, correctional facilities, police stations, and courthouses with cells.

#### 4.2.3 Public assembly occupancy

The public assembly occupancy classification shall apply to that portion of a premises in which persons congregate for civic, political, educational, religious, social, or recreational purposes. Public assembly occupancies include armouries, assembly rooms, auditoria, ballrooms, broadcasting studios, bus terminals, churches, colleges, courthouses without cells, exhibition halls, fraternity halls, ice rinks, libraries, lodge rooms, mortuary chapels, museums, passenger depots, schools, subway stations, and theatres.

#### **4.2.4 Residential occupancy**

The residential occupancy classification shall apply to that portion of a building in which sleeping accommodations are provided. Residential occupancies include clubhouses, convents, dormitories, hotels, lodging houses, multi-storey apartments, residences, studios, and tenements.

#### **4.2.5 Commercial occupancy**

The commercial occupancy classification shall apply to that portion of a premises used for transacting business, rendering professional services, supplying food, drink, or other needs and comforts, manufacturing, or performance of labour (except as specified in Clause 4.2.6). Commercial occupancies include, bakeries, laboratories, lofts, markets, office buildings, restaurants, and stores.

#### **4.2.6 Industrial occupancy**

The industrial occupancy classification shall apply to an entire building or premises, or to that portion of a building used for manufacturing, processing, or storage of materials or products. Industrial occupancies include chemical, food, candy, and ice-cream factories, ice-making plants, meat-packing plants, refineries, perishable food warehouses, and similar locations where only authorized persons have access.

#### **4.2.7 Mixed occupancy**

The mixed occupancy classification shall apply to a building in which different parts are occupied or used for different purposes. When a part is cut off from the rest of the building by tight partitions, floors, and ceilings and protected by self-closing doors, the requirements for the applicable type of occupancy specified in Clauses 4.2.2 to 4.2.6 shall apply to that part of the building. When the parts are not separated in this manner, the occupancy classification requiring the most stringent requirements shall govern (e.g., the cold-storage spaces in hotels might be classified under industrial occupancy, whereas other portions of the building would be classified under other occupancies).

**Note:** Occupancy definitions, including fire separation requirements, are usually listed in the applicable provincial code or the National Building Code of Canada, as applicable.

#### **4.2.8 Adjacent locations**

Equipment, other than piping, located less than 6.1 m (20 ft) from any building opening shall be governed by the occupancy classification of the building.

### **4.3 Classification of refrigeration systems**

#### **4.3.1 Classification by type**

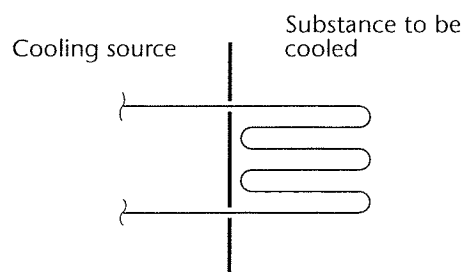
##### **4.3.1.1 General**

Refrigeration system types are classified by the methods employed for extracting or delivering heat, as specified in Clauses 4.3.1.2 and 4.3.1.3.

##### **4.3.1.2 Direct system**

###### **4.3.1.2.1 General**

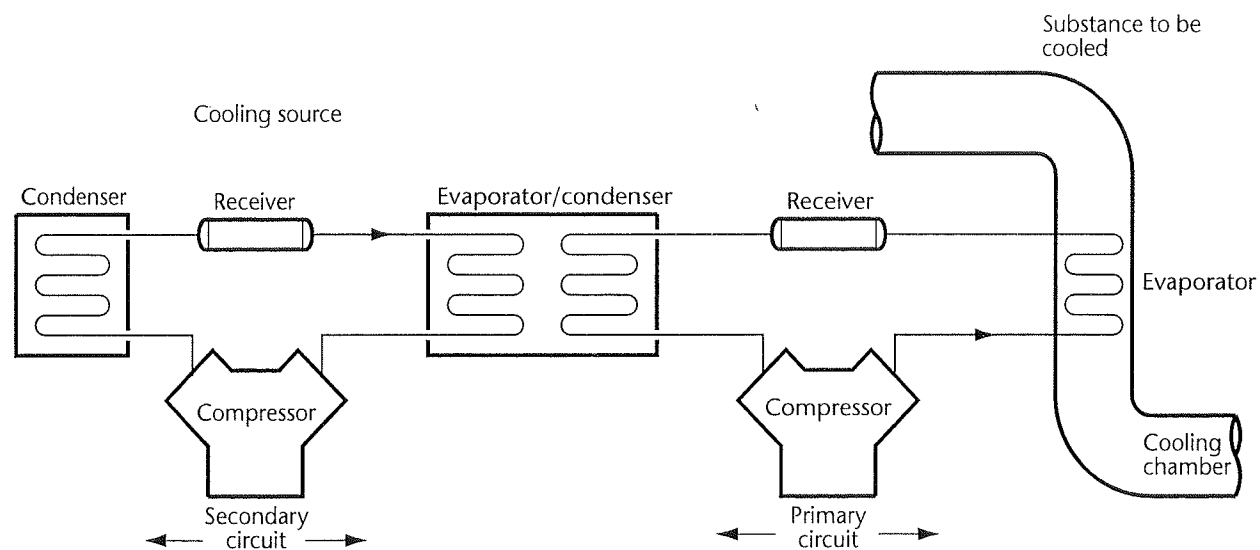
A direct system is one in which the evaporator or condenser of the refrigeration system is in direct contact with the air or other substances to be cooled or heated (see Figure 2).



**Figure 2**  
**Direct system**  
(See Clause 4.3.1.2.1.)

#### 4.3.1.2.2 Double direct system

A double direct system is one in which an evaporative refrigerant is used in a secondary circuit to condense or cool a refrigerant in a primary circuit (see Figure 3). For the purposes of this Standard, each system enclosing a separate body of an evaporative refrigerant shall be considered a separate direct system.

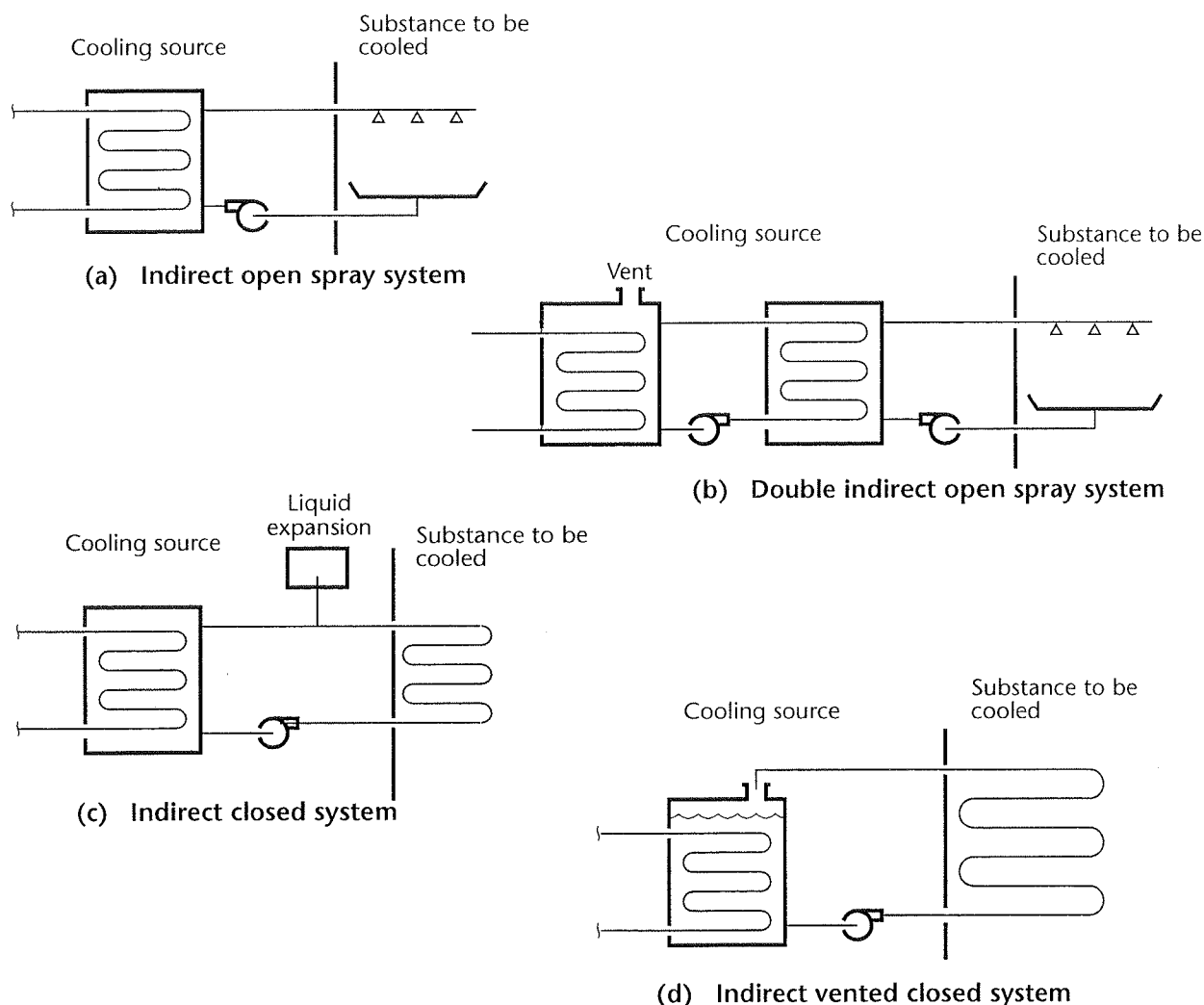


**Figure 3**  
**Double direct system**  
(See Clause 4.3.1.2.2.)

### 4.3.1.3 Indirect system

An indirect system is one in which a secondary coolant that is cooled or heated by a refrigeration system is circulated to the air or other substance to be cooled or heated. Indirect systems are distinguished by the method of application as follows:

- 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 (see Figure 4(a)).
- A double indirect open spray system is one in which the secondary substance for an indirect open spray system described in Item (a) is heated or cooled by the secondary coolant circulated from a second enclosure (see Figure 4(b)).
- 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 (see Figure 4(c)).
- 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 (see Figure 4(d)).



**Figure 4**  
**Indirect system**  
(See Clause 4.3.1.3.)

### 4.3.2 Classification by leakage probability

For the purpose of applying Tables 1 and 2, the refrigeration system shall be classified as follows, in accordance with the degree of probability that a leakage of refrigerant could enter an occupancy-classified area:

- (a) High-probability systems: a high-probability system is one in which the basic design, or the location of components, is such that a leakage of refrigerant from a failed connection, seal, or component could enter the area under consideration. The following are typical high-probability systems:
  - (i) any direct or indirect open spray system; and
  - (ii) any arrangement in which refrigerant-containing parts in the refrigerant circuit are located in such a way that refrigerant leakage could enter the area.
- (b) Low-probability systems: a low-probability system is one that cannot be considered a high-probability system. This class includes indirect closed and double indirect systems, but only if all joints and connections in the refrigerant circuit are effectively isolated from the classified area.

## 4.4 Classification by refrigerant

### 4.4.1

ASHRAE 34 classifies refrigerants into safety groups. Those classifications are used in this Standard and are illustrated in Figure 5.

Single-component refrigerants and azeotropic blends so classified are listed in ASHRAE 34 along with the criteria for classification. Table 1 provides an abbreviated list of commonly used refrigerants.

Increasing flammability ↑	Safety group	
	Higher flammability	A3 B3
	Lower flammability	A2 B2
	No flame propagation	A1 B1
		Lower toxicity      Higher toxicity
		Increasing toxicity →

**Figure 5**  
**Matrix of refrigerant classifications**  
 (See Clause 4.4.1.)

### 4.4.2

Zeotropic blends shall be classified by worst-case composition of fractionation. For example, for refrigerants whose inflammability or toxicity can change, such as by fractionation of zeotropes, a dual rating separated by a slash (/) shall be provided. The first rating shall be the classification of the refrigerants as formulated. The second rating shall be the classification of the worst-case composition of fractionation. See Annex C for details.

**Table 1**  
**Refrigerant classifications and quantities**  
 (See Clauses 4.3.2, 4.4.1, 4.5.2, and 4.6.2.)

			Quantity of refrigerant per occupied space*				
Refrigerant number		Chemical formula	kg/m <sup>3</sup> †	Vol. %	lb/1000 ft <sup>3</sup> †	Limited by‡	TLV®/TWA§
Group A1, Single Fluid							
R-11	Trichlorofluoromethane	CCl <sub>3</sub> F	0.0256	0.40	1.6	Cardiac	1000
R-12	Dichlorodifluoromethane	CCl <sub>2</sub> F <sub>2</sub>	0.1920	4.00	12.0	Cardiac	1000
R-13	Chlorotrifluoromethane	CClF <sub>3</sub>	0.2976	6.91	18.6	Oxygen	1000
R-13B1	Bromotrifluoromethane	CBrF <sub>3</sub>	0.3520	5.70	22.0	Cardiac	1000
	Halon 1301						
R-14	Tetrafluoromethane	CF <sub>4</sub>	0.2528	6.91	15.8	Oxygen	—
	Carbon tetrafluoride						
R-22	Chlorodifluoromethane	CHClF <sub>2</sub>	0.1504	4.20	9.4	Cardiac	1000
R-23	Fluoroform	CHF <sub>3</sub>	0.2000	6.91	12.5	Oxygen	1000
R-113	Trichlorotrifluoroethane	CCl <sub>2</sub> FCClF <sub>2</sub>	0.0304	0.40	1.9	Cardiac	1000
R-114	Dichlorotetrafluoroethane	CClF <sub>2</sub> CClF <sub>2</sub>	0.1504	2.10	9.4	Cardiac	1000
R-124	1-Chloro-1,2,2,2-tetrafluoroethane	CHClFCF <sub>3</sub>	0.1136	2.00	7.1	Cardiac	1000
R-134a	1,1,1,2-Tetrafluoroethane	CH <sub>2</sub> FCF <sub>3</sub>	0.2064	6.00	12.9	Cardiac	1000
R-744	Carbon dioxide	CO <sub>2</sub>	0.0912	5.00	5.7	IDLH	5000
Group A1, Blends§**							
R-401A	R-22/152a/124 (53/13/34)	CHClF <sub>2</sub> /CHF <sub>2</sub> CH <sub>3</sub> /CHClFCF <sub>3</sub>	0.1408	3.60	8.8	Cardiac	1000
R-401B	R-22/152a/124 (61/11/28)	CHClF <sub>2</sub> /CHF <sub>2</sub> CH <sub>3</sub> /CHClFCF <sub>3</sub>	0.1424	3.60	8.9	Cardiac	1000
R-401C	R-22/152a/124 (33/15/52)	CHClF <sub>2</sub> /CHF <sub>2</sub> CH <sub>3</sub> /CHClFCF <sub>3</sub>	0.1408	3.25	8.8	Cardiac	—
R-402A	R-125/290/22 (60/2/38)	CHF <sub>2</sub> CF <sub>3</sub> /CH <sub>3</sub> CH <sub>2</sub> /CHClF <sub>2</sub>	0.2352	5.59	14.7	Cardiac	—
R-402B	R-125/290/22 (38/2/60)	CHF <sub>2</sub> CF <sub>3</sub> /CH <sub>3</sub> CH <sub>2</sub> /CHClF <sub>2</sub>	0.1920	4.87	12.0	Cardiac	—
R-403A	R-290/22/218 (5/75/20)	CH <sub>3</sub> CH <sub>2</sub> CH <sub>3</sub> /CHClF <sub>2</sub> /CF <sub>3</sub> CF <sub>2</sub> CF <sub>3</sub>	0.1792	4.71	11.2	Cardiac	1000
R-403B	R-290/22/218 (5/56/39)	CH <sub>3</sub> CH <sub>2</sub> CH <sub>3</sub> /CHClF <sub>2</sub> /CF <sub>3</sub> CF <sub>2</sub> CF <sub>3</sub>	0.2304	5.38	14.4	Cardiac	1000
R-404A	R-125/143a/134a (44/52/4)	CHF <sub>2</sub> CF <sub>3</sub> /CF <sub>3</sub> CH <sub>3</sub> /CF <sub>3</sub> CH <sub>2</sub> F	0.2800	6.91	17.5	Oxygen	1000
R-405A	R-22/152a/142b/C318 (45/7/5.5/42.5)	CHClF <sub>2</sub> /CHF <sub>2</sub> CH <sub>3</sub> /CClF <sub>2</sub> CH <sub>3</sub> /C <sub>4</sub> F <sub>8</sub>	0.2144	4.63	13.4	Cardiac	1000

(Continued)

