

CHAPTER 11

REFRIGERATION

SECTION 1101 GENERAL

1101.1 Scope. This chapter shall govern the design, installation, construction and repair of refrigeration systems that vaporize and liquefy a fluid during the refrigerating cycle. Refrigerant piping design and installation, including pressure vessels and pressure relief devices, shall conform to this code. Permanently installed refrigerant storage systems and other components shall be considered as part of the refrigeration system to which they are attached.

1101.2 Factory-built equipment and appliances. Listed and labeled self-contained, factory-built equipment and appliances shall be tested in accordance with UL 207, 412, 471 or 1995. Such equipment and appliances are deemed to meet the design, manufacture and factory test requirements of this code if installed in accordance with their listing and the manufacturer's installation instructions.

1101.3 Protection. Any portion of a refrigeration system that is subject to physical damage shall be protected in an approved manner.

1101.4 Water connection. Water supply and discharge connections associated with refrigeration systems shall be made in accordance with this code and the *Arizona State Plumbing Code*.

1101.5 Fuel gas connection. Fuel gas devices, equipment and appliances used with refrigeration systems shall be installed in accordance with the *Arizona State Plumbing Code*.

1101.6 General. Refrigeration systems shall comply with the requirements of this code and, except as modified by this code, ASHRAE 15. Ammonia-refrigerating systems shall comply with this code and, except as modified by this code, ASHRAE 15 and IIAR 2.

1101.7 Maintenance. Mechanical refrigeration systems shall be maintained in proper operating condition, free from accumulations of oil, dirt, waste, excessive corrosion, other debris and leaks.

1101.8 Change in refrigerant type. The type of refrigerant in refrigeration systems having a refrigerant circuit containing more than 220 pounds of Group A1 or 30 pounds of any other group refrigerant shall not be changed without prior notification to the code official and compliance with the applicable code provisions for the new refrigerant type.

[F] 1101.9 Refrigerant discharge. Notification of refrigerant discharge shall be provided in accordance with the *Phoenix Fire Code*.

SECTION 1102 SYSTEM REQUIREMENTS

1102.1 General. The system classification, allowable refrigerants, maximum quantity, enclosure requirements, location limitations, and field pressure test requirements shall be determined as follows:

1. Determine the refrigeration system's classification, in accordance with Section 1103.3.
2. Determine the refrigerant classification in accordance with Section 1103.1.
3. Determine the maximum allowable quantity of refrigerant in accordance with Section 1104, based on type of refrigerant, system classification, and occupancy.
4. Determine the system enclosure requirements in accordance with Section 1104.
5. Refrigeration equipment and appliance location and installation shall be subject to the limitations of Chapter 3.
6. Nonfactory-tested, field-erected equipment and appliances shall be pressure tested in accordance with Section 1108.

1102.2 Refrigerants. The refrigerant shall be that which the equipment or appliance was designed to utilize or converted to utilize. Refrigerants not identified in Table 1103.1 shall be approved before use.

1102.2.1 Mixing. Refrigerants, including refrigerant blends, with different designations in ASHRAE 34 shall not be mixed in a system.

Exception: Addition of a second refrigerant is allowed where permitted by the equipment or appliance manufacturer to improve oil return at low temperatures. The refrigerant and amount added shall be in accordance with the manufacturer's instructions.

1102.2.2 Purity. Refrigerants used in refrigeration systems shall be new, recovered or reclaimed refrigerants in accordance with Section 1102.2.2.1, 1102.2.2.2 or 1102.2.2.3. Where required by the equipment or appliance owner or the code official, the installer shall furnish a signed declaration that the refrigerant used meets the requirements of Section 1102.2.2.1, 1102.2.2.2 or 1102.2.2.3.

Exception: The refrigerant used shall meet the purity specifications set by the manufacturer of the equipment or appliance in which such refrigerant is used where such specifications are different from that specified in Sections 1102.2.2.1, 1102.2.2.2 and 1102.2.2.3.

1102.2.2.1 New refrigerants. Refrigerants shall be of a purity level specified by the equipment or appliance manufacturer.

1102.2.2.2 Recovered refrigerants. Refrigerants that are recovered from refrigeration and air-conditioning systems shall not be reused in other than the system from which they were recovered and in other systems of the same owner. Recovered refrigerants shall be filtered and dried before reuse. Recovered refrigerants that show clear signs of contamination shall not be reused unless reclaimed in accordance with Section 1102.2.2.3.

1102.2.2.3 Reclaimed refrigerants. Used refrigerants shall not be reused in a different owner's equipment or appliances unless tested and found to meet the purity requirements of ARI 700. Contaminated refrigerants shall not be used unless reclaimed and found to meet the purity requirements of ARI 700.

SECTION 1103 REFRIGERATION SYSTEM CLASSIFICATION

1103.1 Refrigerant classification. Refrigerants shall be classified in accordance with ASHRAE 34 as listed in Table 1103.1.

1103.2 Occupancy classification. Locations of refrigerating systems are described by occupancy classifications that consider the ability of people to respond to potential exposure to refrigerants. Where equipment or appliances, other than piping, are located outside a building and within 20 feet (6096 mm) of any building opening, such equipment or appliances shall be governed by the occupancy classification of the building. Occupancy classifications shall be defined as follows:

1. Institutional occupancy is that portion of premises from which, because they are disabled, debilitated or confined, occupants cannot readily leave without the assistance of others. Institutional occupancies include, among others, hospitals, nursing homes, asylums and spaces containing locked cells.
2. Public assembly occupancy is that portion of premises where large numbers of people congregate and from which occupants cannot quickly vacate the space. Public assembly occupancies include, among others, auditoriums, ballrooms, classrooms, passenger depots, restaurants and theaters.
3. Residential occupancy is that portion of premises that provides the occupants with complete independent living facilities, including permanent provisions for living, sleeping, eating, cooking and sanitation. Residential occupancies include, among others, dormitories, hotels, multiunit apartments and private residences.
4. Commercial occupancy is that portion of premises where people transact business, receive personal ser-

vice or purchase food and other goods. Commercial occupancies include, among others, office and professional buildings, markets (but not large mercantile occupancies) and work or storage areas that do not qualify as industrial occupancies.

5. Large mercantile occupancy is that portion of premises where more than 100 persons congregate on levels above or below street level to purchase personal merchandise.
6. Industrial occupancy is that portion of premises that is not open to the public, where access by authorized persons is controlled, and that is used to manufacture, process or store goods such as chemicals, food, ice, meat or petroleum.
7. Mixed occupancy occurs when two or more occupancies are located within the same building. When each occupancy is isolated from the rest of the building by tight walls, floors and ceilings and by self-closing doors, the requirements for each occupancy shall apply to its portion of the building. When the various occupancies are not so isolated, the occupancy having the most stringent requirements shall be the governing occupancy.

1103.3 System classification. Refrigeration systems shall be classified according to the degree of probability that refrigerant leaked from a failed connection, seal, or component could enter an occupied area. The distinction is based on the basic design or location of the components.

1103.3.1 Low-probability systems. Double-indirect open-spray systems, indirect closed systems and indirect-vented closed systems shall be classified as low-probability systems, provided that all refrigerant-containing piping and fittings are isolated when the quantities in Table 1103.1 are exceeded.

1103.3.2 High-probability systems. Direct systems and indirect open-spray systems shall be classified as high-probability systems.

Exception: An indirect open-spray system shall not be required to be classified as a high-probability system if the pressure of the secondary coolant is at all times (operating and standby) greater than the pressure of the refrigerant.

SECTION 1104 SYSTEM APPLICATION REQUIREMENTS

1104.1 General. The refrigerant, occupancy and system classification cited in this section shall be determined in accordance with Sections 1103.1, 1103.2 and 1103.3, respectively. For refrigerant blends assigned dual classifications, as formulated and for the worst case of fractionation, the classifications for the worst case of fractionation shall be used.