**Table 1 (Continued)**

Refrigerant number		Chemical formula	Quantity of refrigerant per occupied space*				
			kg/m <sup>3</sup> †	Vol. %	lb/1000 ft <sup>3</sup> †	Limited by‡	TLV®/ TWA§
R-407A	R-32/125/134a (20/40/40)	CH <sub>2</sub> F <sub>2</sub> /CHF <sub>2</sub> CF <sub>3</sub> / CF <sub>3</sub> CH <sub>2</sub> F	0.2576	6.91	16.1	Oxygen	1000
R-407B	R-32/125/134a (10/70/20)	CH <sub>2</sub> F <sub>2</sub> /CHF <sub>2</sub> CF <sub>3</sub> / CF <sub>3</sub> CH <sub>2</sub> F	0.2944	6.91	18.4	Oxygen	1000
R-407C	R-32/125/134a (23/25/52)	CH <sub>2</sub> F <sub>2</sub> /CHF <sub>2</sub> CF <sub>3</sub> / CF <sub>3</sub> CH <sub>2</sub> F	0.2464	6.91	15.4	Oxygen	1000
R-407D	R-32/125/134a (15/15/70)	CH <sub>2</sub> F <sub>2</sub> /CHF <sub>2</sub> CF <sub>3</sub> / CF <sub>3</sub> CH <sub>2</sub> F	0.2794	6.91	17.5	Oxygen	1000
R-407E	R-32/125/134a (25/15/60)	CH <sub>2</sub> F <sub>2</sub> /CHF <sub>2</sub> CF <sub>3</sub> / CF <sub>3</sub> CH <sub>2</sub> F	0.2399	6.91	14.9	Oxygen	1000
R-408A	R-125/143a/22 (7/46/47)	CHF <sub>2</sub> CF <sub>3</sub> /CF <sub>3</sub> CH <sub>3</sub> / CHClF <sub>2</sub>	0.2432	6.74	15.2	Cardiac	—
R-409A	R-22/124/142b (60/25/15)	CHClF <sub>2</sub> /CHClF <sub>2</sub> CF <sub>3</sub> / CClF <sub>2</sub> CH <sub>3</sub>	0.1216	3.02	7.6	Cardiac	1000
R-409B	R-22/124/142b (65/25/10)	CHClF <sub>2</sub> /CHClF <sub>2</sub> CF <sub>3</sub> / CClF <sub>2</sub> CH <sub>3</sub>	0.1264	3.14	7.9	Cardiac	—
R-410A	R-32/125 (50/50)	CH <sub>2</sub> F <sub>2</sub> /CHF <sub>2</sub> CF <sub>3</sub>	0.2080	6.91	13.0	Oxygen	1000
R-414A	R-22/124/600a/142b (51/28.5/4/16.5)	CHClF <sub>2</sub> /CHClF <sub>2</sub> CF <sub>3</sub> / CH(CH <sub>3</sub> ) <sub>3</sub>	0.1868	4.65	11.6	Cardiac	—
R-414B	R-22/124/600a/142b (50/39/1.5/9.5)	CHClF <sub>2</sub> /CHClF <sub>2</sub> CF <sub>3</sub> / CH(CH <sub>3</sub> ) <sub>3</sub>	0.1873	4.44	11.7	Cardiac	—
R-500	R-12/152a/ (73.8/26.2)	CCl <sub>2</sub> F <sub>2</sub> /CH <sub>3</sub> CHF <sub>2</sub>	0.2240	5.40	14.0	Cardiac	1000
R-502	R-22/115 (48.8/51.2)	CHClF <sub>2</sub> /CClF <sub>2</sub> CF <sub>3</sub>	0.3040	6.50	19.0	Cardiac	—
R-507A	R-125/143a (50/50)	CHF <sub>2</sub> CF <sub>3</sub> /CF <sub>3</sub> CH <sub>3</sub>	0.2832	6.91	17.7	Oxygen	—
R-508A	R-23/116 (39/61)	CHF <sub>3</sub> /CF <sub>3</sub> CF <sub>3</sub>	0.2880	6.91	18.0	Oxygen	1000
R-508B	R-23/116 (46/54)	CHF <sub>3</sub> /CF <sub>3</sub> CF <sub>3</sub>	0.2736	6.91	17.1	Oxygen	1000
R-509A	R-22/218 (44/56)	CHClF <sub>2</sub> /CF <sub>3</sub> CF <sub>2</sub> CF <sub>3</sub>	0.2976	5.78	18.6	Cardiac	1000

(Continued)

**Table 1 (Continued)**

Refrigerant number			Chemical formula	Quantity of refrigerant per occupied space*			
				kg/m <sup>3</sup> †	Vol. %	lb/1000 ft <sup>3</sup> †	Limited by‡
Group A2, Blends <sup>s**</sup>							
R-406A	R-22/600a/142b (55/4/41)	CHClF <sub>2</sub> /CH(CH <sub>3</sub> ) <sub>3</sub> /CClF <sub>2</sub> CH <sub>3</sub>	0.0752	1.70	4.7	LFL	—
R-411A	R-1270/22/152a (1.5/87.5/11)	CH <sub>3</sub> CH=CH <sub>2</sub> /CHClF <sub>2</sub> /CHF <sub>2</sub> CH <sub>3</sub>	0.0704	2.06	4.4	LFL	1000
R-411B	R-1270/22/152a (3/94/3)	CH <sub>3</sub> CH=CH <sub>2</sub> /CHClF <sub>2</sub> /CHF <sub>2</sub> CH <sub>3</sub>	0.0768	2.22	4.8	LFL	1000
R-412A	R-22/218/142b (70/5/25)	CHClF <sub>2</sub> /CF <sub>3</sub> CF <sub>2</sub> CF <sub>3</sub> /CClF <sub>2</sub> CH <sub>3</sub>	0.1088	2.85	6.8	LFL	1000
R-413A	R-218/134a/600a (9/88/3)	CF <sub>3</sub> CF <sub>2</sub> CF <sub>3</sub> /CH <sub>2</sub> FCF <sub>3</sub> /CH(CH <sub>3</sub> ) <sub>3</sub>	0.1392	3.20	8.7	LFL	—
Group A3							
R-170	Ethane	CH <sub>3</sub> CH <sub>3</sub>	0.0080	0.64	0.5	LFL	1000
R-290	Propane	CH <sub>3</sub> CH <sub>2</sub> CH <sub>3</sub>	0.0080	0.44	0.5	LFL	1000
R-1150	Ethylene	C <sub>2</sub> H <sub>4</sub>	0.0064	0.52	0.4	LFL	—
Group B1							
R-123	2,2-Dichloro-1,1,1-trifluoroethane	CHCl <sub>2</sub> CF <sub>3</sub>	0.0064	0.1	0.4	IDLH	50
Group B2							
R-717	Ammonia	NH <sub>3</sub>	0.00035	0.05	0.022	IDLH	25

\*For determining the actual quantity of refrigerant per occupied space, the following requirements shall apply:

- The quantity of refrigerant shall be the amount of refrigerant that could leak into the occupied space at any one time, taking into account a leak that would cause a complete discharge of the refrigerant from any single independent refrigeration circuit.
- When the refrigerant-containing parts of a system are located in one or more unventilated spaces, the volume of the smallest enclosed occupied space, other than a machinery room, shall be used to determine the permissible quantity of refrigerant in the system. The purpose of this requirement is to ensure no ill effects (e.g., narcosis, cardiac sensitization, or insufficient oxygen to support life) for occupants in the event of refrigerant leakage. Where a building consists of several storeys of unpartitioned space, such as a loft, the storey with the smallest occupied space where refrigerant would concentrate by virtue of its density, relative to air, shall be deemed to be the enclosed space.
- When an evaporator or condenser is located in an air duct system, the volume of the smallest occupied space or, in the case of an unpartitioned multi-storey building, the volume of the smallest occupied storey served by the duct, shall determine the permissible quantity of refrigerant in the system. When the air duct system serves several enclosed spaces, the permissible quantity of refrigerant in the system shall not exceed the amount determined by using the total volume of those spaces in which the airflow cannot be reduced to less than one-quarter of its maximum when the fan is operating.

(Continued)

**Table 1 (Concluded)**

- (d) When the space above a suspended ceiling is continuous and part of the air-return system, this space may be included in calculating the volume of the enclosed space.
- †To correct for height,  $h$ , above sea level (km), multiply these values by  $(1 - 7.94 \times 10^{-2} h)$ . To correct for height,  $h$ , above sea level (ft), multiply these values by  $(1 - 2.42 \times 10^{-5} h)$ .
- ‡The quantity of refrigerant is the most restrictive of a minimum oxygen concentration of 19.5% or as follows:
- (a) Group A1 Single Fluid: 80% of the cardiac sensitization level for R-11, 12, 13B1, 22, 113, 114, and 134a and 100% of the IDLH for R-744. Others are limited by levels where oxygen deprivation begins to occur.
  - (b) Groups A1/A2 Blends: 80% of the cardiac sensitization level for R-401A, 401B, 401C, 402A, 402B, 403A, 403B, 405A, 408A, 409A, 409B, 414A, 414B, 500, 502, and 509A. Others are limited by levels where oxygen deprivation begins to occur.
  - (c) Groups A2 and A3: approximately 20% of LFL.
  - (d) Group B1: 100% of the measure consistent with the IDLH for R-123.
  - (e) Group B2: 100% of IDLH.
- §Toxicity measure consistent therewith when TLV®/TWA is not available.
- \*\*Toxicity classification is provisional and will be reviewed upon confirmation by ASHRAE 34.

**Notes:**

- (1) The Group classifications follow ASHRAE 34.
- (2) It shall be the responsibility of the owner to establish the refrigerant group for refrigerants that are not classified in ASHRAE 34 and to obtain the acceptance of the regulatory authority for that classification.

**4.5 System application requirements****4.5.1 General**

System application requirements shall be determined in accordance with Table 2 and based on the occupancy, leakage probability, and refrigerant classifications specified in Clauses 4.2, 4.3.2, and 4.4, respectively.

**Table 2**  
**System application requirements**  
 (See Clauses 4.3.2, 4.5.1, and 4.5.2 and Figure 1.)

Refrigerant group	System leakage probability	Occupancy			
		Institutional	Public assembly/ Residential	Commercial	Industrial
A1	High	(b)	(a)	(a)	(c), (d)
	Low	(e)	(e)	(e)	(e)
A2	High	(f)	(f)	(f)	(c), (d)
	Low	(h)	(h)	(h)	(h)
A3	High	(j)	(j)	(j)	(c), (d)
	Low	(j)	(j)	(j)	(h)
B1	High	(b), (g)	(a), (g)	(a), (g)	(c), (d)
	Low	(e)	(e)	(e)	(e)
B2	High	(f), (g)	(f), (g)	(f), (g)	(c), (d)
	Low	(h)	(h)	(h)	(h)
B3	High	(j)	(j)	(j)	(c), (d)
	Low	(j)	(j)	(j)	(h)

**Note:** The letters in parentheses correspond to the list item designations in Clause 4.5.2.

## 4.5.2 System application rules

**Note:** The list item designations in this Clause correspond to the letters in parentheses in Table 2.

The following system application rules shall be applied, as specified in Table 2:

- (a) The quantity of refrigerant in each system shall be limited in accordance with Table 1.
- (b) The quantity of refrigerant shall be limited to 50% of that specified in Table 1, except that in kitchens, laboratories, and mortuaries the full specified value may be used. If any portion of a refrigeration system containing more than 0.45 kg (1 lb) of refrigerant (except R-744) is in a room with a flame-sustaining device, either this device shall be provided with a hood to exhaust combustion products to the open air or the requirements of Items (f) and (g) shall be met.
- (c) For refrigeration systems of 75 kW (100 hp) or less, when the quantity of refrigerant in each system exceeds Table 1 quantities, the rules for commercial occupancy shall apply unless all of the following occur:

- (i) The area containing the entire refrigeration system is separated from the rest of the building by tight construction with tight-fitting doors.

**Note:** Such areas can include multiple rooms, refrigerated work areas containing low-side components, and rooms containing compressors.

- (ii) Access is restricted to authorized personnel, and personnel density and means of egress are in compliance with workplace safety and health legislation and building codes where applicable.
  - (iii) Detectors are located in areas where refrigerant vapour from a leak will be concentrated, in order to provide a warning at a concentration not exceeding the TLV<sup>®</sup>/TWA of the refrigerant(s), except in the case of ammonia, where the maximum concentration shall be 300 ppm.
  - (iv) When the quantity of refrigerant, except refrigerants in Groups A1 and B1, exceeds Table 3 amounts, no flame-producing device or hot surface above 425 °C (800°F) shall be permitted.
  - (v) When the quantity of refrigerant, except ammonia and refrigerants in Groups A1 and B1, exceeds Table 1 quantities, the area shall be classified as a hazardous location and all electrical equipment shall comply with the Class 1, Zone 2 requirements specified in the *Canadian Electrical Code, Part 1*.
- (d) For refrigeration systems greater than 75 kW (100 hp), the refrigerated work area shall comply with Item (c), and the separate room housing compressors and related equipment shall comply with Item (i).
  - (e) When the quantity of refrigerant in a system exceeds Table 1 amounts, all refrigerant-containing parts, except piping and those parts outside the building, shall be installed in a machinery room constructed in accordance with Clause 6.2.
  - (f) Refrigerant quantities shall be limited in accordance with Table 3.
  - (g) Applications involving air conditioning for human comfort shall not be allowed.
  - (h) When the quantity of refrigerant in a system exceeds Table 3 amounts, all refrigerant-containing parts, except piping and those parts outside the building, shall be installed in a machinery room constructed in accordance with Clause 6.3. The following limitations on refrigerant quantities shall apply:
    - (i) institutional: 250 kg (550 lb);
    - (ii) public assembly: no limit, except as outlined in Item (i);
    - (iii) residential: no limit, except as outlined in Item (i);
    - (iv) commercial: no limit, except as outlined in Item (i); and
    - (v) industrial: no limit, except as outlined in Item (i).
  - (i) When the quantity of refrigerant in a system exceeds Table 1 amounts, all refrigerant-containing parts, except piping, low-side components, condensers, and parts outside the building, shall be installed in a machinery room constructed in accordance with Clause 6.2.

In addition, refrigerants in Groups A2, A3, B2, and B3 shall meet the following requirements:

    - (i) The special machinery room requirements of Clause 6.3 shall apply.
    - (ii) Except for ammonia systems, refrigerant amounts exceeding 500 kg (1100 lb) shall be approved by the authority having jurisdiction.

- (j) The refrigerants that correspond to Item (j) in Table 2 are prohibited, except in laboratories in commercial occupancies. Only unit systems containing not more than 3 kg (6.6 lb) of Group A3 or B3 refrigerant shall be used. If the laboratory is occupied by less than one person per 10 m<sup>2</sup> (108 ft<sup>2</sup>) of floor area, the requirements for industrial occupancies may be applied.

**Note:** Clause 4.5.3 permits a refrigerant charge of 3 kg (6.6 lb) or less of any refrigerant in any system meeting the requirements of that Clause.

**Table 3**  
**Maximum permissible quantities of refrigerants for**  
**high-probability systems**  
(See Clause 4.5.2.)

Type of refrigeration system	Maximum permissible quantities for specified occupancy, kg (lb)			
	Institutional	Public assembly	Residential	Commercial
Unit system in a location other than a public hallway or lobby	0 (0)	0 (0)*	3 (6.6)	10 (22)

\*A quantity of 3 kg (6.6 lb) shall be allowed for systems installed in kitchens, laboratories, and mortuaries.

### 4.5.3 Equipment applied in a high-probability system

In addition to the equipment covered by Clause 5.2, equipment with a refrigerant charge not exceeding 3 kg (6.6 lb) and listed by an approved testing laboratory shall be deemed to meet the system application requirements specified in Clauses 4.5.1 and 4.5.2 when the equipment is installed in accordance with the listing specification.

## 4.6 Additional requirements for institutional, public assembly, residential, and commercial occupancies

### 4.6.1 Public stairway, stair landing, or exit

In addition to the requirements specified in Clause 4.5, no portion of a refrigeration system shall be installed in or on a public stairway, stair landing, or exit.

### 4.6.2 Public hallway or lobby

In addition to the requirements specified in Clause 4.5, no portion of a refrigeration system shall interfere with free passage through a public hallway or lobby. Refrigeration systems installed in a public hallway or lobby shall be limited to unit systems containing not more than the quantity of a Group A1 refrigerant as specified in Table 1.

## 5 Equipment design and construction

### 5.1 Drawings, specifications, and data reports

#### 5.1.1

The design, construction, testing, and stamping of every pressure vessel and its associated piping, as well as the registration of fittings, shall comply with CSA B51.

Compliance with the requirements of CSA B51 and the requirements of the regulatory authorities shall include compliance with applicable requirements for welding procedures, brazing procedures, and quality control procedures, and all related requirements.

In a refrigeration system, all pressure-retaining components within the scope of CSA B51 shall be constructed to a design that is registered as a pressure vessel, fitting, or piping system, unless exempted by Clause 5.8.1.

### 5.1.2

Design drawings and specifications for all vessels and pertinent safety devices shall be submitted to the regulatory authority for acceptance and registration before construction.

### 5.1.3

A data report covering each vessel constructed in accordance with an accepted and registered design shall be submitted to the regulatory authority by the manufacturer.

## 5.2 Refrigeration systems rated 125 kW or less

Refrigeration systems that have a prime mover nameplate rating of 125 kW or less and are covered by the following Standards shall be tested and certified by an approved testing laboratory:

- (a) CSA C22.2 No. 63;
- (b) CSA C22.2 No. 92
- (c) CSA C22.2 No. 117;
- (d) CAN/CSA-C22.2 No. 120;
- (e) CSA C22.2 No. 128; and
- (f) CAN/CSA-C22.2 No. 236.

## 5.3 Filing of drawings

### 5.3.1 Submission of drawings and specifications

Before the construction of a refrigeration system whose prime movers exceed a 125 kW nameplate rating, or as required by the Act, the owner or its designated representative shall submit drawings and specifications to the regulatory authority for registration and acceptance.

**Note:** *The regulatory authority may accept a standard drawing in lieu of a separate drawing for each installation, provided that the registered number of such a drawing is indicated for each installation.*

### 5.3.2 Contents of drawings

Each drawing shall include, at a minimum, the following:

- (a) type of occupancy (see Clause 4.2);
- (b) refrigerant: group number, name, and weight of charge in system;
- (c) machinery room: construction details, including ventilation if applicable;
- (d) position of equipment;
- (e) size, run, material, and type of piping;
- (f) compressors: manufacturer, displacement, setting of relief valves, and prime mover power rating;
- (g) pressure vessels: size, Canadian registration number, and data reports;
- (h) existing machinery: full particulars, where applicable; and
- (i) safety devices: relieving pressures, manufacturer's name, and size and number of safety valves, relief valves, and rupture members.

## 5.4 Materials

### 5.4.1

All materials used in the construction and installation of refrigeration systems shall be suitable for conveying the refrigerant used. No material that will deteriorate in the presence of air or moisture because of the refrigerant, the oil, or the refrigerant or oil combination shall be used.

**Note:** *Some refrigerants are corrosive to certain materials when moisture, air, or both are present.*

**5.4.2**

Magnesium alloys shall not be used in contact with any halogenated refrigerant.

**5.4.3**

Copper and its alloys shall not be used in contact with ammonia, except as a component of bronze alloys for bearings or other uses not involving refrigerants. Aluminum and its alloys may be used in ammonia systems.

**5.5 Design pressures****5.5.1**

Design pressures shall be not less than pressures arising under all operating, shipping, and standby conditions. When design pressure is being selected, suitable allowance should be provided for setting pressure-limiting devices and pressure-relief devices to avoid nuisance shutdowns and refrigerant loss at maximum operating conditions. The minimum design pressure shall be not less than 103 kPa (15 psig) and, except as specified in Clauses 5.5.5 to 5.5.7, shall be not less than the saturation pressure corresponding to the following temperatures:

- (a) low sides of all systems: 27 °C (80°F); and
- (b) high sides of
  - (i) water- or evaporator-cooled systems: 40 °C (105°F); or
  - (ii) air-cooled systems: 52 °C (125°F).

The corresponding pressures for refrigerants in common use are specified in Table 4.

**5.5.2**

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

**Table 4**  
**Minimum design pressures**  
 (See Clauses 5.5.1 and 5.10.4.2.)

Refrigerant number		Minimum design pressure (gauge*)					
		Low side		High side			
		kPa	psig	Water- or evaporator-cooled		Air-cooled	
				kPa	psig	kPa	psig
R-11	Trichlorofluoromethane	103	15	103	15	145	21
R-12	Dichlorodifluoromethane	579	84	875	127	1165	169
R-13	Chlorotrifluoromethane	3766	546	3766	546	3766	546
R-13B1	Bromotrifluoromethane	1586	230	2213	321	2826	410
R-14	Tetrafluoromethane	3690	535	3690	535	3690	535
R-22	Chlorodifluoromethane	993	144	1455	211	1916	278
R-23	Fluoroform	4800	696	4800	696	4800	696
R-113	Trichlorotrifluoroethane	103	15	103	15	103	15
R-114	Dichlorotetrafluoroethane	124	18	241	35	365	53
R-123	2,2-Dichloro-1,1,1-trifluoroethane	103	15	103	15	124	18
R-124	1-Chloro-1,2,2,2-tetrafluoroethane	303	44	496	72	703	102
R-134a	1,1,1,2-Tetrafluoroethane	593	86	938	136	1282	186
R-170	Ethane	4246	616	4887	709	4887	709
R-290	Propane	889	129	1296	188	1682	244
R-401A	R-22/152a/124 (53/13/34)	710	103	1055	153	1420	206
R-401B	R-22/152a/124 (61/11/28)	756	110	1129	164	1504	218
R-401C	R-22/152a/124 (33/15/52)	586	85	893	130	1206	175
R-402A	R-125/290/22 (60/2/38)	1295	188	1863	270	2429	352
R-402B	R-125/290/22 (38/2/60)	1208	175	1744	253	2278	330
R-403A	R-290/22/218 (5/75/20)	1122	163	1616	234	2105	305
R-403B	R-290/22/218 (5/56/39)	1162	169	1667	242	2165	314
R-404A	R-125/143a/134a (44/52/4)	1209	175	1752	254	2294	333
R-405A	R-22/152a/142b/C318 (45/7/5.5/42.5)	771	112	1144	166	1519	220
R-406A	R-22/600a/142b (55/4/41)	719	104	1056	153	1390	202
R-407A	R-32/125/134a (20/40/40)	1205	175	1563	227	2296	333
R-407B	R-32/125/134a (10/70/20)	1274	185	1843	267	2407	349
R-407C	R-32/125/134a (23/25/52)	1142	166	1668	242	2191	318

(Continued)

**Table 4 (Concluded)**

Refrigerant number		Minimum design pressure (gauge*)					
		Low side		High side			
		kPa	psig	Water- or evaporator-cooled		Air-cooled	
				kPa	psig	kPa	psig
R-407D	R-32/125/134a (15/15/70)	958	139	1415	205	1874	272
R-407E	R-32/125/134a (25/15/60)	1101	160	1612	234	2123	308
R-408A	R-125/143a/22 (7/46/47)	1125	163	1633	237	2139	310
R-409A	R-22/124/142b (60/25/15)	749	109	1110	161	1281	186
R-409B	R-22/124/142b (65/25/10)	798	116	1179	171	1560	226
R-410A	R-32/125 (50/50)	1626	236	2343	340	3064	444
R-411A	R-1270/22/152a (1.5/87.5/11)	922	134	1357	197	1792	260
R-411B	R-1270/22/152a (3/94/3)	974	141	1428	207	1881	273
R-411C	R-1270/22/152a (3/95.5/1.5)	989	144	1449	210	1908	277
R-412A	R-22/218/142b (70/5/25)	864	125	1257	182	1647	239
R-413A	R-218/134a/600a (9/88/3)	731	106	1095	159	1463	212
R-414A	R-22/124/600a/142b (51/28.5/4/16.5)	723	105	1070	155	1415	205
R-414B	R-22/124/600a/142b (50/39/1.5/9.5)	716	104	1065	155	1412	205
R-415A	R-23/22/152a (5/80/15)	1026	149	1480	215	1929	280
R-500	R-12/152a (73.8/26.2)	705	102	1050	152	1395	202
R-502	R-22/115 (48.8/51.2)	1112	161	1594	231	2077	301
R-503	R-23/13 (40.1/59.9)	4253	617	4253	617	4253	617
R-507A	R-125/143a (50/50)	1243	180	1803	262	2373	344
R-508A	R-23/116 (39/61)	3959	574	3959	574	3959	574
R-508B	R-23/116 (46/54)	3821	554	3821	554	3821	554
R-509A	R-22/218 (44/56)	1190	173	1708	248	2218	322
R-717	Ammonia	951	138	1473	214	2016	292
R-744	Carbon dioxide	7275	1055	7275	1055	7275	1055
R-1150	Ethylene	4938	716	4938	716	4938	716

\*Saturated pressures correspond to a low-side temperature of 27 °C (80°F), a water- or evaporator-cooled temperature of 40 °C (105°F), and an air-cooled temperature of 52 °C (125°F).

**Note:** It is sometimes necessary to select higher design pressures to satisfy actual shipping, operating, or standby conditions.

**5.5.3**

Standby conditions shall include all normal conditions that can be attained in the system when it is not operating. Selection of the design pressure for low-side components shall also take into consideration pressure developed in the low side of the system from equalization or heating after the system has stopped.

**5.5.4**

Selection of the design pressure for low-side and high-side components shipped as part of gas- or refrigerant-charged systems shall take into consideration internal pressures arising from exposure to maximum temperatures anticipated during the course of shipment.

**5.5.5**

It shall not be necessary for the design pressure for either the low side or high side to exceed the critical pressure of the refrigerant unless such pressures are anticipated for operating, standby, or shipping conditions.

**5.5.6**

When part of a limited charge system is protected by a pressure-relief device, it shall not be necessary for the design pressure of that part to exceed the setting of the pressure-relief device.

**5.5.7**

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 low side (see Clause 7.2.3).

**5.5.8**

All components connected to pressure vessels and subject to the same pressure as the pressure vessel shall have a design pressure not less than that of the pressure vessel.

**5.6 Refrigerant-containing pressure vessels****5.6.1**

Refrigerant-containing pressure vessels shall comply with CSA B51.

**5.6.2**

Liquid receivers or parts of a system designed to receive the refrigerant charge during pumpdown shall have sufficient capacity to receive the pumpdown charge without the liquid occupying more than 90% of the volume when the temperature of the refrigerant is 32 °C (90°F).

**5.6.3**

All non-critically-charged systems using a liquid/vapour separation pressure vessel that has an internal diameter greater than 300 mm (12 in) and is located on the low side of the compressor(s) shall have a high-liquid-level sensing device fitted to that vessel. This device shall be installed to stop the compressor(s) before damaging quantities of liquid refrigerant enter the compressor(s).

**5.7 Refrigerant piping, fittings, evaporator and condenser coils, and associated headers****5.7.1 Refrigerant piping and fittings**

Refrigerant piping and fittings shall be registered in accordance with CSA B51. If applicable, they shall be listed either individually or as part of refrigeration equipment by an approved testing laboratory or shall comply with the requirements of ASME B31.5 and the requirements of Clause 5.5.2 of this Standard.

## 5.7.2 Minimum requirements for unprotected refrigerant piping and tubing

### 5.7.2.1

Unprotected, hard-drawn copper tubing used for refrigerant piping erected on the premises shall be ASTM B 88 Type K or L. Copper tubing with an outside diameter of 6 mm (1/4 in) shall have a nominal wall thickness of not less than 0.76 mm (0.030 in).

### 5.7.2.2

Unprotected soft annealed copper tubing used for refrigerant piping erected on the premises shall not be used in sizes larger than 35 mm (1-3/8 in) outside diameter and shall comply with ASTM B 280. The minimum nominal wall thickness of unprotected soft annealed copper tubing shall be as specified in Table 5 of this Standard.

### 5.7.2.3

Rigid or flexible metal enclosures shall be provided for soft annealed copper tubing used for piping erected on the premises and containing any refrigerant other than a Group A1 refrigerant. However, no enclosures shall be required for connections between a condensing unit and the nearest riser box, provided that such connections are not longer than 1.8 m (6 ft).

### 5.7.2.4

The joints on copper tubing used in refrigeration systems shall be brazed. Soldered joints shall not be used in such refrigeration systems.

**Table 5**  
**Unprotected soft annealed copper tubing —**  
**Minimum nominal wall thickness**  
(See Clause 5.7.2.2.)

Outside diameter		Wall thickness	
mm	in	mm	in
6	0.250	0.8	0.030
10	0.375	0.8	0.030
13	0.500	0.8	0.030
16	0.625	0.9	0.035
19	0.750	1.0	0.042
22	0.875	1.1	0.045
25*	1.000*	1.3	0.050
28	1.125	1.3	0.050
32*	1.250*	1.4	0.055
35	1.375	1.4	0.055

\*Not a standard size in ASTM B 280.

## 5.7.3 Evaporator and condenser coils and associated headers

Evaporator and condenser coils and associated headers that are not a part of equipment tested and certified by an approved testing laboratory shall

- (a) be designed, constructed, and tested in accordance with ASME B31.5 or the ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 1; and
- (b) have their design registered in accordance with CSA B51.

## 5.8 Components other than pressure vessels, piping, and fittings

### 5.8.1

Every pressure-containing component of a refrigeration system, other than pressure vessels, piping, and fittings within the scope of CSA B51, shall be listed either individually or as part of refrigeration equipment by an approved testing laboratory, or shall be designed, constructed, and assembled to withstand at least three times the design pressure for which it is rated for the low side and at least five times the design pressure for which it is rated for the high side. For high-side design pressures of 103 kPa (15 psig) or lower, it shall not be necessary for the test pressure to exceed 310 kPa (45 psig).

### 5.8.2

Liquid-level gauge glasses, except those of the bull's-eye or reflex type, shall have automatically closing shut-off valves and shall be adequately protected against damage.

### 5.8.3

A pressure gauge, when permanently installed on the high side of a refrigeration system, shall be constructed for at least 1.2 times the design pressure.

## 5.9 Design provisions for service

### 5.9.1

All systems shall have provisions for safely handling the refrigerant charge for servicing purposes without venting the charge to atmosphere.

**Note:** *These provisions may include properly located stop valves, liquid transfer valves, and refrigerant storage tanks required for the safe transfer, discharge, and disposal of the charge without venting the charge to atmosphere.*

### 5.9.2

#### 5.9.2.1

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

- (a) on each suction inlet of each compressor, compressor unit, or condensing unit; and
- (b) on each discharge outlet of each compressor, compressor unit, or condensing unit, and on each liquid receiver.

#### 5.9.2.2

The following systems shall not require stop valves installed at the locations specified in Clause 5.9.2.1:

- (a) those having a refrigerant pump-out function capable of storing the entire refrigerant charge;
- (b) those equipped with provisions for pump-out of the refrigerant; or
- (c) those that are self-contained.

### 5.9.3

#### 5.9.3.1

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

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

**5.9.3.2**

The following systems shall not require stop valves installed at the locations specified in Clause 5.9.3.1:

- (a) those having a refrigerant pump-out function capable of storing the entire refrigerant charge;
- (b) those equipped with provisions for pump-out of the refrigerant; or
- (c) those that are self-contained.

**5.9.4**

Stop valves used with soft annealed copper tubing or hard-drawn copper tubing 22 mm (7/8 in) in outside diameter or smaller shall be securely mounted, independent of tubing fastenings or supports.

**5.9.5**

Stop valves shall be suitably labelled if what they control is not obvious. Numbers may be used to label the valves, provided that a key to the numbers is located near the valves.

**5.10 Pressure testing****5.10.1 General**

The means used to build up the test pressure shall have either a pressure-limiting device or a pressure-reducing device. There shall be a pressure-relief device and a gauge on the test side. The pressure-relief device shall be set above the test pressure but low enough to prevent permanent deformation of the system components.

**5.10.2 Test medium****5.10.2.1**

Mixed gases containing more than 20% by volume of oxygen or any combustible gas or combustible mixture of gases shall not be used within the system for testing.

If any oxygen is present in the test medium, precautions shall be taken to avoid contact with ignition sources.

**5.10.2.2**

Water or aqueous solutions shall not be used to test refrigerant piping.

**5.10.3 Factory tests****5.10.3.1**

Every refrigerant-containing part of a system shall be tested and proved tight by the manufacturer at not less than the design pressure for which it is rated, as specified in Clauses 5.10.3.2 to 5.10.3.4.

**5.10.3.2**

Factory-assembled refrigeration systems and components listed by an approved testing laboratory and tested in accordance with the provisions of the listing shall be deemed to meet the requirements of Clause 5.10.3.1. Factory-assembled refrigeration systems and components that are not listed by an approved testing laboratory shall meet the requirements of Clause 5.10.3.3.

**5.10.3.3**

The test pressure applied to the high side of each factory-assembled refrigeration system shall be at least 1.25 times the design pressure of the component in the high side that has the lowest rated design pressure. The test pressure applied to the low side of each factory-assembled refrigeration system shall be equal to or greater than 1.25 times the design pressure of the component in the low side that has the lowest rated design pressure.

**5.10.3.4**

Units with a design pressure of 103.4 kPa gauge (15 psig) or less shall be tested at a pressure not less than 1.33 times the design pressure.

**5.10.4 Field tests****5.10.4.1**

Every refrigerant-containing part of a system that is erected on the premises, except compressors, condensers, evaporators, safety devices, pressure gauges, control mechanisms, and systems that are factory tested, shall be tested and proved tight after complete installation and before operation.

**5.10.4.2**

The high and low sides of each system shall be tested and proved tight at not less than the lesser of the design pressure (see Table 4) or the setting of the pressure-relief device protecting the high and low sides of the system. The system shall sustain the test pressure for a minimum test period of 2 h, or as specified by the regulatory authority having jurisdiction.

**5.10.4.3**

In pressure-testing systems using non-positive-displacement compressors, the entire system shall be considered at the low-side pressure for test purposes.

**5.10.4.4**

Refrigerant pipe joints erected on the premises shall be exposed to view for visual inspection at the discretion of the regulatory authority.

**5.10.4.5**

A dated declaration of test signed by the installer shall be provided for all systems containing 23 kg (50 lb) or more of refrigerant. The declaration shall state the name of the refrigerant, the field test pressures applied to the high side and the low side of the system, and the duration of the test. When requested, copies of the declaration shall be furnished to the regulatory authority. The test shall be witnessed by an authorized inspector when required by the regulatory authority.

**5.11 Marking and labelling****5.11.1 Signs (all systems)**

Each refrigeration system shall be provided with a permanent sign that is securely attached, readily accessible, and legible, and that indicates the following:

- (a) name and address of installer;
- (b) refrigerant type;
- (c) lubricant type and amount;
- (d) total weight of refrigerant required for normal operation;
- (e) field test pressures applied;
- (f) refrigeration capacity at design or nominal conditions; and
- (g) for prime mover(s), the rating in kilowatts (hp) or full-load current and voltage.

**5.11.2 Nameplates for unit systems, condensing units, compressors, and compressor units**

Each unit system and separate condensing unit sold for field assembly in a refrigeration system shall carry a nameplate marked with the manufacturer's name, the nationally registered trademark or tradename, the identification number, the test pressures, and the refrigerant for which it is designed. The refrigerant shall be designated in accordance with ASHRAE 34. Each compressor or compressor unit sold for field assembly

in a refrigeration system shall carry a nameplate marked with the manufacturer's name, the nationally registered trademark or tradename, the identification number, and the test pressures (see also Clause 5.11.1).

### **5.11.3 Signs for systems containing more than 45 kg (100 lb) of refrigerant**

In addition to meeting the requirements of Clauses 5.11.1 and 5.11.2, systems containing more than 45 kg (100 lb) of refrigerant shall be provided with durable signs with letters not less than 13 mm (1/2 in) in height designating the following:

- (a) the main electrical disconnect switch(es);
- (b) any remote control switch(es);
- (c) any pressure-limiting device(s);
- (d) each pressure vessel;
- (e) the main shut-off to each vessel; and
- (f) the refrigerant piping (indicating whether it is at the high-side or low-side pressure and whether it is normally in the liquid or vapour state).

### **5.11.4 New signs for changed refrigerant**

When the type of refrigerant is changed, as outlined in Clause 5.12, there shall be a new sign in accordance with Clause 5.11.1, indicating clearly that a substitution has been made and stating the equivalent information for the new refrigerant.

### **5.11.5 Posting of instructions**

It shall be the duty of the owner of a refrigeration system or systems with a prime mover or movers having a capacity exceeding 125 kW (175 hp) to place in a conspicuous location and as near as practicable to the refrigerant compressor(s) a card giving directions for operating the system, including precautions to be observed in case of breakdown or leakage, as follows:

- (a) the telephone number of the appropriate first-response organization for an emergency situation;
- (b) instructions for shutting down the system in case of emergency;
- (c) the name, address, and day and night telephone numbers for obtaining service; and
- (d) the name, address, and telephone number of the nearest regulatory authority, and instructions to notify the authority immediately in case of emergency.

**Note:** Consideration should be given to preparing an emergency evacuation plan for those installations for which a plan is deemed appropriate.

## **5.12 Substitution of refrigerant type**

Substitution of refrigerant type shall not be made without

- (a) permission of the regulatory authority (where required);
- (b) compliance with this Standard; and
- (c) verification of compliance with this Standard's design requirements by
  - (i) the original equipment manufacturer; or
  - (ii) a professional engineer.

**Note:** Because the use of hydrocarbon systems is expected to increase, Annex I provides, as a convenience for users of this Standard, a copy of the CSA B52 Information Bulletin on hydrocarbon refrigerants, published in March 2002. This Bulletin includes information on hydrocarbon refrigerants as drop-in replacements for other classes of refrigerants.

## 6 Installation

### 6.1 General

#### 6.1.1

Foundations and supports for condensers, condensing units, and compressor units shall be structurally sound and of non-combustible construction.

#### 6.1.2

Moving machinery shall comply with all applicable workplace safety and health regulations.