[F] TABLE 1103.1
REFRIGERANT CLASSIFICATION, AMOUNT AND TLV-TWA

REFRIGERANT	CHEMICAL FORMULA	CHEMICAL NAME OR BLEND	HAZARD CATEGORIES ^a	REFRIGERANT CLASSIFICATION	DEGREES OF HAZARD ^b	[M] AMOUNT OF REFRIGERANT PER OCCUPIED SPACE			
						Pounds per 1,000 cubic feet	ppm	g/m	TLV-TWA ^f (ppm)
R-11 ^e	CCl3F	Trichlorofluoromethane	OHH	A1	2-0-0 ^c	0.39	1,100	6.2	C1,000
R-12 ^e	CCl2F2	Dichlorodifluoromethane	CG,OHH	A1	2-0-0 ^c	5.6	18,000	90	1,000
R-13 ^e	CClF3	Chlorotrifluoromethane	CG,OHH	A1	2-0-0 ^c	18	67,000	290	1,000
R-13B1 ^e	CBrF3	Bromotrifluoromethane	CG,OHH	A1	2-0-0 ^c	22	57,000	350	1,000
R-14	CF4	Tetrafluoromethane (carbon tetrafluoride)	CG,OHH	A1	2-0-0 ^c	16	69,000	250	1,000
R-22	CHClF2	Chlorodifluoromethane	CG,OHH	A1	2-0-0 ^c	5.5	25,000	89	1,000
R-23	CHF3	Trifluoromethane (fluoroform)	CG,OHH	A1	2-0-0 ^c	7.3	41,000	120	1,000
R-32	CH2F2	Difluoromethane (methylene fluoride)	CG,F,OHH	A2		4.2	32,000	68	—
R-113 ^e	CCl3FCClF2	1, 1,2-trichloro-1,2,2-trifluoroethane	OHH	A1	2-0-0 ^c	1.2	2,600	20	1,000
R-114 ^e	CClF2CClF2	1,2-dichloro-1,2,2-tetrafluoroethane	CG,OHH	A1	2-0-0 ^c	8.7	20,000	140	1,000
R-116	CF3CF3	Hexafluoroethane	CH,OHH	A1	1-0-0	24	69,000	390	—
R-123	CHCl2CF3	2,2-dichloro-1,1,1-trifluoroethane	OHH	B1	2-0-0 ^c	3.5	9,100	57	50
R-124	CHClFCF3	2-chloro-1,1,1,2-tetrafluoroethane	CG,OHH	A1	2-0-0 ^c	3.5	10,000	56	1,000
R-125	CHF2CF3	Pentafluoroethane	CG,OHH	A1	2-0-0 ^c	21	69,000	340	—
R-134a	CH2FCF3	1,1,1,2-tetrafluoroethane	CG,OHH	A1	2-0-0 ^c	13	50,000	210	1,000
R-143a	CH3CF3	1,1,1-trifluoroethane	CG,F,OHH	A2	2-0-0 ^c	3.8	18,000	60	—
R-152a	CH3CHF2	1,1-difluoroethane	CG,F,OHH	A2	1-4-0	1.6	9,300	25	—
R-170	CH3CH3	Ethane	CG,F,OHH	A3	2-4-0	0.54	7,000	8.7	1,000
R-218	CF3CF2CF3	Octafluoropropane	CG,OHH	A1	2-0-0 ^c	33	69,000	530	—
R-236fa	CF3CH2CF3	1,1,1,3,3,3-hexafluoropropane	CG,OHH	A1	2-0-0 ^c	21	55,000	—	1,000
R-245fa	CHF2CH2CF3	1,1,1,3,3-pentafluoropropane	CG,OHH	B1	2-0-0 ^c	12	34,000	—	300
R-290	CH3CH2CH3	Propane	CG,F,OHH	A3	2-4-0	0.56	5,000	9.0	2,500
R400e	zeotrope	R-12/114	CG,OHH	A1	2-0-0 ^c	9.3	26,000	150	—
R-401A	zeotrope	R-22/152a/124 (53/13/34)	CG,OHH	A1	2-0-0 ^c	4.8	20,000	77	—
R-401B	zeotrope	R-22/152a/124 (61/11/28)	CG,OHH	A1	2-0-0 ^c	4.9	21,000	79	—
R-401C	zeotrope	R-22/152a/124 (33/15/52)	CG,OHH	A1	2-0-0 ^c	4.4	17,000	71	—
R-402A	zeotrope	R-125/290/22 (60/2/38)	CG,OHH	A1	2-0-0 ^c	10	39,000	160	—
R-402B	zeotrope	R-125/290/22 (38/2/60)	CG,OHH	A1	2-0-0 ^c	7.8	32,000	120	—
R-403A	zeotrope	R-290/22/218 (5/75/20)	CG,OHH	A1	2-0-0 ^c	—	—	—	—
R-403B	zeotrope	R-290/22/218 (5/56/39)	CG,OHH	A1	2-0-0 ^c	—	—	—	—
R-404A	zeotrope	R-125/143a/134a (44/52/4)	CG,OHH	A1	2-0-0 ^c	17	69,000	280	—

(continued)