#### 6.1.3

The safe inspection and maintenance of refrigeration system equipment shall be provided in at least one of the following ways:

- (a) Floor-mounted equipment shall be installed in a manner that allows sufficient clearance around the equipment for safe maintenance and service.
- (b) Equipment that is not accessible from floor level shall be installed so that it can be safely reached
  - (i) by a permanently installed staircase(s) or ladder(s) with a platform(s) and railings meeting the workplace safety requirements of the jurisdiction where the equipment is installed; or
  - (ii) by a mobile device(s) for lifting personnel to the equipment. The use of such a device, as an alternative to the fixed means of access specified in Item (b)(i), shall be permitted only if it is normally on the premises at all times, is acceptable under the workplace safety requirements of the jurisdiction, and if the nature of the refrigeration equipment is such that it can be safely serviced in this way.
- (c) Roof- and mezzanine-mounted equipment shall be set back 3 m (10 ft) from any edge where a fall hazard exists, except under the conditions specified in Item (d). If the workplace safety requirements of the jurisdiction of installation impose a greater setback, those requirements shall apply.
- (d) Where roof- and mezzanine-mounted equipment cannot be set back as specified in Item (c), railings and fall-arrest system attachment points shall be provided in accordance with the workplace safety requirements of the jurisdiction of installation.

#### 6.1.4

Condensing units or compressor units within enclosures shall be readily accessible for servicing and inspection.

### 6.2 Machinery rooms

**Note:** See also Clauses 6.3 and 6.4.

#### 6.2.1 General

When a refrigeration system is located indoors, a machinery room shall be provided when required by Clause 4.5. A machinery room shall have dimensions that make all equipment easily accessible, with adequate space for proper service, maintenance, and operation. Access to the machinery room shall be restricted to authorized personnel.

#### 6.2.2 Doors

Each machinery room shall have a door or doors that open outward, are self-closing (and tight fitting if they open into the building), and are of a number large enough to ensure that persons can escape in an emergency. The door(s) shall not open to a public corridor or any room used for assembly. With the exception of access doors and panels in air ducts and air handler units complying with Clause 6.2.5.8, there shall be no openings that will permit passage of escaping refrigerant to other parts of the building.

### 6.2.3 Refrigerant vapour detector

For all refrigerants except ammonia, a refrigerant vapour detector shall be located in an area where refrigerant from a leak is most likely to concentrate and shall be actuated at a value not greater than the corresponding TLV<sup>®</sup>/TWA (or a consistent toxicity measure). The sensors, when activated, shall

- (a) sound a sufficiently audible alarm; and
- (b) initiate mechanical ventilation in accordance with Clause 6.2.5.5.

For ammonia, the requirements of Item (h) of Clause 6.3 shall apply.

**Note:** In certain situations, more than one detector or multiple-sensing points can be necessary (e.g., because of the machinery room configuration or airflow patterns).

### 6.2.4 Explosion protection

#### 6.2.4.1

Except as permitted by Clause 6.2.4.3, no open flames or apparatus to produce an open flame shall be installed in a machinery room where any refrigerant other than carbon dioxide is used.

#### 6.2.4.2

The use of matches, lighters, halide leak detectors, and similar devices shall not be considered a violation of Clause 6.2.4.1.

#### 6.2.4.3

Combustion equipment may be installed in the same machinery room with refrigerant-containing equipment under one of the following conditions:

- (a) combustion air is ducted from outside the machinery room and sealed in a manner that prevents any refrigerant leakage from entering the combustion chamber; or
- (b) a refrigerant vapour detector (see Clause 6.2.3) is employed to automatically shut down the combustion process in the event of a refrigerant leak at a level not exceeding the refrigerant TLV<sup>®</sup>/TWA value. When the TLV<sup>®</sup>/TWA values are not available, a consistent measure shall be used.

### 6.2.5 Ventilation

#### 6.2.5.1 General

Machinery rooms shall be ventilated to the outdoors. Mechanical ventilation shall be required in accordance with Clause 6.2.5.5 unless the provisions of Clause 6.2.5.6 are met, in which case natural ventilation shall be permitted.

#### 6.2.5.2 Ventilation fans

The mechanical ventilation specified in Clause 6.2.5.1 shall be provided by one or more power-driven fans capable of exhausting air from the machinery room in at least the amount calculated in accordance with Clause 6.2.5.5 and installed in accordance with Clauses 6.2.5.3 and 6.2.5.4. To obtain a reduced airflow for normal ventilation, multiple fans, multi-speed fans, or variable-speed fans may be used.

#### 6.2.5.3 Location of air inlets and the provision of makeup air

The air inlets to the exhaust ventilation system shall be located near the machinery, suitably guarded, and at an elevation where refrigerant from a leak is most likely to concentrate. Provision shall be made for outdoor makeup air to replace that being exhausted. Openings for makeup air shall be positioned to avoid intake of discharge air. The air shall be discharged to the outdoors in a manner that does not cause inconvenience or danger. The air supply for and exhaust ducts to a machinery room shall serve no other area.

#### 6.2.5.4 Fan switches

Readily accessible independent fan switches shall be installed inside and outside the machinery room. Fan switches located outside the machinery room shall be capable of starting but not stopping the ventilation.

#### 6.2.5.5 Mechanical ventilation

##### 6.2.5.5.1 Leaks or ruptures calculation

The mechanical ventilation required to exhaust a potential accumulation of refrigerant due to leaks or a rupture of the system shall be capable of removing air from the machinery room in the following amounts:

For system refrigerant charges of 7000 kg (15 400 lb) or less:

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

For system refrigerant charges greater than 7000 kg (15 400 lb):

$$Q = 16 \times G^{2/3} \quad (Q = 20 \times G^{2/3})$$

where

$Q$  = airflow, L/s (ft<sup>3</sup>/min)

$G$  = mass of refrigerant, in kg (lb), in the largest system that is located or partly located in the machinery room

##### 6.2.5.5.2 Minimum ventilation

Whenever the refrigeration system is operating or whenever the room is occupied, a sufficient part of the mechanical ventilation shall be operated to provide normal volumes equal to the greater of the following:

- (a) 2.54 L/s/m<sup>2</sup> (0.5 cfm/ft<sup>2</sup>) of machinery room area; or
- (b) the volume required to prevent a maximum temperature rise above ambient greater than 10 °C (18°F), based on all of the heat-producing machinery in the room.

##### 6.2.5.6 Natural ventilation calculation

When a refrigeration system is located outdoors more than 6.1 m (20 ft) from any building opening and is enclosed by a penthouse, lean-to, or other open structure, natural ventilation may be employed as an alternative to mechanical ventilation through the use of permanent openings or grilles. The sum of the opening areas for such ventilation shall be related to the mass of refrigerant in the largest refrigeration system, any part of which is in the machinery room, in accordance with the formula specified in this Clause. Flow area for natural ventilation shall not be obstructed by shaft walls or surrounding buildings.

Natural ventilation shall not be used where the openings for such ventilation cannot be located with due regard for the density of the refrigerant vapour.

The free aperture cross-section for the ventilation of the machinery room shall amount to at least

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

where

$F$  = free opening area, m<sup>2</sup> (ft<sup>2</sup>)

$G$  = mass of refrigerant, in kg (lb), in the largest system that is located or partly located in the machinery room

##### 6.2.5.7 Minimum temperature

Supplementary heating shall be provided to maintain a minimum machinery room temperature of 5 °C (40°F) where damage could result at temperatures below freezing.

### 6.2.5.8 Air to or from an occupied space

The passage of air to or from an occupied space through a machinery room shall be permitted only when the air is ducted and sealed in a manner that prevents any refrigerant leakage from entering the airstream. Access doors and panels in ductwork and air handler units shall be gasketed and tight fitting.

## 6.3 Class T machinery rooms

In cases specified in Clause 4.5.2, a machinery room shall meet the following special requirements in addition to those specified in Clause 6.2:

- (a) There shall be no flame-producing device or hot surface over 427 °C (800°F) permanently installed in the room.
- (b) The room shall have at least one exit door that opens directly to the outer air. Other exits communicating with the building shall be permitted, but shall be through a vestibule equipped with approved self-closing, tight-fitting fire doors.
- (c) The machinery room envelope, including any vestibule, shall be of tight construction.
- (d) The machinery room envelope, including any vestibule, shall have not less than one-hour fire-resistive construction as defined by the *National Building Code of Canada*.
- (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 a Class T machinery room shall be tightly sealed to the walls, ceiling, or floor through which they pass.
- (g) Air ducts passing through a Class T machinery room shall be of tight construction and shall have no openings in such rooms.
- (h) Remote pilot control of the mechanical equipment in the machinery room shall be located immediately outside the machinery room and shall be provided solely for shutting down the equipment in an emergency. Ventilation fans shall have a control switch on a separate circuit located immediately outside of the machinery room, and shall be permitted to run as long as power is available.
- (i) An independent mechanical ventilation system shall be provided as specified in Clause 6.2.5.5. In basements, the ventilation system shall be operated continuously. All locations shall be equipped with a vapour detector that shall automatically start the ventilation system and actuate an alarm at the lowest practical detection levels not exceeding the concentration limits specified in Item (c)(iii) of Clause 4.5.2 or 300 ppm for ammonia. The vapour detector shall also initiate a supervised alarm so that corrective action can be initiated.
- (j) When refrigerants of Groups A2, A3, B2 other than ammonia, and B3 are used, the machinery room shall conform to the requirements for Class 1, Zone 2 locations as defined in the *Canadian Electrical Code, Part I*.

## 6.4 Machinery rooms — Electrical requirements for ammonia systems

### 6.4.1 Class T machinery rooms

When ammonia is used in a refrigeration system and all refrigerant-containing parts, except piping and evaporators, are installed in a Class T machinery room (see Clauses 6.2 and 6.3), this room shall not be considered a hazardous location as defined in the *Canadian Electrical Code, Part I*.

### 6.4.2 Machinery rooms

When ammonia is used in a refrigeration system and all refrigerant-containing parts, except piping and evaporators, are installed in a machinery room (see Clause 6.2), this room shall be considered a Class 1, Zone 2 hazardous location, and all electrical equipment in the room shall comply with the requirements for Class 1, Zone 2 locations as defined in the *Canadian Electrical Code, Part I*.

## 6.5 Water supply and discharge connections

### 6.5.1

Water supply and discharge connections shall be made in accordance with requirements of the appropriate regulatory authorities.

### 6.5.2

Discharge water lines shall not be directly connected to the waste or sewer systems. The waste or discharge from such equipment shall be through an accepted air gap and trap.

## 6.6 Electrical wiring

All electrical work and wiring, including the installation of electrical equipment, shall be done in accordance with the requirements of the *Canadian Electrical Code, Part I*.

## 6.7 Gas devices

All gas fuel devices and equipment used with refrigeration systems shall be installed in accordance with CAN/CSA-B149.1 or CAN/CSA-B149.2.

## 6.8 Location of refrigerant piping

### 6.8.1

When refrigerant piping is being installed, consideration shall be given to its location to minimize the danger of the piping being struck from any direction (such as by falling objects, material handling equipment, or general traffic). Should such a danger exist, appropriate protection shall be provided.

### 6.8.2

In any building, refrigerant piping crossing an open space that provides a passageway shall be not less than 2.3 m (7-1/2 ft) above the floor unless it is against the ceiling of such a space.

### 6.8.3

Passages shall not be obstructed by refrigerant piping. Refrigerant piping shall not be placed in any elevator, dumb waiter, or other shaft containing a moving object, or in any shaft that has openings to living quarters or to main exits. Refrigerant piping shall not be installed in any enclosed stairway, stair landing, or exit.

### 6.8.4

Refrigerant piping shall not be installed vertically through floors from one storey to another, except as follows:

- (a) It may be installed from the basement to the first floor, from the top floor to a machinery penthouse or to the roof, or between adjacent floors served by the refrigeration system.
- (b) For the purpose of interconnecting separate pieces of equipment not located as described in Item (a), the piping may be carried in an approved rigid and tight continuous fire-resisting pipe duct or shaft without openings into floors not served by the refrigeration system, or it may be carried on the outer wall of the building, provided that it is not located in an air shaft, closed court, or similar space enclosed within the outer walls of the building. The pipe duct or shaft shall be vented to the outside or to the space served by the system.
- (c) It shall not be necessary to enclose piping of a direct system containing Group A1 refrigerants where the piping passes through space served by that system.
- (d) It shall not be necessary to enclose piping of direct systems containing Group A2, B1, or B2 refrigerants where the piping passes through space defined by Clause 4.2.6 as industrial occupancy.

### 6.8.5

Refrigerant piping may be installed horizontally in closed floors or in open joist spaces. Piping installed in concrete floors shall be encased in pipe duct, except in the case of ice rinks.

### 6.9 Joints and refrigerant-containing parts in air ducts

Joints and all refrigerant-containing parts of a refrigeration system located in an air duct carrying conditioned air to and from a human-occupied space shall be constructed to withstand a temperature of 427 °C (800°F) without leakage into the airstream.

### 6.10 Emergency discharge

In the design of a refrigeration system, consideration shall be given to the provision of an emergency discharge system (see Annex B).

### 6.11 Purge discharge

The discharge of purge systems shall be governed by the same requirements as pressure-relief devices and fusible plugs (see Clause 7.3.6) and may be piped in conjunction with those devices.

## 7 Overpressure protection

### 7.1 Pressure vessel protection

#### 7.1.1 ASME *Boiler and Pressure Vessel Code* requirements

Pressure vessels shall be provided with pressure-relief protection in accordance with rules specified in paragraphs UG-125 to UG-134, Section VIII, Division 1, of the ASME *Boiler and Pressure Vessel Code*, with such modifications as are necessary for control of refrigerants.

#### 7.1.2 Pressure vessels with an internal gross volume of 0.085 m<sup>3</sup> (3 ft<sup>3</sup>) or less

Pressure vessels with an internal gross volume of 0.085 m<sup>3</sup> (3 ft<sup>3</sup>) or less containing liquid refrigerant, except as specified in Clause 7.1.4, and that can be shut off by valves from all other parts of a refrigeration system, shall be protected by a pressure-relief device or fusible plug. However, pressure vessels of less than 152 mm (6 in) inside diameter shall be exempt from this requirement.

#### 7.1.3 Pressure vessels with an internal gross volume exceeding 0.085 m<sup>3</sup> (3 ft<sup>3</sup>)

##### 7.1.3.1 General

Pressure vessels with an internal gross volume exceeding 0.085 m<sup>3</sup> (3 ft<sup>3</sup>) containing liquid refrigerant, except as specified in Clause 7.1.4, and that can be shut off by valves from all other parts of a refrigeration system, shall be protected by a pressure-relief device with sufficient capacity to prevent the pressure in the pressure vessel from rising more than 10% above the setting of the pressure-relief device.

##### 7.1.3.2 Pressure vessels with an internal gross volume exceeding 0.085 m<sup>3</sup> (3 ft<sup>3</sup>) but less than 0.28 m<sup>3</sup> (10 ft<sup>3</sup>)

Under the conditions specified in Clause 7.1.3.1, a single pressure-relief device may be used on pressure vessels with an internal gross volume of less than 0.28 m<sup>3</sup> (10 ft<sup>3</sup>).

### **7.1.3.3 Pressure vessels with an internal gross volume of 0.28 m<sup>3</sup> (10 ft<sup>3</sup>) or more**

#### **7.1.3.3.1 General**

If a pressure-relief valve is used under the conditions specified in Clause 7.1.3.1, a relief device system consisting of a pressure-relief valve, in parallel with a second pressure-relief valve as described in Clause 7.3.1.2, shall be provided on pressure vessels with an internal gross volume of 0.28 m<sup>3</sup> (10 ft<sup>3</sup>) or more. Each pressure-relief valve shall have sufficient capacity to prevent the pressure in the pressure vessel from rising more than 10% above the setting of the pressure-relief valve. Dual pressure-relief valves shall be installed with a three-way valve to allow testing or repair.

#### **7.1.3.3.2 Pressure-relief valves discharging into the low side of the system**

Under the conditions permitted in Clause 7.3.6.2, a single relief valve (not rupture member) of the required relieving capacity may be used on vessels with an internal gross volume of 0.28 m<sup>3</sup> (10 ft<sup>3</sup>) or more.

#### **7.1.3.3.3 Pressure-relief devices in parallel on large vessels**

Except as specified in Clause 7.1.4, in cases where large pressure vessels containing liquid refrigerant require two or more pressure-relief devices used in parallel to obtain the required capacity, the battery of pressure-relief devices shall be considered a unit and therefore shall be considered one pressure-relief device.

### **7.1.4 Pressure-relief devices for pressure vessels used as, or as part of, evaporators**

Pressure vessels with an internal diameter greater than nominal 150 mm (6 in) that are used as, or as part of, evaporators that are insulated or installed in insulated space, and that can be shut off by valves from all other parts of a refrigeration system, shall be protected by a pressure-relief device in accordance with Clauses 7.1.2 and 7.1.3, except that the Clause 7.1.3.3 requirement of a second parallel pressure-relief valve shall not apply. Pressure vessels with an internal diameter of nominal 150 mm (6 in) or less that are used as evaporators shall be exempt from the pressure-relief device requirements specified in Clause 7.

## **7.2 System protection**

### **7.2.1 Pressure-limiting devices**

Pressure-limiting devices shall be provided on all systems operating above atmospheric pressure, except that a pressure-limiting device may be omitted on any factory-sealed system that contains less than 10 kg (22 lb) of Group A1 refrigerant and has been listed by an approved testing laboratory.

### **7.2.2 Setting of pressure-limiting devices**

#### **7.2.2.1**

When required by Clause 7.2.1 on systems not equipped with a pressure-relief device, the maximum setting of an adjustable pressure-limiting device shall not exceed the system high-side design pressure. On systems equipped with a pressure-relief device, the setting of this device shall be not more than 90% of the system high-side design pressure, except as provided in Clause 7.2.2.2. In all cases, the pressure-limiting device shall stop the action of the pressure-imposing element at a pressure not higher than this maximum setting.

### 7.2.2.2

On systems using non-positive-displacement compressors, the pressure-limiting device may be set at the system high-side design pressure, provided that the pressure-relief device is subject to low-side pressure and there are no stop valves on the system.

### 7.2.2.3

Pressure-limiting devices shall be connected, with no intervening stop valves, between the pressure-imposing element and any stop valve on the discharge side.

## 7.2.3 Positive-displacement compressor protection

### 7.2.3.1

When equipped with a stop valve in the discharge connection, every positive-displacement compressor shall be equipped with a pressure-relief device of adequate capacity setting (as specified by the compressor manufacturer) to prevent rupture of the compressor and 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 on the discharge side or in accordance with Clause 7.3.4.1, whichever is higher. The pressure-relief device shall discharge into the low-pressure side of the system or in accordance with Clause 7.3.6.

### 7.2.3.2

The sizing of the relief device(s) shall be based on compressor flow under the following conditions:

- (a) High-stage or single-stage compressors: flow shall be calculated based on 10 °C (50°F) saturated suction temperature at the compressor suction.
- (b) Low-stage or booster compressors: for compressors that can run only when discharging to the suction of a high-stage compressor, flow shall be calculated based on the saturated suction temperature equal to the design operating intermediate temperature.

### 7.2.3.3

The discharge capacity of the relief device may 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.
- (c) A pressure-limiting device is installed and set in accordance with Clauses 7.2.1 and 7.2.2.

**Note:** Annex E describes one acceptable method of calculating the discharge capacity of pressure-relief devices for positive displacement compressors.

## 7.2.4 Expansion of liquid refrigerant

Consideration shall be given to expansion of liquid refrigerant trapped in or between closed valves and a means to prevent overpressure.

## 7.3 Pressure-relief devices

### 7.3.1 General

#### 7.3.1.1

Every refrigeration system shall be protected by a pressure-relief device or some other means designed to relieve, in a safe manner, pressure due to fire or other abnormal conditions. In addition, all pressure vessels shall be protected in accordance with Clause 7.3.2.2. All pressure-relief devices (except fusible plugs) shall be directly pressure actuated.

Pilot pressure-relief valves may be used, provided that the pilot is self actuated by the system pressure. The main valve shall open automatically at a pressure not greater than the set pressure and shall discharge its full-rated capacity if the pilot fails.

### 7.3.1.2

Stop valves shall not be located between the means of pressure relief and the part or parts of the system protected thereby, except when the parallel relief devices specified in Clause 7.1.3.3 are arranged so that only one at a time can be rendered inoperative for testing or repair purposes.

### 7.3.1.3

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

## 7.3.2 Location of pressure-relief devices

### 7.3.2.1

Evaporators or condensers located downstream or upstream from, and in proximity to, a heating coil, or located upstream within 460 mm (18 in) of a heating coil, shall be fitted with a pressure-relief device that discharges to the outside of the building in accordance with Clause 7.3.6. Such a relief device shall not be required on unit or self-contained systems if the internal volume of the low side of the system, which may be shut off by valves, divided by the total weight of refrigerant in the system less the weight of refrigerant vapour contained in the other parts of the system at 43 °C (110°F), exceeds the specific volume of the refrigerant at critical conditions of temperature and pressure. This can be represented as follows:

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

where

$V_1$  = low-side volume, m<sup>3</sup> (ft<sup>3</sup>)

$W_1$  = total weight of refrigerant in system, kg (lb)

$V_2$  = total volume of system, m<sup>3</sup> (ft<sup>3</sup>)

$V_{gt}$  = specific volume of refrigerant vapour at 43 °C (110°F), m<sup>3</sup>/kg (ft<sup>3</sup>/lb)

$V_{gc}$  = specific volume at critical temperature and pressure, m<sup>3</sup>/kg (ft<sup>3</sup>/lb)

### 7.3.2.2

All fusible plugs and other pressure-relief devices shall be connected as directly as possible to the pressure vessel or other parts of the system protected thereby, above the liquid refrigerant level. They shall also be installed in such a way that they are readily accessible for inspection and repair and cannot be readily rendered inoperative. Fusible plugs may be located above or below the liquid refrigerant level, except on the low side.

## 7.3.3 Setting of pressure-relief devices

### 7.3.3.1 Pressure-relief valve setting

All pressure-relief valves shall start to function at a pressure not exceeding the design pressure of the protected parts of the system.

### 7.3.3.2 Rupture member setting

All rupture members used in lieu of, or in series with, a relief valve shall have a nominal-rated rupture pressure not exceeding the design pressure of the protected parts of the system. The conditions of application shall comply with paragraph UG-127, Section VIII, Division 1, of the ASME *Boiler and Pressure Vessel Code*. Rupture members installed ahead of relief valves shall not be smaller than the relief valve inlet.

## 7.3.4 Capacity of pressure-relief devices

### 7.3.4.1 Required capacity

The minimum required discharge capacity of the fusible plug or other pressure-relief device for each pressure vessel shall be determined as follows:

$$C = fDL$$

where

$C$  = minimum required discharge capacity of the pressure-relief device, kg (lb) of air per minute

$f$  = a factor based on the type of refrigerant, as specified in Table 6

$D$  = outside diameter of the vessel, m (ft)

$L$  = length of the vessel, m (ft)

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

### 7.3.4.2 Rated discharge capacity

#### 7.3.4.2.1

The rated discharge capacity of a pressure-relief valve, expressed in kilograms (pounds) of air per minute, shall be determined in accordance with paragraph UG-131, Section VIII, Division 1, of the ASME *Boiler and Pressure Vessel Code*. 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.

#### 7.3.4.2.2

The rated discharge capacity of a rupture member or fusible plug discharging to atmosphere under critical flow conditions in kilograms (pounds) of air per minute shall be determined as follows:

$$C = 8.2 \times 10^{-5} P_1 d^2 \quad \left( C = 0.8 P_1 d^2 \right)$$

$$d = 1.10 \times 10^2 \sqrt{\frac{C}{P_1}} \quad \left( d = 1.2 \sqrt{\frac{C}{P_1}} \right)$$

where

$C$  = rated discharge capacity, kg (lb) of air per minute

$P_1$  (for rupture members) = (rated pressure  $\times$  1.10) + 101.325 kPa

= (rated pressure  $\times$  1.10) + 14.7 psia

$P_1$  (for fusible plugs) = 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, kPa (psia)

$d$  = smallest internal diameter, mm (in), of the internal diameters of the following: inlet pipe, retaining flanges, fusible plug, rupture member

**Table 6**  
**Discharge capacity calculation factor,  $f$ , for refrigerants**  
 (See Clause 7.3.4.1.)

Refrigerant number	Factor for SI calculations	Factor for imperial calculations	Refrigerant number	Factor for SI calculations	Factor for imperial calculations
R-11	4.9	1	R-407B	12.3	2.5
R-12	7.8	1.6	R-407C	7.8	1.6
R-13	9.8	2 L	R-407D	7.8	1.6
R-13B1	9.8	2 L	R-407E	7.8	1.6
R-14	12.3	2.5 L	R-408A	9.8	2
R-22	7.8	1.6	R-409A	7.8	1.6
R-23	4.9	1 L	R-409B	7.8	1.6
R-113	4.9	1	R-410A	12.3	2.5
R-114	7.8	1.6	R-411A	7.8	1.6
R-123	4.9	1	R-411B	7.8	1.6
R-124	7.8	1.6	R-412A	7.8	1.6
R-134a	7.8	1.6	R-413A	9.8	2.0
R-170	4.9	1 L	R-414A	7.8	1.6
R-290	4.9	1	R-414B	7.8	1.6
R-401A	7.8	1.6	R-415A	9.8	2
R-401B	7.8	1.6	R-500	7.8	1.6
R-401C	7.8	1.6	R-502	12.3	2.5
R-402A	12.3	2.5	R-507A	12.3	2.5
R-402B	9.8	2	R-508A	4.9	1 L
R-403A	9.8	2	R-508B	4.9	1 L
R-403B	12.3	2.5	R-509A	12.3	2.5
R-404A	12.3	2.5	R-717	2.5	0.5
R-405A	7.8	1.6	R-744	4.9	1 L
R-406A	7.8	1.6	R-1150	4.9	1 L
R-407A	9.8	2			

**Notes:**

- (1) Single fluids used only in blends are not shown.  
 (2) L = used in the low side of a limited charge cascade system.

### 7.3.5 Marking of fusible plugs and other pressure-relief devices

#### 7.3.5.1

All pressure-relief valves for refrigerant-containing components shall be set and sealed by the manufacturer or an assembler, as defined in paragraph UG-136(c)(4), Section VIII, Division 1, of the ASME *Boiler and Pressure Vessel Code*. Each pressure-relief valve shall be marked by the manufacturer or assembler with the data required by paragraph UG-129(a), Section VIII, Division 1, of the ASME *Boiler and Pressure Vessel Code*, except that relief valves for systems with design pressures of 103.4 kPa gauge (15 psig) or less may be marked by the manufacturer with the pressure setting and capacity.

#### 7.3.5.2

Each rupture member for refrigerant-containing pressure vessels shall be marked with the data required by paragraph UG-129(d), Section VIII, Division 1, of the ASME *Boiler and Pressure Vessel Code*.

#### 7.3.5.3

Fusible plugs shall be marked with the melting temperature in degrees Celsius (degrees Fahrenheit).

### 7.3.6 Discharge of fusible plugs and other pressure-relief devices

#### 7.3.6.1

##### 7.3.6.1.1

Fusible plugs and other pressure-relief devices shall discharge to the outside of the building, as required by Clause 7.3.6.1.2, on any system containing

- (a) a Group A3 or B3 refrigerant;
- (b) more than 3 kg (6.6 lb) of a Group A2, B1, or B2 refrigerant; or
- (c) more than 50 kg (110 lb) of a Group A1 refrigerant.

The discharge termination shall be fashioned in a manner that prevents direct spray of discharged refrigerant on personnel in the vicinity, and shall prevent foreign material or debris from entering the discharge piping. Discharge piping shall allow for drainage of rain and snow and shall be adequately braced.

##### 7.3.6.1.2

The discharge to the atmosphere shall be not less than 4.6 m (15 ft) above the adjoining ground level and not less than 7.6 m (25 ft) from any window, ventilation opening, or exit in any building. Discharge piping connected to the discharge side of a fusible plug or rupture member shall be equipped to prevent plugging of the piping in the event that the fusible plug or rupture member functions.

##### 7.3.6.1.3

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

- (a) the atmosphere, as specified in Clauses 7.3.6.1.1 and 7.3.6.1.2;
- (b) a tank containing 8 kg of water for each kilogram of ammonia (8 lb of water for 1 lb of ammonia) that will be released in 1 h 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 not lower than 10 m (33 ft) below the maximum liquid level. The tank shall contain the water and ammonia without overflowing; or
- (c) another treatment system that meets the requirements of the regulatory authority.

#### 7.3.6.2

Pressure-relief valves may discharge into the low side of the system provided that the pressure-relief devices are of a type not appreciably affected by back pressures and provided that the low side of the system is equipped with pressure-relief devices. The relief devices on the low side of the system shall have

sufficient capacity to protect the pressure vessels that are relieved into the low side of the system, or to protect all pressure vessels on the low side of the system, whichever relieving capacity is larger, when calculated in accordance with the equation specified in Clause 7.3.4.1. Such low-side pressure-relief devices shall be set in accordance with Clause 7.3.3.1 and vented to the outside of the building in accordance with Clause 7.3.6.1.

#### **7.3.6.3**

The size of the discharge pipe from the fusible plug or other pressure-relief device shall be not less than the size of the fusible plug or other pressure-relief device outlet. If the discharge from more than one plug or relief device is connected into a common header, the size and maximum equivalent length of the discharge header shall be determined by

- (a) the sum of the rated capacities of all valves discharging into the header, at the lowest pressure setting of any of the relief valves discharging into the header; or
- (b) the sum of the areas of the pipes connecting into the common header.

#### **7.3.6.4**

The length of the discharge piping that may be installed on the outlet of a fusible plug or other pressure-relief device discharging to the atmosphere shall be determined by the method specified in Annex H. Tables 7 and 8 show values for pressure-relief valve discharge line capacity for various discharge line lengths for steel and copper respectively.

**Table 7**  
**Pressure-relief valve discharge line capacity (lb/min of air)**  
**for various equivalent discharge line lengths for steel**  
**(expressed in imperial units\*)**  
 (See Clause 7.3.6.4.)

Set (psig)	Length (ft)	Nominal pipe size (NPS)										
		1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	4	5	6
5	2	2.8	5.8	10.7	21.3	31.4	57.8	88.8	148.0	278.9	469	704
5	3	2.3	4.8	9.0	18.1	26.8	49.9	77.3	130.4	249.8	426	647
5	4	2.0	4.2	7.9	16.0	23.7	44.5	69.4	117.8	228.2	393	601
5	5	1.8	3.8	7.1	14.4	21.5	40.6	63.5	108.3	211.4	367	564
5	6	1.7	3.5	6.6	13.3	19.8	37.5	58.9	100.8	197.8	346	533
5	8	1.5	3.0	5.7	11.6	17.4	33.1	52.0	89.5	177.0	312	484
5	10	1.3	2.7	5.1	10.5	15.7	29.9	47.1	81.3	161.7	286	446
5	15	1.1	2.2	4.2	8.6	12.9	24.7	39.2	67.9	135.9	243	380
5	20	0.9	1.9	3.7	7.5	11.3	21.6	34.2	59.4	119.5	214	337
5	25	0.8	1.7	3.3	6.7	10.1	19.4	30.8	53.5	107.9	194	306
5	30	0.8	1.6	3.0	6.2	9.3	17.8	28.2	49.1	99.1	179	282
5	40	0.7	1.4	2.6	5.3	8.0	15.4	24.5	42.8	86.5	156	247
5	60	0.5	1.1	2.1	4.4	6.6	12.6	20.1	35.1	71.2	129	205
5	100	0.4	0.9	1.7	3.4	5.1	9.8	15.6	27.3	55.6	101	160
5	160	0.3	0.7	1.3	2.7	4.0	7.8	12.4	21.7	44.1	80	127
5	250	0.3	0.6	1.0	2.1	3.2	6.2	9.9	17.4	35.3	64	102
15	2	4.6	9.3	16.7	32.0	46.0	81.6	121.8	196.5	355.2	577	849
15	3	3.9	8.0	15.5	28.3	41.0	74.0	111.6	182.3	334.5	550	815
15	4	3.5	7.1	13.0	25.6	37.4	68.1	103.6	170.8	317.1	526	784
15	5	3.1	6.5	11.9	23.6	34.6	63.5	97.1	161.2	302.2	506	757
15	6	2.9	6.0	11.0	22.0	32.3	59.7	91.7	153.1	289.2	487	732
15	8	2.5	5.2	9.7	19.5	28.9	53.8	83.2	140.0	267.5	455	689
15	10	2.3	4.7	8.8	17.8	26.3	49.3	76.7	129.7	250.1	429	683
15	15	1.9	3.9	7.3	14.8	22.1	41.7	65.3	111.6	218.0	379	583
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

**Note:** The information in this Table applies to conventional relief valves only.

(Continued)

**Table 7 (Continued)**

Set (psig)	Length (ft)	Nominal pipe size (NPS)										
		1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	4	5	6
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
50	2	7.6	14.7	25.4	46.5	65.3	111.7	162.8	256	451	718	1045
50	3	6.8	13.2	23.2	43.4	61.4	106.3	156.1	248	439	704	1027
50	4	6.1	12.2	21.6	40.8	58.1	101.6	150.2	240	429	691	1011
50	5	5.7	11.3	20.2	38.6	55.2	97.4	144.9	233	419	678	996
50	6	5.3	10.6	19.1	36.7	52.8	93.8	140.1	226	410	666	981
50	8	4.7	9.5	17.3	33.6	48.7	87.5	131.8	215	393	644	953
50	10	4.3	8.7	15.9	31.2	45.5	82.4	124.8	205	378	624	927
50	15	3.6	7.4	13.6	26.9	39.6	72.7	113.3	185	347	582	872
50	20	3.1	6.5	12.0	24.0	35.5	65.8	101.4	170	323	547	825
50	25	2.8	5.9	10.9	21.9	32.4	60.5	93.8	158	303	517	785
50	30	2.6	5.4	10.0	20.3	30.1	56.3	87.6	148	286	492	750
50	40	2.3	4.7	8.8	17.8	26.6	50.1	78.3	133	260	451	692
50	60	1.9	3.9	7.3	14.8	22.1	42.0	66.0	113	224	393	608

**Note:** The information in this Table applies to conventional relief valves only.

(Continued)

**Table 7 (Continued)**

Set (psig)	Length (ft)	Nominal pipe size (NPS)										
		1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	4	5	6
50	100	1.4	3.0	5.7	11.6	17.4	33.3	52.6	91	182	323	504
50	160	1.1	2.4	4.5	9.3	13.9	26.7	42.3	73	148	265	416
50	250	0.9	1.9	3.6	7.5	11.2	21.5	34.2	59	120	217	342
75	2	9.1	17.2	29.4	53.3	74.3	126.0	182.7	286	501	795	1154
75	3	8.2	15.8	27.3	50.4	70.7	121.2	176.9	279	491	783	1140
75	4	7.5	14.6	25.7	47.8	67.6	116.9	171.6	272	482	772	1127
75	5	7.0	13.7	24.3	45.7	64.8	113.1	166.8	266	474	762	1114
75	6	6.5	13.0	23.1	43.7	62.4	109.6	162.3	260	466	751	1101
75	8	5.9	11.8	21.1	40.6	58.3	103.4	154.4	249	450	732	1077
75	10	5.4	10.8	19.6	38.0	54.9	98.2	147.5	240	437	714	1054
75	15	4.5	9.2	16.9	33.2	48.4	88.0	133.7	220	407	675	1004
75	20	4.0	8.2	15.1	29.9	43.8	80.5	123.1	204	383	641	96
75	25	3.6	7.4	13.7	27.4	40.3	74.6	114.8	192	363	612	92
75	30	3.3	6.8	12.7	25.4	37.6	69.8	107.9	181	345	587	88
75	40	2.9	6.0	11.2	22.5	33.4	62.5	97.2	164	317	544	82
75	60	2.4	5.0	9.3	16.8	28.0	52.9	82.8	141	276	481	73
75	100	1.9	3.9	7.3	14.8	22.2	42.2	66.5	115	227	401	62
75	160	1.5	3.1	5.8	11.9	17.8	34.0	53.8	93	186	332	52
75	250	1.2	2.5	4.7	9.6	14.4	27.5	43.6	76	153	274	43
100	2	10.3	19.4	32.9	59.3	82.2	138.8	200.8	314	547	868	124
100	3	9.4	17.9	30.9	56.4	78.9	134.4	195.4	307	539	857	124
100	4	8.7	16.8	29.2	54.0	75.9	130.3	190.4	301	531	847	123
100	5	8.1	15.8	27.8	51.8	73.2	126.6	185.9	295	523	837	123
100	6	7.6	15.0	26.5	49.9	70.8	123.2	181.7	289	515	828	123
100	8	6.9	13.7	24.5	46.6	66.6	117.2	174.0	279	501	810	118
100	10	6.3	12.7	22.8	43.9	63.1	112.0	167.2	270	488	793	116
100	15	5.4	10.9	19.9	38.7	56.3	101.4	153.1	250	459	756	117
100	20	4.7	9.7	17.8	35.1	51.3	93.4	142.1	234	435	723	107
100	25	4.3	8.8	16.3	32.3	47.4	87.0	133.2	221	415	694	108
100	30	4.0	8.2	15.1	30.1	44.3	81.8	125.8	210	397	668	100
100	40	3.5	7.2	13.3	26.7	39.5	73.7	114.0	192	367	625	94
100	60	2.9	5.9	11.1	22.4	33.4	62.7	97.9	166	323	558	85