[F] TABLE 1103.1—continued
REFRIGERANT CLASSIFICATION, AMOUNT AND TLV-TWA

REFRIGERANT	CHEMICAL FORMULA	CHEMICAL NAME OR BLEND	HAZARD CATEGORIES ^a	REFRIGERANT CLASSIFICATION	DEGREES OF HAZARD ^b	[M] AMOUNT OF REFRIGERANT PER OCCUPIED SPACE			TLV-TWA ^c (ppm)
						Pounds per 1,000 cubic feet	ppm	g/m	
R-406A	zeotrope	R-22/600a/142b (55/4/41)	CG,F,OHH	A2	—	—	—	—	—
R-407A	zeotrope	R-32/125/134a (20/40/40)	CG,OHH	A1	2-0-0 ^c	16	69,000	260	—
R-407B	zeotrope	R-32/125/134a (10/70/20)	CG,OHH	A1	2-0-0 ^c	18	69,000	290	—
R-407C	zeotrope	R-32/125/134a (23/25/52)	CG,OHH	A1	2-0-0 ^c	15	69,000	240	—
R-407D	zeotrope	R-32/125/134a (15/15/70)	CG,OHH	A1	2-0-0 ^c	15	65,000	240	—
R-407E	zeotrope	R-32/125/134a (25/15/60)	CG,OHH	A1	2-0-0 ^c	15	69,000	240	—
R-408A	zeotrope	R-125/143a/22 (7/46/47)	CG,OHH	A1	2-0-0 ^c	10	47,000	170	—
R-409A	zeotrope	R-22/124/142b (60/25/15)	CG,OHH	A1	2-0-0 ^c	4.9	20,000	79	—
R-409B	zeotrope	R-22/124/142b (65/25/10)	CG,OHH	A1	2-0-0 ^c	4.9	20,000	78	—
R410A	zeotrope	R-32/125 (50/50)	CG,OHH	A1	2-0-0 ^c	10	55,000	160	—
R-410B	zeotrope	R-32/125 (45/55)	CG,OHH	A1	2-0-0 ^c	11	58,000	180	—
R-411A	zeotrope	R-127/22/152a (1.5/87.5/11.0)	CG,F,OHH	A2	—	—	—	—	—
R-411B	zeotrope	R-127/22/152a (3/94/3)	CG,F,OHH	A2	—	—	—	—	—
R-412A	zeotrope	R-22/318/142b (70/5/25)	CG,F,OHH	A2	—	—	—	—	—
R-413A	zeotrope	R-218/134a/600a (9/88/3)	CG,F,OHH	A2	—	—	—	—	—
R-414A	zeotrope	R-22/124/600a/142b (51/28.5/4/16.5)	CG,OHH	A1	—	—	—	—	—
R-414B	zeotrope	R-22/124/600a/142b (50/39/1.5/9.5)	CG,OHH	A1	—	—	—	—	—
R-416A	zeotrope	R-134a/124/600 (59/39.5/1.5)	CG,OHH	A1	2-0-0 ^c	6	21,000	96	—
R-417A	zeotrope	R-125/134a/600 (45.5/50/3.5)	CG,OHH	A1	2-0-0 ^c	—	—	—	—
R-500 ^e	azeotrope	R-12/152a (73.8/26.2)	CG,OHH	A1	2-0-0 ^c	7.4	29,000	120	1,000
R-502 ^e	azeotrope	R-22/115 (48.8/51.2)	CG,OHH	A1	2-0-0 ^c	10	35,000	160	1,000
R-503 ^e	azeotrope	R-23/13 (40.1/59.9)	CG,OHH	A1	2-0-0 ^c	15	67,000	240	1,000
R-507A	azeotrope	R-125/143a (50/50)	CG,OHH	A1	2-0-0 ^c	17	69,000	280	—
R-508A	azeotrope	R-23/116 (39/61)	CG,OHH	A1	2-0-0 ^c	14	55,000	220	—
R-508B	azeotrope	R-23/116 (46/54)	CG,OHH	A1	2-0-0 ^c	13	52,000	200	—
R-509A	zeotrope	R-22/218 (44/56)	CG,OHH	A1	2-0-0 ^c	12	38,000	190	—
R-600	CH ₃ CH ₂ CH ₂ CH ₃	Butane	CG,F,OHH	A3	1-4-0	—	—	—	—
R-600a	CH(CH ₃) ₂ -CH ₃	Isobutane (2-methyl propane)	CG,F,OHH	A3	2-4-0	0.51	2,500	6.0	800

(continued)

[F] TABLE 1103.1—continued
REFRIGERANT CLASSIFICATION, AMOUNT AND TLV-TWA

REFRIGERANT	CHEMICAL FORMULA	CHEMICAL NAME OR BLEND	HAZARD CATEGORIES ^a	REFRIGERANT CLASSIFICATION	DEGREES OF HAZARD ^b	[M] AMOUNT OF REFRIGERANT PER OCCUPIED SPACE			
						Pounds per 1,000 cubic feet	ppm	g/m	TLV-TWA ^f (ppm)
R-717	NH ₃	Ammonia	CG,C,F,OHH	B2	3-3-0 ^d	0.022	500	0.35	25
R-718	H ₂ O	Water	—	A1	0-0-0	—	—	—	—
R-744	CO ₂	Carbon dioxide	CG,OHH	A1	2-0-0 ^e	4.5	40,000	72	5,000
R-1150	CH ₂ =CH ₂	Ethene (ethylene)	CG,F,OHH	A3	1-4-2	0.38	5,200	6.0	1,000
R-1270	CH ₃ CH=CH ₂	Propene (propylene)	CG,F,OHH	B3	1-4-1	0.37	3,400	5.0	660

For SI: 1 pound = 0.454 kg, 1 cubic foot = 0.0283 m³

a. CG = Compressed gas; C = Corrosive; F = Flammable; OHH = Other Health Hazard.

b. Degrees of hazard are for health, fire, and reactivity, respectively, in accordance with NFPA 704.

c. Reduction to 1-0-0 is allowed if analysis satisfactory to the code official shows that the maximum concentration for a rupture or full loss of refrigerant charge would not exceed the IDLH, considering both the refrigerant quantity and room volume.

d. For installations that are entirely outdoors, use 3-1-0.

e. Class I ozone depleting substance; prohibited for new installations.

f. PEL or consistent occupational exposure limit on a time-weighted average (TWA) basis (unless noted C for ceiling) for an 8 hr/d and 40 hr/wk.]

1104.2 Machinery room. Except as provided in Sections 1104.2.1 and 1104.2.2, all components containing the refrigerant shall be located either outdoors or in a machinery room where the quantity of refrigerant in an independent circuit of a system exceeds the amounts shown in Table 1103.1. For refrigerant blends not listed in Table 1103.1, the same requirement shall apply when the amount for any blend component exceeds that indicated in Table 1103.1 for that component. This requirement shall also apply when the combined amount of the blend components exceeds a limit of 69,100 parts per million (ppm) by volume. Machinery rooms required by this section shall be constructed and maintained in accordance with Section 1105 for Group A1 and B1 refrigerants and in accordance with Sections 1105 and 1106 for Group A2, B2, A3 and B3 refrigerants.

Exceptions:

1. Machinery rooms are not required for listed equipment and appliances containing not more than 6.6 pounds (3 kg) of refrigerant, regardless of the refrigerant's safety classification, where installed in accordance with the equipment's or appliance's listing and the equipment or appliance manufacturer's installation instructions.
2. Piping in conformance with Section 1107 is allowed in other locations to connect components installed in a machinery room with those installed outdoors.

1104.2.1 Institutional occupancies. The amounts shown in Table 1103.1 shall be reduced by 50 percent for all areas of institutional occupancies except kitchens, laboratories, and mortuaries. The total of all Group A2, B2, A3 and B3 refrigerants shall not exceed 550 pounds (250 kg) in occupied areas or machinery rooms.

1104.2.2 Industrial occupancies and refrigerated rooms. This section applies only to industrial occupancies and refrigerated rooms for manufacturing, food and beverage preparation, meat cutting, other processes and storage. Machinery rooms are not required where all of the following conditions are met:

1. The space containing the machinery is separated from other occupancies by tight construction with tight-fitting doors.
2. Access is restricted to authorized personnel.

3. The floor area per occupant is not less than 100 square feet (9.3 m²) where machinery is located on floor levels with exits more than 6.6 feet (2012 mm) above the ground. Where provided with egress directly to the outdoors or into approved building exits, the minimum floor area shall not apply.
4. Refrigerant detectors are installed as required for machinery rooms in accordance with Section 1105.3.
5. Surfaces having temperatures exceeding 800°F (427°C) and open flames are not present where any Group A2, B2, A3 or B3 refrigerant is used (see Section 1104.3.4).
6. All electrical equipment and appliances conform to Class 1, Division 2, hazardous location classification requirements of NFPA 70 where the quantity of any Group A2, B2, A3 or B3 refrigerant in a single independent circuit would exceed 25 percent of the lower flammability limit (LFL) upon release to the space.
7. All refrigerant-containing parts in systems exceeding 100 hp (74.6 kW) drive power, except evaporators used for refrigeration or dehumidification; condensers used for heating; control and pressure relief valves for either; and connecting piping, shall be located either outdoors or in a machinery room.

1104.3 Refrigerant restrictions. Refrigerant applications, maximum quantities and use shall be restricted in accordance with Sections 1104.3.1 through 1104.3.4.

1104.3.1 Air-conditioning for human comfort. In other than industrial occupancies where the quantity in a single independent circuit does not exceed the amount in Table 1103.1, Group B1, B2 and B3 refrigerants shall not be used in high-probability systems for air-conditioning for human comfort.

1104.3.2 Nonindustrial occupancies. Group A2 and B2 refrigerants shall not be used in high-probability systems where the quantity of refrigerant in any independent refrigerant circuit exceeds the amount shown in Table 1104.3.2. Group A3 and B3 refrigerants shall not be used except where approved.

Exception: This section does not apply to laboratories where the floor area per occupant is not less than 100 square feet (9.3 m²).

**TABLE 1104.3.2
MAXIMUM PERMISSIBLE QUANTITIES OF REFRIGERANTS**

TYPE OF REFRIGERATION SYSTEM	MAXIMUM POUNDS FOR VARIOUS OCCUPANCIES			
	Institutional	Assembly	Residential	All other occupancies
Sealed absorption system				
In exit access	0	0	3.3	3.3
In adjacent outdoor locations	0	0	22	22
In other than exit access	0	6.6	6.6	6.6
Unit systems				
In other than exit access	0	0	6.6	6.6

For SI: 1 pound = 0.454 kg.

1104.3.3 All occupancies. The total of all Group A2, B2, A3 and B3 refrigerants other than R-717, ammonia, shall not exceed 1,100 pounds (499 kg) except where approved.

1104.3.4 Protection from refrigerant decomposition. Where any device having an open flame or surface temperature greater than 800°F (427°C) is used in a room containing more than 6.6 pounds (3 kg) of refrigerant in a single independent circuit, a hood and exhaust system shall be provided in accordance with Section 510. Such exhaust system shall exhaust combustion products to the outdoors.

Exception: A hood and exhaust system shall not be required:

1. Where the refrigerant is R-717, R-718, or R-744;
2. Where the combustion air is ducted from the outdoors in a manner that prevents leaked refrigerant from being combusted; or
3. Where a refrigerant detector is used to stop the combustion in the event of a refrigerant leak (see Sections 1105.3 and 1105.5).

1104.4 Volume calculations. Volume calculations shall be in accordance with Sections 1104.4.1 through 1104.4.3.

1104.4.1 Noncommunicating spaces. Where the refrigerant-containing parts of a system are located in one or more spaces that do not communicate through permanent openings or HVAC ducts, the volume of the smallest, enclosed occupied space shall be used to determine the permissible quantity of refrigerant in the system.