**Note:** The information in this Table applies to conventional relief valves only.

(Continued)

**Table 7 (Continued)**

Set (psig)	Length (ft)	Nominal pipe size (NPS)										
		1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	4	5	6
100	100	2.2	4.7	8.7	17.8	26.6	50.4	79.2	136	268	471	72
100	160	1.8	3.7	7.0	14.3	21.4	40.7	64.3	111	222	393	61
100	250	1.4	3.0	5.6	11.5	17.3	33.0	52.3	91	182	326	51
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	158.3	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
200	25	6.8	13.9	24.3	49.5	72.0	130.1	196.6	322	592	967	1447
200	30	6.3	12.9	23.6	46.5	67.9	123.4	187.6	309	572	949	1412
200	40	5.6	11.4	21.1	41.8	61.4	112.8	172.6	287	538	901	1349
200	60	4.6	9.6	17.7	35.5	52.5	97.7	151.1	254	484	823	1245

**Note:** The information in this Table applies to conventional relief valves only.

(Continued)

**Table 7 (Continued)**

Set (psig)	Length (ft)	Nominal pipe size (NPS)										
		1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	4	5	6
200	100	3.6	7.5	14.1	28.5	42.4	79.9	124.7	212	413	714	1094
200	160	2.9	6.0	11.3	23.0	34.4	65.2	102.5	176	347	610	944
200	250	2.3	4.9	9.1	18.6	27.9	53.3	84.1	145	290	514	802
250	2	16.5	30.4	50.7	89.9	123.8	207.0	297.7	463	803	1268	1836
250	3	15.5	28.8	48.6	87.2	120.7	203.0	293.0	457	796	1260	1826
250	4	14.6	27.5	46.9	84.7	117.8	199.3	288.5	452	789	1251	1815
250	5	13.8	26.4	45.2	82.4	115.1	195.7	284.2	446	782	1243	1805
250	6	13.2	25.4	43.8	80.3	112.5	192.3	280.2	441	775	1234	1795
250	8	12.2	23.6	41.3	76.6	107.9	186.1	272.5	431	762	1219	1776
250	10	11.3	22.2	39.1	73.3	103.9	180.4	265.4	422	750	1203	1757
250	15	9.8	19.6	35.0	66.7	95.4	168.2	249.8	401	721	1167	1713
250	20	8.8	17.7	31.9	61.5	88.7	158.1	236.7	383	696	1135	1672
250	25	8.0	16.3	29.5	57.5	83.3	149.7	225.5	368	673	1104	1634
250	30	7.4	15.1	27.6	54.1	78.7	142.5	215.7	354	652	1076	1598
250	40	6.5	13.4	24.7	48.8	71.5	130.7	199.5	330	616	1026	1533
250	60	5.4	11.3	20.9	41.7	61.5	114.0	175.6	294	558	944	1423
250	100	4.3	8.9	16.6	33.6	49.9	93.7	145.9	248	479	826	1261
250	160	3.4	7.1	13.4	27.2	40.6	76.8	120.5	207	406	710	1096
250	250	2.7	5.8	10.8	22.1	33.0	62.9	99.2	171	340	692	937
300	2	18.4	33.7	56.1	99.4	136.7	228.3	328	510	884	1395	2019
300	3	17.3	32.7	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	1051	1595

**Note:** The information in this Table applies to conventional relief valves only.

(Continued)

**Table 7 (Continued)**

Set (psig)	Length (ft)	Nominal pipe size (NPS)										
		1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	4	5	6
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
350	25	10.3	20.8	37.6	72.8	105	187	280	455	827	1347	19
350	30	9.6	19.4	35.3	68.8	99	178	269	440	804	1317	19
350	40	8.5	17.3	31.7	62.4	91	163	250	413	764	1262	18
350	60	7.1	14.6	26.9	53.7	79	145	222	372	699	1170	17
350	100	5.6	11.6	21.6	43.5	64	120	186	316	607	1034	15
350	160	4.5	9.3	17.4	35.4	52	99	155	266	519	897	13
350	250	3.6	7.5	14.1	28.8	43	81	128	222	438	766	12
400	2	22.0	40.2	66.6	117.7	161.7	269.6	387	601	1041	1642	23
400	3	20.9	38.5	64.5	114.8	158.4	265.5	382	595	1034	1633	23
400	4	19.8	37.0	62.5	112.2	155.3	261.5	378	589	1026	1625	23
400	5	18.9	35.7	60.7	109.7	152.4	257.7	373	584	1019	1616	23
400	6	18.2	34.5	59.1	107.4	149.6	254.1	369	578	1012	1608	23
400	8	16.9	32.5	56.1	103.1	144.5	247.3	360	568	999	1591	23
400	10	15.8	30.7	53.6	99.3	139.9	241.0	353	558	986	1575	22
400	15	13.9	27.4	48.5	91.5	130.1	227.1	335	535	955	1537	22
400	20	12.5	24.9	44.6	85.2	122.0	215.4	320	515	927	1502	22
400	25	11.4	23.0	41.6	80.1	115.3	205.4	307	497	902	1469	21
400	30	10.6	21.5	39.0	75.8	109.6	196.6	296	481	878	1438	21
400	40	9.4	19.2	35.1	68.9	100.4	182.0	276	453	836	1382	20
400	60	7.9	16.2	26.9	59.4	87.2	160.4	246	409	767	1286	19

**Note:** The information in this Table applies to conventional relief valves only.

(Continued)

**Table 7 (Concluded)**

Set (psig)	Length (ft)	Nominal pipe size (NPS)										
		1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	4	5	6
400	100	6.2	12.9	24.0	48.3	71.5	133.4	207	349	669	1143	17
400	160	5.0	10.4	19.4	39.3	58.5	110.3	173	294	574	996	15
400	250	4.0	8.4	15.7	32.0	47.9	90.9	143	246	468	854	13

\*SI conversions:

(a)  $\text{kPa} = \text{psig} \times 6.895$ ;

(b)  $\text{mm} = \text{in} \times 25.4$ ;

(c)  $\text{kg/s} = \text{lb/min} \times 0.007559$ ; and

(d)  $\text{m} = \text{ft} \times 0.3048$ .

**Note:** The information in this Table applies to conventional relief valves only.

**Table 8**  
**Pressure-relief valve discharge line capacity (lb/min of air) for various**  
**discharge line lengths for copper (expressed in imperial units\*)**  
 (See Clause 7.3.6.4.)

Set Length (psig) (ft)		Nominal copper tube (Type L and ACR)									
		3/8	1/2	5/8	3/4	7/8	1-1/8	1-3/8	1-5/8	2-1/8	2-5/8
		Inside diameter of tube (in)									
		0.315	0.430	0.545	0.666	0.785	1.025	1.265	1.505	1.985	2.465
5	2	0.7	1.6	2.8	4.7	7.0	13.5	22.4	33.9	64.4	105.8
5	3	0.6	1.3	2.4	4.0	6.0	11.6	19.4	29.6	57.1	95.0
5	4	0.5	1.1	2.1	3.5	5.3	10.3	17.4	26.6	51.8	86.9
5	5	0.5	1.0	1.9	3.2	4.8	9.4	15.9	24.4	47.8	80.6
5	6	0.4	0.9	1.7	2.9	4.4	8.7	14.7	22.6	44.6	75.5
5	8	0.4	0.8	1.5	2.5	3.8	7.6	13.0	20.0	39.7	67.7
5	10	0.3	0.7	1.4	2.3	3.5	6.9	11.7	18.2	36.2	61.9
5	15	0.3	0.6	1.1	1.9	2.9	5.7	9.7	15.1	30.3	52.1
5	20	0.2	0.5	1.0	1.6	2.5	4.9	8.5	13.2	26.5	45.8
5	25	0.2	0.5	0.9	1.5	2.2	4.4	7.6	11.9	23.9	41.4
5	30	0.2	0.4	0.8	1.3	2.0	4.1	7.0	10.9	22.0	38.0
5	40	0.2	0.4	0.7	1.2	1.8	3.5	6.1	9.5	19.1	33.2
5	60	0.1	0.3	0.6	0.9	1.4	2.9	5.0	7.8	15.7	27.4
5	100	0.1	0.2	0.4	0.7	1.1	2.2	3.9	6.1	12.3	21.3
5	160	0.1	0.2	0.3	0.6	0.9	1.8	3.1	4.8	9.7	16.9
5	250	0.1	0.2	0.3	0.5	0.7	1.4	2.5	3.8	7.8	13.6
15	2	1.2	2.5	4.4	7.1	10.5	19.4	31.2	45.9	84.0	134.0
15	3	1.0	2.2	3.9	6.3	9.3	17.5	28.4	42.3	78.5	126.4
15	4	0.9	1.9	3.5	5.7	8.4	16.0	26.3	39.4	73.9	120.1
15	5	0.8	1.7	3.2	5.2	7.8	14.9	24.6	37.0	70.0	114.6
15	6	0.7	1.6	2.9	4.8	7.2	13.9	23.1	35.0	66.7	109.7
15	8	0.6	1.4	2.6	4.3	6.4	12.5	20.9	31.8	61.3	101.7
15	10	0.6	1.3	2.3	3.9	5.9	11.4	19.2	29.4	57.0	95.2
15	15	0.5	1.1	1.9	3.2	4.9	9.6	16.3	25.1	49.3	83.2
15	20	0.4	0.9	1.7	2.8	4.3	8.5	14.4	22.3	44.0	74.8
15	25	0.4	0.8	1.5	2.5	3.9	7.7	13.1	20.2	40.2	68.6
15	30	0.3	0.8	1.4	2.3	3.6	7.0	12.0	18.7	37.2	63.6

**Note:** The information in this Table applies to standard relief valves only.

(Continued)

**Table 8 (Continued)**

Set (psig)	Length (ft)	Nominal copper tube (Type L and ACR)									
		3/8	1/2	5/8	3/4	7/8	1-1/8	1-3/8	1-5/8	2-1/8	2-5/8
		Inside diameter of tube (in)									
		0.315	0.430	0.545	0.666	0.785	1.025	1.265	1.505	1.985	2.465
15	40	0.3	0.7	1.2	2.0	3.1	6.2	10.5	16.4	32.8	56.3
15	60	0.2	0.5	1.0	1.7	2.5	5.1	8.7	13.6	27.2	47.0
15	100	0.2	0.4	0.8	1.3	2.0	4.0	6.8	10.6	21.4	37.1
15	160	0.1	0.3	0.6	1.0	1.6	3.1	5.4	8.5	17.1	29.7
15	250	0.1	0.3	0.5	0.8	1.3	2.5	4.3	6.8	13.7	23.9
25	2.0	1.5	3.1	5.3	8.5	12.3	22.4	35.5	51.7	93.2	147.0
25	3.0	1.3	2.7	4.7	7.6	11.2	20.6	33.1	48.6	88.7	141.2
25	4.0	1.1	2.4	4.3	7.0	10.3	19.2	31.1	46.0	84.8	136.0
25	5.0	1.0	2.2	4.0	6.5	9.6	18.0	29.4	43.8	81.4	131.3
25	6.0	0.9	2.1	3.7	6.1	9.0	17.1	28.0	41.9	78.3	127.1
25	8.0	0.8	1.8	3.3	5.4	8.1	15.5	25.7	38.7	73.2	119.7
25	10.0	0.7	1.6	3.0	5.0	7.4	14.3	23.9	36.1	68.9	113.5
25	15.0	0.6	1.4	2.5	4.2	6.3	12.3	20.6	31.4	60.8	101.5
25	20.0	0.5	1.2	2.2	3.7	5.6	10.9	18.4	28.2	55.1	92.6
25	25.0	0.5	1.1	2.0	3.3	5.0	9.9	16.8	25.8	50.7	85.7
25	30.0	0.4	1.0	1.8	3.0	4.6	9.1	15.5	23.9	47.2	80.1
25	40.0	0.4	0.9	1.6	2.7	4.0	8.0	13.7	21.1	42.0	71.6
25	60.0	0.3	0.7	1.3	2.2	3.3	6.6	11.3	17.6	35.2	60.5
25	100.0	0.2	0.6	1.0	1.7	2.6	5.2	8.9	13.9	27.9	48.2
25	160.0	0.2	0.4	0.8	1.4	2.1	4.1	7.1	11.1	22.4	38.8
25	250.0	0.2	0.4	0.6	1.1	1.7	3.3	5.7	8.9	18.0	31.4
50	2	1.94	3.98	6.80	10.61	15.19	27.02	42.27	60.92	108.3	169.4
50	3	1.72	3.59	6.21	9.81	14.17	25.57	40.36	58.57	105.1	165.3
50	4	1.56	3.29	5.75	9.17	13.34	24.32	38.70	56.48	102.1	161.5
50	5	1.43	3.06	5.39	8.64	12.63	23.24	37.22	54.59	99.4	157.9
50	6	1.34	2.87	5.08	8.19	12.03	22.29	35.90	52.88	96.8	154.5
50	8	1.19	2.57	4.60	7.47	11.05	20.70	33.63	49.90	92.3	148.4
50	10	1.08	2.35	4.23	6.92	10.27	19.41	31.75	47.37	88.4	143.0

**Note:** The information in this Table applies to conventional relief valves only.

(Continued)

**Table 8 (Continued)**

Set (psig)	Length (ft)	Nominal copper tube (Type L and ACR)									
		3/8	1/2	5/8	3/4	7/8	1-1/8	1-3/8	1-5/8	2-1/8	2-5/8
		Inside diameter of tube (in)									
		0.315	0.430	0.545	0.666	0.785	1.025	1.265	1.505	1.985	2.465
50	15	0.90	1.99	3.60	5.93	8.87	17.01	28.15	42.42	80.4	131.7
50	20	0.79	1.75	3.19	5.27	7.93	15.32	25.54	38.75	74.2	122.7
50	25	0.71	1.58	2.89	4.80	7.23	14.05	23.55	35.90	69.3	115.3
50	30	0.65	1.45	2.66	4.43	6.69	13.05	21.96	33.59	65.2	109.1
50	40	0.57	1.27	2.33	3.89	5.89	11.57	19.56	30.07	58.9	99.2
50	60	0.47	1.05	1.93	3.23	4.90	9.67	16.45	25.43	50.3	85.5
50	100	0.37	0.82	1.51	2.53	3.85	7.64	13.07	20.30	40.5	69.5
50	160	0.29	0.65	1.20	2.01	3.07	6.11	10.48	16.33	32.8	56.6
50	250	0.23	0.52	0.96	1.62	2.47	4.93	8.46	13.21	26.6	46.1
75	2	2.3	4.7	7.9	12.2	17.4	30.6	47.6	68.2	120.7	188.1
75	3	2.1	4.3	7.3	11.4	16.4	29.3	45.9	66.2	118.0	184.7
75	4	1.9	4.0	6.9	10.8	15.6	28.1	44.4	64.4	115.4	181.4
75	5	1.8	3.7	6.5	10.3	14.9	27.1	43.0	62.7	113.0	178.3
75	6	1.7	3.5	6.2	9.8	14.3	26.2	41.8	61.1	110.7	175.4
75	8	1.5	3.2	5.6	9.1	13.3	24.6	39.6	58.3	106.6	169.9
75	10	1.4	2.9	5.2	8.5	12.5	23.3	37.7	55.8	102.8	164.9
75	15	1.1	2.5	4.5	7.3	10.9	20.7	34.0	50.8	95.0	154.1
75	20	1.0	2.2	4.0	6.6	9.8	18.8	31.1	46.9	88.8	145.2
75	25	0.9	2.0	3.6	6.0	9.0	17.4	28.9	43.8	83.6	137.7
75	30	0.8	1.8	3.4	5.6	8.4	16.2	27.1	41.2	79.2	131.3
75	40	0.7	1.6	3.0	4.9	7.4	14.5	24.4	37.2	72.2	120.7
75	60	0.6	1.3	2.5	4.1	6.2	12.2	20.7	31.8	62.4	105.4
75	100	0.5	1.0	1.9	3.2	4.9	9.7	16.6	25.6	50.9	86.9
75	160	0.4	0.8	1.5	2.6	3.9	7.8	13.4	20.8	41.5	71.4
75	250	0.3	0.7	1.2	2.1	3.2	6.3	10.8	16.9	33.9	58.5
100	2	2.6	5.3	8.8	13.6	19.3	33.8	52.3	74.9	132.1	205.5
100	3	2.4	4.9	8.3	12.9	18.4	32.6	50.8	73.1	129.7	202.4
100	4	2.2	4.5	7.8	12.2	17.6	31.5	49.4	71.4	127.3	199.5

**Note:** The information in this Table applies to conventional relief valves only.

(Continued)

**Table 8 (Continued)**

Set (psig)	Length (ft)	Nominal copper tube (Type L and ACR)									
		3/8	1/2	5/8	3/4	7/8	1-1/8	1-3/8	1-5/8	2-1/8	2-5/8
		Inside diameter of tube (in)									
		0.315	0.430	0.545	0.666	0.785	1.025	1.265	1.505	1.985	2.465
100	5	2.1	4.3	7.4	11.7	16.9	30.5	48.1	69.7	125.1	196.6
100	6	1.9	4.1	7.1	11.2	16.3	29.6	46.9	68.2	122.9	193.9
100	8	1.7	3.7	6.5	10.4	15.3	28.0	44.7	65.5	119.0	188.8
100	10	1.6	3.4	6.1	9.8	14.4	26.6	42.8	63.1	115.4	184.1
100	15	1.4	2.9	5.3	8.6	12.7	23.9	39.0	58.0	107.7	173.7
100	20	1.2	2.6	4.7	7.7	11.5	21.9	36.1	54.0	101.4	164.8
100	25	1.1	2.4	4.3	7.1	10.6	20.4	33.7	50.7	96.0	157.2
100	30	1.0	2.2	4.0	6.6	9.9	19.1	31.7	48.0	91.5	150.6
100	40	0.9	1.9	3.5	5.9	8.8	17.1	28.6	43.6	84.0	139.5
100	60	0.7	1.6	2.9	4.9	7.4	14.5	24.5	37.6	73.3	123.1
100	100	0.6	1.3	2.3	3.9	5.9	11.6	19.7	30.5	60.3	102.5
100	160	0.4	1.0	1.8	3.1	4.7	9.4	16.0	24.8	49.5	84.8
100	250	0.4	0.8	1.5	2.5	3.8	7.6	13.0	20.2	40.5	69.9
150	2	3.2	6.3	10.5	16.1	22.8	39.7	61.2	87.4	153.8	238.7
150	3	2.9	5.9	10.0	15.4	21.9	38.5	59.8	85.8	151.5	235.9
150	4	2.7	5.6	9.5	14.8	21.1	37.5	58.5	84.2	149.3	233.2
150	5	2.6	5.3	9.1	14.3	20.5	36.5	57.2	82.6	147.3	230.6
150	6	2.4	5.1	8.7	13.8	19.8	35.6	56.1	81.2	145.3	228.1
150	8	2.2	4.7	8.1	12.9	18.7	34.0	54.0	78.5	141.5	223.3
150	10	2.1	4.4	7.6	12.2	17.8	32.6	52.0	76.1	138.1	218.8
150	15	1.8	3.8	6.7	10.9	16.0	29.7	48.0	71.0	130.4	208.7
150	20	1.6	3.4	6.1	9.9	14.6	27.5	44.8	66.7	123.9	199.8
150	25	1.4	3.1	5.6	9.1	13.6	25.7	42.2	63.1	118.3	192.0
150	30	1.3	2.9	5.2	8.5	12.7	24.2	40.0	60.1	113.4	185.0
150	40	1.1	2.5	4.6	7.6	11.4	21.9	36.4	55.1	105.1	173.1
150	60	0.9	2.1	3.8	6.4	9.6	18.8	31.5	48.0	92.9	154.8
150	100	0.7	1.7	3.0	5.1	7.7	15.1	25.6	39.5	77.5	130.9
150	160	0.6	1.3	2.4	4.1	6.2	12.3	20.9	32.4	64.2	109.5
150	250	0.5	1.1	2.0	3.3	5.0	10.0	17.0	26.5	52.9	91.0

**Note:** The information in this Table applies to conventional relief valves only.

(Continued)

**Table 8 (Continued)**

Set (psig)	Length (ft)	Nominal copper tube (Type L and ACR)									
		3/8	1/2	5/8	3/4	7/8	1-1/8	1-3/8	1-5/8	2-1/8	2-5/8
		Inside diameter of tube (in)									
		0.315	0.430	0.545	0.666	0.785	1.025	1.265	1.505	1.985	2.465
200	2	3.7	7.3	12.1	18.5	26.0	45.2	69.7	99.4	174.4	270.5
200	3	3.5	6.9	11.6	17.8	25.2	44.1	68.3	97.7	172.2	267.8
200	4	3.2	6.6	11.1	17.2	24.4	43.1	67.0	96.2	170.2	265.2
200	5	3.1	6.3	10.7	16.6	23.7	42.1	65.8	94.7	168.1	262.7
200	6	2.9	6.0	10.3	16.1	23.1	41.2	64.6	93.3	166.2	260.3
200	8	2.7	5.6	9.6	15.2	21.9	39.6	62.5	90.6	162.5	255.6
200	10	2.5	5.2	9.1	14.4	21.0	38.1	60.5	88.2	159.1	251.1
200	15	2.1	4.6	8.0	12.9	19.0	35.1	56.3	82.8	151.3	241.0
200	20	1.9	4.1	7.3	11.8	17.5	32.6	52.9	78.4	144.6	232.0
200	25	1.7	3.8	6.7	11.0	16.3	30.7	50.1	74.5	138.7	223.9
200	30	1.6	3.5	6.3	10.3	15.3	29.0	47.6	71.2	133.4	216.6
200	40	1.4	3.1	5.6	9.2	13.8	26.4	43.6	65.8	124.5	204.0
200	60	1.2	2.6	4.7	7.8	11.7	22.7	38.0	57.8	111.0	184.1
200	100	0.9	2.0	3.7	6.2	9.4	18.5	31.2	47.9	93.5	157.3
200	160	0.7	1.6	3.0	5.0	7.6	15.0	25.5	39.5	78.0	132.7
200	250	0.6	1.3	2.4	4.1	6.2	12.2	20.9	32.5	64.7	110.9
250	2	4.2	8.2	13.6	20.7	29.2	50.6	77.8	110.9	194.5	301.4
250	3	3.9	7.8	13.1	20.0	28.3	49.5	76.5	109.3	192.3	298.7
250	4	3.7	7.5	12.6	19.4	27.6	48.4	75.2	107.7	190.3	296.2
250	5	3.5	7.2	12.1	18.8	26.8	47.5	73.9	106.2	188.3	293.7
250	6	3.4	6.9	11.7	18.3	26.2	46.5	72.8	104.8	186.3	291.3
250	8	3.1	6.4	11.0	17.4	25.0	44.9	70.6	102.1	182.6	286.6
250	10	2.9	6.0	10.5	16.5	24.0	43.3	68.6	99.6	179.1	282.1
250	15	2.5	5.3	9.3	14.9	21.8	40.1	64.2	94.1	171.2	271.9
250	20	2.2	4.8	8.5	13.7	20.2	37.5	60.6	89.4	164.2	262.6
250	25	2.0	4.4	7.9	12.8	18.9	35.4	57.5	85.4	158.1	254.3
250	30	1.9	4.1	7.3	12.0	17.8	33.6	54.9	81.8	152.5	246.6
250	40	1.7	3.6	6.6	10.8	16.1	30.7	50.5	75.9	143.0	233.3
250	60	1.4	3.0	5.5	9.2	13.7	26.5	44.2	67.1	128.4	212.0

**Note:** The information in this Table applies to conventional relief valves only.

(Continued)

**Table 8 (Continued)**

Set (psig)	Length (ft)	Nominal copper tube (Type L and ACR)									
		3/8	1/2	5/8	3/4	7/8	1-1/8	1-3/8	1-5/8	2-1/8	2-5/8
		Inside diameter of tube (in)									
		0.315	0.430	0.545	0.666	0.785	1.025	1.265	1.505	1.985	2.465
250	100	1.1	2.4	4.4	7.3	11.1	21.7	36.5	56.0	108.9	182.6
250	160	0.9	1.9	3.5	5.9	9.0	17.7	30.1	46.4	91.4	155.0
250	250	0.7	1.6	2.9	4.8	7.3	14.5	24.7	38.2	76.1	130.1
300	2	4.7	9.2	15.1	22.9	32.2	55.8	85.8	122.2	214.1	331.6
300	3	4.4	8.7	14.5	22.2	31.4	54.7	84.4	120.5	211.9	329.0
300	4	4.2	8.3	14.0	21.6	30.6	53.6	83.1	119.0	209.9	326.4
300	5	4.0	8.0	13.5	21.0	29.9	52.6	81.9	117.5	207.8	323.9
300	6	3.8	7.7	13.1	20.4	29.2	51.7	80.7	116.0	205.9	321.5
300	8	3.5	7.2	12.4	19.4	27.9	50.0	78.4	113.3	202.1	316.8
300	10	3.3	6.8	11.8	18.6	26.8	48.4	76.3	110.7	198.6	312.3
300	15	2.8	6.0	10.6	16.9	24.6	45.0	71.8	105.0	190.4	301.8
300	20	2.5	5.4	9.6	15.5	22.8	42.3	68.0	100.1	183.2	292.2
300	25	2.3	5.0	8.9	14.5	21.4	40.0	64.7	95.8	176.8	283.6
300	30	2.2	4.7	8.4	13.6	20.2	38.0	61.9	92.1	171.0	275.6
300	40	1.9	4.2	7.5	12.3	18.3	34.8	57.2	85.7	160.9	261.6
300	60	1.6	3.5	6.3	10.5	15.7	30.3	50.3	76.1	145.1	238.9
300	100	1.2	2.8	5.1	8.4	12.7	24.8	41.8	63.8	123.9	207.0
300	160	1.0	2.2	4.1	6.8	10.3	20.3	34.5	53.1	104.4	176.7
300	250	0.8	1.8	3.3	5.5	8.4	16.6	28.4	43.9	87.2	148.9
350	2	5.2	10.0	16.5	25.1	35.2	60.9	93.6	133.2	233.3	361.3
350	3	4.9	9.6	15.9	24.4	34.4	59.8	92.2	131.6	231.2	358.7
350	4	4.6	9.2	15.4	23.7	33.5	58.7	90.9	130.0	229.1	356.1
350	5	4.4	8.9	14.9	23.1	32.8	57.7	89.6	128.5	227.0	353.6
350	6	4.2	8.5	14.5	22.5	32.1	56.7	88.4	127.0	225.0	351.1
350	8	3.9	8.0	13.7	21.5	30.8	54.9	86.1	124.2	221.2	346.3
350	10	3.6	7.6	13.1	20.6	29.7	53.3	83.9	121.6	217.6	341.7
350	15	3.2	6.7	11.8	18.7	27.3	49.8	79.2	115.7	209.2	330.9
350	20	2.9	6.1	10.8	17.3	25.4	46.9	75.2	110.5	201.7	321.2
350	25	2.6	5.6	10.0	16.2	23.8	44.4	71.8	106.0	195.0	312.2

**Note:** The information in this Table applies to conventional relief valves only.

(Continued)

**Table 8 (Concluded)**

Set (psig)	Length (ft)	Nominal copper tube (Type L and ACR)									
		3/8	1/2	5/8	3/4	7/8	1-1/8	1-3/8	1-5/8	2-1/8	2-5/8
		Inside diameter of tube (in)									
		0.315	0.430	0.545	0.666	0.785	1.025	1.265	1.505	1.985	2.465
350	30	2.4	5.2	9.4	15.3	22.6	42.3	68.8	102.1	188.9	303.9
350	40	2.1	4.7	8.4	13.8	20.5	38.9	63.7	95.3	178.3	289.2
350	60	1.8	3.9	7.1	11.8	17.7	33.9	56.3	85.0	161.5	265.2
350	100	1.4	3.1	5.7	9.5	14.3	27.9	46.9	71.6	138.5	231.0
350	160	1.1	2.5	4.6	7.7	11.7	22.9	38.8	59.7	117.2	197.9
350	250	0.9	2.0	3.7	6.3	9.5	18.8	32.0	49.5	98.1	167.3
400	2	5.6	10.9	17.9	27.2	38.2	66.0	101.3	144.1	252.3	390.6
400	3	5.3	10.5	17.3	26.5	37.3	64.8	99.9	142.5	250.1	387.9
400	4	5.1	10.0	16.8	25.8	36.5	63.7	98.5	140.8	248.0	385.3
400	5	4.8	9.7	16.3	25.1	35.7	62.7	97.2	139.3	245.9	382.7
400	6	4.6	9.4	15.8	24.5	34.9	61.7	95.9	137.8	243.9	380.2
400	8	4.3	8.8	15.0	23.5	33.6	59.8	93.6	134.9	240.0	375.3
400	10	4.0	8.3	14.3	22.5	32.4	58.1	91.4	132.2	236.2	370.6
400	15	3.5	7.4	12.9	20.6	29.9	54.4	86.5	126.1	227.6	359.6
400	20	3.2	6.7	11.9	19.1	27.9	51.4	82.3	120.7	219.9	349.5
400	25	2.9	6.2	11.1	17.9	26.3	48.8	78.7	116.0	212.9	340.2
400	30	2.7	5.8	10.4	16.8	24.9	46.5	75.5	111.8	206.5	331.6
400	40	2.4	5.2	9.3	15.3	22.7	42.8	70.1	104.6	195.3	316.2
400	60	2.0	4.4	7.9	13.1	19.6	37.5	62.1	93.6	177.5	290.9
400	100	1.6	3.5	6.4	10.6	15.9	31.0	51.9	79.2	152.9	254.5
400	160	1.3	2.8	5.1	8.6	13.0	25.5	43.1	66.3	129.8	218.8
400	250	1.0	2.3	4.2	7.0	10.6	20.9	35.6	55.1	109.0	185.6

\*SI conversions:

(a) kPa = psig × 6.895;

(b) mm = in × 25.4;

(c) kg/s = lb/min × 0.007559; and

(d) m = ft × 0.3048.

**Note:** The information in this Table applies to conventional relief valves only.

## 8 Maintenance of systems

### 8.1 Charging and withdrawal of refrigerants

No service containers shall be left connected to a system, except while refrigerant is being charged or withdrawn. Except for discharging fusible plugs and other pressure-relief devices and incidental minimal releases due to leaks, purging of non-condensables, draining of oil, and other routine operating or maintenance procedures, no refrigerant shall be discharged as governed by the applicable local codes and regulations.

### 8.2 Refrigerants withdrawn from refrigeration systems

Refrigerants withdrawn from refrigeration systems shall be transferred to acceptable containers only. When a refrigerant is withdrawn from a refrigeration system into containers, the filling weight shall be limited to that prescribed for the refrigerant in the applicable regulations of the Canadian Transport Commission for such containers. The containers shall be carefully weighed each time they are used as described in this Clause.

### 8.3 Refrigerant storage

Refrigerant, in addition to that in the system, shall be stored only in a machinery room. Such refrigerant shall not exceed a maximum limit of 136 kg (300 lb) and shall be stored in acceptable storage containers. Storage of the refrigerant in any other room shall first be approved by the regulatory authority having jurisdiction.

## 8.4 Maintenance

### 8.4.1

The following minimum maintenance requirements shall apply to all refrigeration systems unless exempted by Clause 8.4.2:

- (a) Pressure-relief valves shall be replaced or recertified at intervals no longer than five years. Recertification of relief valves shall be conducted in accordance with the requirements of the regulatory authority having jurisdiction and CSA B51.
- (b) Pressure-limiting devices shall be tested at least once every 12 months for set point accuracy and for their ability to properly stop the affected equipment.
- (c) Other safety devices shall be tested at least once every 12 months for set point accuracy and for their ability to properly stop the affected equipment.
- (d) Leak detectors shall be tested for function at the specified refrigerant concentration in accordance with the manufacturer's instructions. The maximum interval between tests shall not exceed one year. The leak detector, in the simulated leak test, shall initiate an audible and visible alarm and begin ventilation at a rate not less than that specified in Clause 6.2.5.5. Failure of any of the three functions shall require corrective action.
- (e) All safety-related maintenance recommendations by the equipment manufacturer(s) shall be followed.
- (f) All power and control electrical terminations shall be checked at least once every 12 months and tightened if necessary.
- (g) Periodic visual inspection for developing problems shall be carried out at intervals appropriate to the nature of the equipment involved.
- (h) Testing for refrigerant leaks shall be carried out periodically.

At the end of each test, a tag noting the test date and the tester's name shall be affixed to the tested components specified in Items (a) to (h).

**8.4.2**

A refrigeration system shall be exempted from the maintenance requirements of Clause 8.4.1 if

- (a) It is listed by an approved testing laboratory.
- (b) It has not been equipped by the original manufacturer with a pressure-relief valve, a pressure-limiting device, or other safety controls.

Exempted refrigeration systems shall be maintained in accordance with the manufacturer's minimum recommendations.

**8.4.3**

All refrigeration systems shall be kept clean by the owner (including kept free from accumulations of water and oily dirt and other debris) and be readily accessible at all times.

**9 Precautions****9.1 Protective equipment****9.1.1**

The owner of a refrigeration system shall supply and maintain for its employees the personal protective equipment required by the jurisdiction where the system is located.

**9.1.2**

Installation and service personnel working on a refrigeration system shall be equipped, on arrival at the premises, with the personal protective equipment required by the jurisdiction where the system is located.

**9.2 Enclosed spaces**

Any enclosed space (cold-storage room) that provides a means for the entry of personnel and is maintained by a refrigeration system at temperatures detrimental to health shall be equipped with a door that can be readily opened from the inside and at least one of the following protective measures, depending on local conditions:

- (a) a suitable alarm system that can be operated from within the refrigerated room; and
- (b) a second door or knockout panel that can be readily opened from within the refrigerated room.

However, an alarm system alone shall not be considered an adequate form of protection unless personnel are available at all times to respond to alarms.

## Annex A (informative)

# Maximum allowable concentration of mixtures

**Note:** This Annex is not a mandatory part of this Standard.

### A.1

Calculation of the maximum allowable concentration ( $C_m$ ) of a mixture is carried out as follows:

- (a) For 100 lb of mixture, determine the ideal gas volumes occupied by each component and by the mixture at 70°F and 1 atm:

$$387 W_1/(MW_1) = V_1$$

$$387 W_2/(MW_2) = V_2$$

$$387 W_i/(MW_i) = V_i$$

$$V_T = V_1 + V_2 \dots V_i$$

where

$W_i$  = weight, lb, of component  $i$  in 100 lb of mixture

$MW_i$  = molecular weight of component  $i$

$V_i$  = volume, ft<sup>3</sup>, of component  $i$  in 100 lb of mixture at 70°F and 1 atm pressure

$V_T$  = volume, ft<sup>3</sup>, of mixture at 70°F and 1 atm pressure

- (b) Determine the dilution volume required for the 100 lb mixture and each of its components:

$$V_1/LV_1 = DV_1$$

$$V_i/LV_i = DV_i$$

$$V_T/LV_{max} = DV_T$$

where

$LV_i$  = (limiting volume % specified in Table 1)/100

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

$LV_{max}$  = highest value of  $LV_i$

- (c) Determine the maximum allowable concentration ( $C_m$ ) of a mixture:

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

where

$C_m$  = the maximum allowable concentration of mixture, in pounds, divided by 1000 ft<sup>3</sup> (multiply this value by 0.016 to obtain  $C_m$  in kg/m<sup>3</sup>)

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

## Annex B (informative)

# Guidelines for emergency discharge of refrigerants

**Note:** This informative Annex has been written in normative (mandatory) language to facilitate adoption where users of the Standard or regulatory authorities wish to adopt it formally as additional requirements to this Standard.