1104.4.2 Communicating spaces. Where an evaporator or condenser is located in an air duct system, the volume of the smallest, enclosed occupied space served by the duct system shall be used to determine the maximum allowable quantity of refrigerant in the system.

Exception: If airflow to any enclosed space cannot be reduced below one-quarter of its maximum, the entire space served by the air duct system shall be used to determine the maximum allowable quantity of refrigerant in the system.

1104.4.3 Plenums. Where the space above a suspended ceiling is continuous and part of the supply or return air plenum system, this space shall be included in calculating the volume of the enclosed space.

SECTION 1105 MACHINERY ROOM, GENERAL REQUIREMENTS

[B] 1105.1 Design and construction. Machinery rooms shall be designed and constructed in accordance with the *International Building Code* and this section.

1105.2 Openings. Ducts and air handlers in the machinery room that operate at a lower pressure than the room shall be sealed to prevent any refrigerant leakage from entering the airstream.

[F] 1105.3 Refrigerant detector. Machinery rooms shall contain a refrigerant detector with an audible and visual alarm. The alarm signaling device(s) shall provide a sound level of at least 15 dBA above the operating ambient noise level of the space in which they are installed and provide an approved, distinctive

visual alarm. The detector or sampling tube that draws air to the detector shall be located in an area where refrigerant from a leak may be expected to concentrate. The alarm shall be actuated at a value not greater than the corresponding TLV-TWA values shown in Table 1103.1. Detectors and alarms shall be placed in one or more locations to assure notification of all occupants.

1105.4 Tests. Periodic tests of the mechanical ventilating system shall be performed in accordance with manufacturer's specifications and as required by the code official.

1105.5 Fuel-burning appliances. Open flames that use combustion air from the machinery room shall not be installed in a machinery room.

Exceptions:

1. Matches, lighters, halide leak detectors and similar devices.
2. Where the refrigerant is carbon dioxide or water.
3. Fuel-burning appliances shall not be prohibited in the same machinery room with refrigerant-containing equipment or appliances where combustion air is ducted from outside the machinery room and sealed in such a manner as to prevent any refrigerant leakage from entering the combustion chamber. Refrigeration equipment that is being replaced in existing refrigeration machinery rooms which contain fuel-burning appliances shall be equipped with a refrigerant vapor detection device designed to automatically shut off fuel supply to the fuel-burning appliances in the event of refrigerant leakage. This detection device shall simultaneously activate the ventilation system as required elsewhere in this chapter. Applicable controls, switches and interlocks shall be provided as required for new installations.

1105.6 Ventilation. Machinery rooms shall be mechanically ventilated to the outdoors. Mechanical ventilation shall be capable of exhausting the minimum quantity of air both at normal operating and emergency conditions. Multiple fans or multispeed fans shall be allowed in order to produce the emergency ventilation rate and to obtain a reduced airflow for normal ventilation.

Exception: Where a refrigerating system is located outdoors more than 20 feet (6096 mm) from any building opening and is enclosed by a penthouse, lean-to or other open structure, natural or mechanical ventilation shall be provided. Location of the openings shall be based on the relative density of the refrigerant to air. The free-aperture cross section for the ventilation of the machinery room shall be not less than:

$$F = \sqrt{G} \quad \text{(Equation 11-1)}$$

$$\text{For SI: } F = 0.138 \sqrt{G}$$

where:

F = The free opening area in square feet (m²).

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

1105.6.1 Discharge location. The discharge of the air shall be to the outdoors in accordance with Chapter 5. Exhaust from mechanical ventilation systems shall be discharged not less than 20 feet (6096 mm) from a property line or openings into buildings.

1105.6.2 Makeup air. Provisions shall be made for makeup air to replace that being exhausted. Openings for makeup air shall be located to avoid intake of exhaust air. Supply and exhaust ducts to the machinery room shall serve no other area, shall be constructed in accordance with Chapter 5 and shall be covered with corrosion-resistant screen of not less than 1/4-inch (6.4 mm) mesh.

1105.6.3 Quantity—normal ventilation. During occupied conditions, the mechanical ventilation system shall exhaust the larger of the following:

1. Not less than 0.5 cfm per square foot (0.0025 m³/s · m²) of machinery room area or 20 cfm (0.009 m³/s) per person; or
2. A volume required to limit the room temperature rise to 18°F (10°C) taking into account the ambient heating effect of all machinery in the room.

1105.6.4 Quantity—emergency conditions. Upon actuation of the refrigerant detector required in Section 1105.3, the mechanical ventilation system shall exhaust air from the machinery room in the following quantity:

$$Q = 100 \times \sqrt{G} \quad (\text{Equation 11-2})$$

$$\text{For SI: } Q = 0.07 \times \sqrt{G}$$

where:

Q = The airflow in cubic feet per minute (m³/s).

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

1105.7 Termination of relief devices. Pressure relief devices, fusible plugs and purge systems located within the machinery room shall terminate outside of the structure at a location not less than 15 feet (4572 mm) above the adjoining grade level and not less than 20 feet (6096 mm) from any window, ventilation opening or exit.

1105.8 Ammonia discharge. Pressure relief valves for ammonia systems shall discharge in accordance with ASHRAE 15.

SECTION 1106 MACHINERY ROOM, SPECIAL REQUIREMENTS

1106.1 General. Where required by Section 1104.2, the machinery room shall meet the requirements of this section in addition to the requirements of Section 1105.

1106.1.1 Dimensions. Refrigeration machinery rooms shall be of such dimensions that all system parts are readily accessible with adequate space for maintenance and operations. An unobstructed walking space at least three (3) feet (914 mm) in width and six (6) feet eight (8) inches (2032 mm) in height shall be maintained throughout allowing free access to at least two sides of all moving machinery and ap-

proaching each stop valve. Access to refrigeration machinery rooms shall be restricted to authorized personnel and posted with a permanent sign.

1106.2 Elevated temperature. There shall not be an open flame-producing device or continuously operating hot surface over 800°F (427°C) permanently installed in the room.

1106.3 Ammonia room ventilation. Ventilation systems in ammonia machinery rooms shall be operated continuously.

Exceptions:

1. Machinery rooms equipped with a vapor detector that will automatically start the ventilation system and actuate an alarm at a detection level not to exceed 1,000 ppm; or
2. Machinery rooms conforming to the Class 1, Division 2, hazardous location classification requirements of NFPA 70.

1106.4 Flammable refrigerants. Where refrigerants of Groups A2, A3, B2 and B3 are used, the machinery room shall conform to the Class 1, Division 2, hazardous location classification requirements of NFPA 70.

Exception: Ammonia machinery rooms.

[F] 1106.5 Remote controls. Remote control of the mechanical equipment and appliances located in the machinery room shall be provided as required by the *Phoenix Fire Code*.

[F 1106.5.1 Refrigeration system. A clearly identified switch of the break-glass type shall provide off-only control of all electrically energized equipment and appliances in the machinery room, other than refrigerant leak detectors and machinery room ventilation.

[F 1106.5.2 Ventilation system. A clearly identified switch of the break-glass type shall provide on-only control of the machinery room ventilation fans.

[F]1106.6 Emergency signs and labels. Refrigeration units and systems shall be provided with approved emergency signs, charts, and labels in accordance with the *Phoenix Fire Code*.

SECTION 1107 REFRIGERANT PIPING

1107.1 General. All refrigerant piping shall be installed, tested and placed in operation in accordance with this chapter.

1107.2 Pipe enclosures. Rigid or flexible metal enclosures or pipe ducts shall be provided for soft, annealed copper tubing and used for refrigerant piping erected on the premises and containing other than Group A1 or B1 refrigerants. Enclosures shall not be required for connections between condensing units and the nearest riser box(es), provided such connections do not exceed 6 feet (1829 mm) in length.

1107.3 Condensation. All refrigerating piping and fittings, brine piping and fittings that, during normal operation, will reach a surface temperature below the dew point of the surrounding air, and are located in spaces or areas where condensation will cause a safety hazard to the building occupants, structure, electrical equipment or any other equipment or appliances, shall be protected in an approved manner to prevent such damage.

1107.4 Materials for refrigerant pipe and tubing. Piping materials shall be as set forth in Sections 1107.4.1 through 1107.4.5.

1107.4.1 Steel pipe. Carbon steel pipe with a wall thickness not less than Schedule 80 shall be used for Group A2, A3, B2 or B3 refrigerant liquid lines for sizes 1.5 inches (38 mm) and smaller. Carbon steel pipe with a wall thickness not less than Schedule 40 shall be used for Group A1 or B1 refrigerant liquid lines 6 inches (152 mm) and smaller, Group A2, A3, B2 or B3 refrigerant liquid lines sizes 2 inches (51 mm) through 6 inches (152 mm) and all refrigerant suction and discharge lines 6 inches (152 mm) and smaller. Type F steel pipe shall not be used for refrigerant lines having an operating temperature less than -20°F (-29°C).

1107.4.2 Copper and brass pipe. Standard iron-pipe size, copper and red brass (not less than 80-percent copper) pipe shall conform to ASTM B 42 and ASTM B 43.

1107.4.3 Copper tube. Copper tube used for refrigerant piping erected on the premises shall be seamless copper tube of Type ACR (hard or annealed) complying with ASTM B 280. Where approved, copper tube for refrigerant piping erected on the premises shall be seamless copper tube of Type K, L or

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M (drawn or annealed) in accordance with ASTM B 88. Annealed temper copper tube shall not be used in sizes larger than a 2-inch (51 mm) nominal size. Mechanical joints shall not be used on annealed temper copper tube in sizes larger than $\frac{7}{8}$ -inch (22.2 mm) OD size.