### B.1

This Annex is included as a guide for designers of refrigeration systems that will include facilities for rapidly discharging refrigerants into the atmosphere during a fire or other emergency.

### B.2

#### B.2.1

Systems designed for operation over 103 kPa (15 psig) and containing 182 kg (400 lb) or more of Group A1 or 91 kg (200 lb) or more of all other refrigerants shall be constructed so that, in an emergency, the refrigerant can be safely and rapidly discharged into the atmosphere.

#### B.2.2

The emergency discharge line shall be independent of any other line and shall be connected directly on top of the receiver, the condenser/receiver, or other vessel used for storing liquid refrigerant. The size of the line shall be determined in accordance with the following equations:

$$C = \frac{3.4 \times 10^{-5} P d^{5/2}}{L_1^{1/2}} \quad \left( C = \frac{3 P d^{5/2}}{L_1^{1/2}} \right)$$

$$d = 100 \sqrt[5]{\frac{C^2 L_1}{11.6 P^2}} \quad \left( d = \sqrt[5]{\frac{C^2 L_1}{9 P^2}} \right)$$

where

$C$  = minimum required discharge capacity, kg (lb) of air per minute, where  $C$  is as defined in Clause 7.3.4.1

$P$  =  $0.80 \times [(\text{design pressure} \times 1.10) + 101.325]$ , kPa  
       =  $0.80 \times [(\text{design pressure} \times 1.10) + 14.7]$ , psi

$d$  = internal diameter of pipe, mm (in)

$L_1$  = equivalent length of discharge pipe, m (ft)

#### B.2.3

When it is impossible to install the emergency line directly on top of the receiver, condenser/receiver, or other vessel, it shall be installed at some other suitable location.

#### B.2.4

No valve shall be installed between the vessel and the emergency discharge valve. The emergency valve shall not be smaller than the emergency line.

**B.2.5**

When an emergency discharge line is not connected to a common header or riser, it shall be provided at its upper extremity with a diffuser located in accordance with Clause 7.3.6.1.2.

**B.2.6**

When more than one emergency discharge line is connected to a common header or riser, a diffuser shall be installed from the common header or riser. The common header or riser, and the diffuser inlet, shall have a cross-sectional area at least equal to the combined areas of all emergency discharge lines feeding into it.

**B.2.7**

The emergency discharge line shall be installed so that it slopes toward the receiver, the condenser/receiver, or other vessel. Adequately sized drip pockets shall be provided on every emergency discharge line beyond the emergency valve exposed to the atmosphere.

**B.2.8**

An emergency switch to stop the refrigeration equipment shall be provided alongside the emergency valve.

**B.2.9**

The emergency valve shall be installed in a glass-fronted box that is painted bright red and placed outside the building in a location where it cannot be operated by anyone other than the plant operator, a firefighter, or a person who could be called on to open the valve in an emergency. The valve shall be located at least 2.3 m (7 ft) above finished grade, except as permitted by the regulatory authority.

## Annex C (informative)

# **Worst-case composition of fractionation**

**Note:** This Annex is not a mandatory part of this Standard.

### C.1

Because fractionation can be caused by a system leak, both the fractionation of the blend remaining in the system and the composition of the blend leaking into the machinery room or equipment space should be considered when worst-case composition is being determined. The phrase "worst-case composition of fractionation" means the composition, either as formulated or as occurs during fractionation, that

- (a) for flammability, results in the highest concentration of the flammable component(s) in either the vapour or liquid phase; and
- (b) for toxicity, results in the highest concentration of the toxic component(s) in either the vapour or liquid phase.

The worst-case composition for toxicity is not necessarily the same as the worst-case composition for flammability. Each parameter is therefore considered independently.

The toxicity of blends is defined in accordance with Annex C of the ACGIH annual manual of threshold limit values. The basic formula is as follows:

$$TLV^{\circledR} = \frac{1}{\frac{\text{mol frac } A}{TLV^{\circledR} A} + \frac{\text{mol frac } B}{TLV^{\circledR} B} + \frac{\text{mol frac } C}{TLV^{\circledR} C}, \text{etc.}}$$

## *Annex D (informative)*

### **Conversion factors**

**Note:** *This Annex is not a mandatory part of this Standard.*

#### **D.1**

1 mm	= 0.0393701 in
1 m	= 3.28084 ft or 1.09361 yd
1 m <sup>2</sup>	= 10.7639 ft <sup>2</sup>
1 m <sup>3</sup>	= 35.3147 ft <sup>3</sup>
1 dm <sup>3</sup> = 1 L	= 0.21997 imp gal = 0.264172 US gal
1 kg	= 2.20462 lb
°C	= (°F – 32) / 1.8
1 kPa	= 0.145038 psi
1 atm (standard)	= 101.325 kPa
1 L/s	= 2.11888 cfm (ft <sup>3</sup> /m)
1 kW	= 1.341022 hp = 0.28434 tons of refrigeration (TR)

For additional information on SI units, see CAN/CSA-Z234.1.

## Annex E (informative)

# A method for calculating the discharge capacity of pressure-relief devices for positive displacement compressors

**Note:** This Annex is not a mandatory part of this Standard.

## E.1 Calculation method

The following provides a calculation method for the required discharge capacity of the compressor pressure-relief device specified in Clause 7.2.3:

$$W_r = Q\eta_v/v_g$$

where

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

$Q$  = swept volume of compressor, m<sup>3</sup>/s (ft<sup>3</sup>/min)

$\eta_v$  = volumetric efficiency (assume 0.90 unless actual volumetric efficiency at relieving pressure is known)

$v_g$  = specific volume of refrigerant vapour as specified in Clause 7.2.3

After calculating  $W_r$ , find the relieving capacity in mass flow of air,  $W_a$ , for pressure-relief devices rated by the ASME *Boiler and Pressure Vessel Code*, Section VIII, as follows.

$$W_a = W_r r_w$$

where

$$r_w = \frac{C_a}{C_r} \sqrt{\frac{T_r}{T_a}} \sqrt{\frac{M_a}{M_r}}$$

where

$C_a$  = constant for air  
= 199 (356)

$$C_r = 290 \sqrt{k \left( \frac{2}{k+1} \right)^{\frac{k+1}{k-1}}} \quad \left( C_r = 520 \sqrt{k \left( \frac{2}{k+1} \right)^{\frac{k+1}{k-1}}} \right)$$

$T_r$  = absolute temperature of refrigerant  
= 285 K (510°R)

$T_a$  = absolute temperature of the air  
= 290 K (520°R)

$M_a$  = molecular mass of air  
= 28.97

$M_r$  = molecular mass of refrigerant

where

$k$  = specific heat ratio

$$= C_p/C_v$$

where

$C_p$  = specific heat of refrigerant at constant pressure

$C_v$  = specific heat of refrigerant at constant volume

**Table E.1**  
**Values for constants**

Refrigerant number	$k$	Molecular mass	SI		Imperial	
			$C_r$	$r_w$	$C_r$	$r_w$
R-12	1.22	120.93	189.2	0.52	339.2	0.52
R-22	1.32	86.48	194.6	0.59	348.9	0.59
R-134a	1.19	102.03	187.5	0.57	336.2	0.57
R-290	1.24	44.10	190.3	0.85	341.2	0.85
R-500	1.19	99.31	187.5	0.58	336.2	0.58
R-502	1.26	111.63	191.4	0.57	343.2	0.53
R-717	1.30	17.03	193.5	1.35	347.0	1.35

## E.2 Example

Determine the flow capacity of a relief device for an ammonia (R-717) screw compressor with swept volume,  $Q$ , of  $0.787 \text{ m}^3/\text{s}$  ( $1667 \text{ ft}^3/\text{min}$ ):

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

$$v_g = 0.2061 \text{ m}^3/\text{kg} \text{ (3.2997 ft}^3/\text{lb)}$$

$$W_r = 0.787 (0.9)/0.2061 = 3.44 \text{ kg/s (1667 (0.90)/3.2997 = 455 lb/min of ammonia) (see Clause E.1)}$$

$$W_a = W_r r_w \text{ (see Clause E.1)}$$

$$= 3.44 (1.35) = 4.64 \text{ kg/s (455 (1.33) = 614 lb/min)}$$

Convert to standard cubic feet per minute (SCFM),

where

$$v_a = \text{specific volume of air}$$

$$= 0.816 \text{ m}^3/\text{kg} \text{ (13.1 ft}^3/\text{lb) for dry air at 15 } ^\circ\text{C (60} ^\circ\text{F)}$$

$$\text{SCFM} = (0.816 \text{ m}^3/\text{kg})(4.64 \text{ kg/s}) = 3.79 \text{ m}^3/\text{s (13.1 (614) = 8041 ft}^3/\text{min)}$$

*Annex F*  
***Reserved***

# *Annex G*

## ***Reserved***

## Annex H (normative)

# Allowable equivalent length of discharge piping

**Note:** This Annex is a normative (mandatory) part of this Standard.

### H.1

The design back pressure due to flow in the discharge piping at the outlets of fusible plugs and other pressure-relief devices discharging to the atmosphere shall be limited by the allowable equivalent length of piping determined by the equations provided in this Annex. See Tables 7 and 8 for the flow capacity of various equivalent lengths of discharge piping for conventional relief valves.

$$L = \frac{0.2146 d^5 (P_0^2 - P_2^2)}{f C_r^2} - \frac{d \ln (P_0 / P_2)}{6f} \quad (\text{Imperial})$$

$$L = \frac{7.4381 \cdot 10^{-15} d^5 (P_0^2 - P_2^2)}{f C_r^2} - \frac{d \ln (P_0 / P_2)}{500f} \quad (\text{SI})$$

where

$L$  = equivalent length of discharge piping, ft (m)

$d$  = inside diameter of pipe or tube, in (mm)

$P_0$  = allowed back pressure (absolute) at outlet of pressure-relief device, psi (kPa)

$P_2$  = absolute pressure at outlet of discharge piping, psi (kPa);

$f$  = Moody friction factor in fully turbulent flow (see Table H.1)

$C_r$  = rated capacity, as follows:

- (a) as stamped on the relief device in lb/min (kg/s);
- (b) in standard cubic feet per minute multiplied by 0.0764;
- (c) as calculated in Clause 7.3.4.2.2 for a rupture member or fusible plug;
- (d) as adjusted for reduced capacity due to piping, as specified by the manufacturer of the device; or
- (e) as adjusted for reduced capacity due to piping, as estimated in accordance with an approved method

$\ln$  = natural logarithm

For the allowed back pressure,  $P_0$ , use the percentage 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:

- (a) for conventional relief valves: 15% of set pressure, i.e.,  $P_0 = (0.15 P) + \text{atmospheric pressure}$ ;
- (b) for balanced relief valves: 25% of set pressure, i.e.,  $P_0 = (0.25 P) + \text{atmospheric pressure}$ ; or
- (c) for rupture members, fusible plugs, and pilot-operated relief valves: 50% of set pressure, i.e.,  $P_0 = (0.50 P) + \text{atmospheric pressure}$ .

**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, in kilopascals (or pounds per square inch), and atmospheric pressure is the pressure at the elevation of the installation above sea level. A default value is the atmospheric pressure at sea level, i.e., 101.325 kPa (14.7 psi).

**Table H.1**  
**Typical Moody friction factors,  $f$ , for fully turbulent flow**

Tubing				Piping			
OD, in	DN	ID, in	Moody friction factor, $f$	NPS	DN	ID, in	Moody friction factor, $f$
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
2-1/8	54	1.985	0.0098	4	100	4.026	0.0163
2-5/8	67	2.465	0.0095	5	125	5.047	0.0155
				6	150	6.065	0.0149

## H.2

It should be noted that for conventional refrigeration pressure-relief valves (assuming that the outlet pipe inside diameter is equal to the connection size of the valve) the allowable equivalent length of discharge piping, determined using the equations in Clause H.1, can result in very short lengths, or even a negative length. When this occurs, ASHRAE 15 permits a transition to a larger pipe size using the appropriate standard ANSI fittings close-coupled to the relief valve's outlet.

## Annex I (informative)

# CSA B52 Information Bulletin on use of hydrocarbon refrigerants in new equipment and as drop-in replacements for other classes of refrigerants in existing systems

### Notes:

- (1) This Annex is not a mandatory part of this Standard.
- (2) The B52 Information Bulletin was published in March 2002 and reflected the provisions of the 1999 edition of this Standard. It is reproduced in this Annex with minor changes to bring it into conformity with the current edition of this Standard.

CSA B52, *Mechanical refrigeration code*, establishes requirements for the design, construction, installation and maintenance of mechanical refrigeration systems, so as to minimize the risk of injuries to workers and the general public.

CSA B52 has specific provisions for the use of hydrocarbon refrigerants. Currently, hydrocarbon refrigerants are being promoted as drop-in replacements to refrigeration systems that have been designed for other classes of refrigerants. Substitution of refrigerant type shall not be made without

- (a) permission of the regulatory authority, when required;
- (b) compliance with this Standard; and
- (c) verification of design compliance with the requirements of Item (b) by
  - (i) the original equipment manufacturer; or
  - (ii) a professional engineer.

Before substitution of refrigerants of any kind, and in this case, the use of hydrocarbon refrigerants, all individuals involved must review the following information carefully.

## 1. CSA B52 safety requirements

In addition to the equipment covered by Clause 4.5.2, equipment with a refrigerant charge not exceeding 3 kg (6.6 lb) and listed by an approved testing laboratory shall be deemed to meet the system application requirements when the equipment is installed in accordance with the listing specification.

CSA B52 permits the use of hydrocarbon refrigerants under the following conditions:

**Table 1 (excerpt)**

			Quantity of refrigerant per occupied space		
			kg/m <sup>3</sup>	Vol. %	lb/1000 ft <sup>3</sup>
Refrigerant number		Chemical formula			
Group A3					
R-170	Ethane	CH <sub>3</sub> CH <sub>3</sub>	0.0080	0.64	0.5
R-290	Propane	CH <sub>3</sub> CH <sub>2</sub> CH <sub>3</sub>	0.0080	0.44	0.5
R-1150	Ethylene	C <sub>2</sub> H <sub>4</sub>	0.0064	0.52	0.4

**Table 2 (excerpt)**

Refrigerant group	System leakage probability	Occupancy			
		Institutional	Public assembly/ Residential	Commercial	Industrial
A3 (Hydrocarbons)	High	(j)	(j)	(j)	(c), (d)
	Low	(j)	(j)	(j)	(h)

- (c) For refrigeration systems of 75 kW (100 HP) or less, when the quantity of refrigerant in each system exceeds Table 1 quantities, the rules for commercial occupancy shall apply unless all of the following occur:
- (i) The area containing the entire refrigeration system is separated from the rest of the building by tight construction with tight-fitting doors.  
**Note:** *This area may include multiple rooms, refrigerated work areas containing low-side components, and rooms containing compressors.*
  - (ii) Access is restricted to authorized personnel, and personnel density and means of egress are in compliance with workplace safety and health legislation and building codes where applicable.
  - (iii) Detectors are located in areas where refrigerant vapour from a leak will be concentrated, in order to provide a warning at a concentration not exceeding the TLV<sup>®</sup>/TWA of the refrigerant(s), except in the case of ammonia, where the maximum concentration shall be 300 ppm.
  - (iv) When the quantity of refrigerant, except refrigerants in Groups A1 and B1, exceeds Table 3 amounts, no flame-producing device or hot surface above 425 °C (800°F) shall be permitted.
  - (v) When the quantity of refrigerant, except ammonia and refrigerants Groups A1 and B1, exceeds Table 1 quantities, the area shall be classified as a hazardous location and all electrical equipment shall comply with the Class 1, Zone 2 requirements specified in the *Canadian Electrical Code, Part I*.
- (d) For refrigeration systems greater than 75 kW (100 hp), the refrigerated work area shall comply with Item (c), and the separate room housing compressors and related equipment shall comply with Item (i).
- (h) When the quantity of refrigerant in any system exceeds Table 3 amounts, all refrigerant-containing parts, except piping and those parts outside the building, shall be installed in a machinery room constructed in accordance with the provisions of Clause 6.3 with limitations on refrigerant quantities as follows:
- (i) institutional: 250 kg (550 lb);
  - (ii) public assembly: no limit except Item (h);
  - (iii) residential: no limit except Item (h);
  - (iv) commercial: no limit except Item (h); and
  - (v) industrial: no limit except Item (h);
- (j) The refrigerants that correspond to Item (j) in Table 2 are prohibited except in laboratories in commercial occupancies. Only unit systems containing not more than 3 kg (6.6 lb) of Group A3 or B3 refrigerant shall be used. If the laboratory is occupied by less than one person per 10 m<sup>2</sup> (108 ft<sup>2</sup>) of floor area, the requirements of industrial occupancies may be applied.

**Table 3**

Type of refrigerant system	Maximum permissible quantities for specified occupancy, kg (lb)			
	Institutional	Public	Residential	Commercial
Unit systems in a location other than a public hallway or lobby	0 (0)	0 (0)*	3 (6.6)	10 (22)

\*A quantity of 3 kg (6.6 lb) shall be allowed for systems installed in kitchens, laboratories, and mortuaries.

## 2. Regulatory requirements

CSA B52 is adopted as part of regulations of all provincial pressure equipment jurisdictions. Users are advised to contact the authorities having jurisdiction for regulatory requirements before modification of pressure equipment or substitution of refrigerants in a refrigeration system to ensure full compliance with the law.

## 3. Warranty and liability

The use of a hydrocarbon refrigerant as a replacement for the refrigerant in a system designed for another refrigerant class voids the approval or certification of the system, and may result in the warranty becoming null and void. As well, this may result in liability.

## 4. Conclusion

Use of hydrocarbon refrigerants, particularly in a drop-in refrigerant replacement situation, violates the requirements of B52 and/or the provincial regulatory requirements. For change of refrigerants, in addition to a review of operation effectiveness, a process of verifying their safety in refrigeration systems must be put in place. Organizations promoting hydrocarbon refrigerants as a drop-in replacement and all parties involved may be creating an unnecessary hazard and may be held liable for doing so.

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**Note:** References are to clause numbers.

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