1107.4.4 Copper tubing joints. Copper tubing joints used in refrigerating systems containing Group A2, A3, B2 or B3 refrigerants shall be brazed. Soldered joints shall not be used in such refrigerating systems.

1107.4.5 Aluminum tube. Type 3003-0 aluminum tubing with high-pressure fittings shall not be used with methyl chloride and other refrigerants known to attack aluminum.

1107.5 Joints and refrigerant-containing parts in air ducts. Joints and all refrigerant-containing parts of a refrigerating system located in an air duct of an air-conditioning system carrying conditioned air to and from human-occupied space shall be constructed to withstand, without leakage, a pressure of 150 percent of the higher of the design pressure or pressure relief device setting.

1107.6 Exposure of refrigerant pipe joints. Refrigerant pipe joints erected on the premises shall be exposed for visual inspection prior to being covered or enclosed.

1107.7 Stop valves. All systems containing more than 6.6 pounds (3 kg) of a refrigerant in systems using positive-displacement compressors shall have stop valves installed as follows:

1. At the inlet of each compressor, compressor unit or condensing unit.
2. At the discharge outlet of each compressor, compressor unit or condensing unit and of each liquid receiver.

Exceptions:

1. Systems that have a refrigerant pumpout function capable of storing the entire refrigerant charge in a receiver or heat exchanger.
2. Systems that are equipped with provisions for pumpout of the refrigerant using either portable or permanently installed recovery equipment.
3. Self-contained systems.

1107.7.1 Liquid receivers. All systems containing 100 pounds (45 kg) or more of a refrigerant, other than systems utilizing nonpositive displacement compressors, shall have stop valves, in addition to those required by Section 1107.7, on each inlet of each liquid receiver. Stop valves shall not be required on the inlet of a receiver in a condensing unit, nor on the inlet of a receiver which is an integral part of the condenser.

1107.7.2 Copper tubing. Stop valves used with soft annealed copper tubing or hard-drawn copper tubing $\frac{7}{8}$ -inch (22.2 mm) OD standard size or smaller shall be securely mounted, independent of tubing fastenings or supports.

1107.7.3 Identification. Stop valves shall be identified where their intended purpose is not obvious. Numbers shall not be used to label the valves, unless a key to the numbers is located near the valves.

SECTION 1108 FIELD TEST

1108.1 General. Every refrigerant-containing part of every system that is erected on the premises, except compressors, condensers, vessels, evaporators, safety devices, pressure gauges and control mechanisms that are listed and factory tested, shall be tested and proved tight after complete installation, and before operation. Tests shall include both the high- and low-pressure sides of each system at not less than the lower of the design pressures or the setting of the pressure relief device(s). The design pressures for testing shall be those listed on the condensing unit, compressor or compressor unit name-plate, as required by ASHRAE 15.

Exceptions:

1. Gas bulk storage tanks that are not permanently connected to a refrigeration system.
2. Systems erected on the premises with copper tubing not exceeding $\frac{5}{8}$ -inch (15.8 mm) OD, with wall thickness as required by ASHRAE 15, shall be tested in accordance with Section 1108.1, or by means of refrigerant charged into the system at the saturated vapor pressure of the refrigerant at 70°F (21°C) or higher.
3. Limited-charge systems equipped with a pressure relief device, erected on the premises, shall be tested at a pressure not less than one and one-half times the pressure setting of the relief device. If the equipment or appliance has been tested by the manufacturer at one and one-half times the design pressure, the test after erection on the premises shall be conducted at the design pressure.

1108.1.1 Booster compressor. Where a compressor is used as a booster to obtain an intermediate pressure and discharges into the suction side of another compressor, the booster compressor shall be considered a part of the low side, provided that it is protected by a pressure relief device.

1108.1.2 Centrifugal/nonpositive displacement compressors. In field-testing systems using centrifugal or other nonpositive displacement compressors, the entire system shall be considered as the low-side pressure for field test purposes.

1108.2 Test gases. Tests shall be performed with an inert dried gas including, but not limited to, nitrogen and carbon dioxide. Oxygen, air, combustible gases and mixtures containing such gases shall not be used.

Exception: The use of air is allowed to test R-717, ammonia, systems provided that they are subsequently evacuated before charging with refrigerant.

1108.3 Test apparatus. The means used to build up the test pressure shall have either a pressure-limiting device or a pressure-reducing device and a gauge on the outlet side.

1108.4 Declaration. A certificate of test shall be provided for all systems containing 55 pounds (25 kg) or more of refrigerant. The certificate shall give the name of the refrigerant and the field test pressure applied to the high side and the low side of the system. The certification of test shall be signed by the installer and shall be made part of the public record.

**[F]SECTION 1109
PERIODIC TESTING**

1109.1 Testing required. The following emergency devices and systems shall be periodically tested in accordance with the manufacturer's instructions and as required by the code official:

1. Treatment and flaring systems.
2. Valves and appurtenances necessary to the operation of emergency refrigeration control boxes.
3. Fans and associated equipment intended to operate emergency pure ventilation systems.
4. Detection and alarm systems.