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.

Note: Brazing certifications required. A person qualified for inspection of brazing or welding of refrigeration *piping* shall have a valid certification meeting the requirements in **OAR 918-098-0900.** A person engaged in the brazing or welding of refrigeration *piping* shall have a valid certification meeting the requirements in **OAR 918-440-0015**. For refrigeration *piping* regulated by the State of Oregon Boiler and Pressure Vessel Program, see requirements listed in **OAR 918-225-0310**. All three of these administrative rules were **effective July 1, 2001**.

918-098-0900
Refrigeration Inspector Certification

(1) All persons engaged in the inspection of brazing or welding related to the installation, alteration or repair of refrigeration *piping* systems, except as regulated by the Oregon Boiler and Pressure Vessel Program under OAR Chapter 918, Division 225, shall:

(a) Possess a current and valid A- or B-level Mechanical Inspector Certification issued under OAR 918-098-0120 or 918-098-0130; and

(b) Successfully complete a training program in accordance with either Section IX, "Welding and Brazing Qualification" of the ASME *Boiler and Pressure Vessel Code*, or AWS B2.2, "Standard for Brazing Procedure and Performance Qualification" issued by a division-*approved* organization.

(2) Inspector certification for refrigeration *piping* in one- and two-family dwellings is not required.

918-440-0015
Refrigeration Installer Certification

All persons engaged in brazing or welding related to the installation, alteration or repair of refrigeration *piping* systems not regulated by the Oregon Boiler and Pressure Vessel Program under OAR Chapter 918, Division 225, shall be certified in accordance with the requirements of this rule.

(1) The minimum requirement for persons engaged in brazing or welding of refrigeration *piping* systems is a current and valid certification issued upon completion of a class by a division-*approved* certifying organization in brazing or welding in accordance with either:

(a) Section IX, Welding and Brazing Qualifications of the ASME *Boiler and Pressure Vessel Code*; or

(b) AWS B2.2, Standard for Brazing Procedure and Performance Qualification.

(2) Refrigeration systems installed in dwelling units regulated under the *Oregon Residential Specialty Code* are exempt from this rule.

(3) All refrigeration *piping* system requirements not regulated by OAR 918-225-0310 are subject to the *Oregon Mechanical Specialty Code*.

918-225-0310
Refrigerant Piping Systems; Components

(1) The requirements of OAR 918-225-0430(5) shall be enforced under this rule for all refrigerant *piping* systems consisting of welded, brazed or mechanically assembled *piping* and *piping* fittings exceeding 2 inches NPS, and containing any refrigerant chemical rated as other than A-1 or B-1 by the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE 34) as adopted by the *Oregon Mechanical Specialty Code.*

(2) One- and two-family dwelling units and air conditioning refrigeration systems used solely for human comfort are exempt from this rule.

(3) All refrigeration *piping* system requirements other than those regulated by this rule are subject to the *Oregon Mechanical Specialty Code.*

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 *Plumbing Code*.

1101.5 Fuel gas connection. Fuel gas devices, *equipment* and appliances used with refrigeration systems shall be installed in accordance with Appendix C.

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 Locking access port caps. Refrigerant circuit access ports located outdoors shall be fitted with locking-type tamper-resistant caps.

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

TABLE 1103.1
REFRIGERANT CLASSIFICATION, AMOUNT AND OEL

CHEMICAL REFRIGERANT	FORMULA	CHEMICAL NAME OF BLEND	REFRIGERANT CLASSIFICATION	DEGREES OF HAZARD[a]	[M] AMOUNT OF REFRIGERANT PER OCCUPIED SPACE			
					Pounds per 1,000 cubic feet	ppm	g/m^3	OEL[e]
R-11[d]	CCl_3F	trichlorofluoromethane	A1	2-0-0[b]	0.39	1,100	6.2	C1,000
R-12[d]	CCl_2F_2	dichlorodifluoromethane	A1	2-0-0[b]	5.6	18,000	90	1,000
R-13[d]	$CClF_3$	chlorotrifluoromethane	A1	2-0-0[b]	—	—	—	1,000
R-13B1[d]	$CBrF_3$	bromotrifluoromethane	A1	2-0-0[b]	—	—	—	1,000
R-14	CF_4	tetrafluoromethane (carbon tetrafluoride)	A1	2-0-0[b]	25	110,000	400	1,000
R-22	$CHClF_2$	chlorodifluoromethane	A1	2-0-0[b]	13	59,000	210	1,000
R-23	CHF_3	trifluoromethane (fluoroform)	A1	2-0-0[b]	7.3	41,000	120	1,000
R-32	CH_2F_2	difluoromethane (methylene fluoride)	A2	—	4.8	36,000	77	1,000
R-113[d]	CCl_2FCClF_2	1,1,2-trichloro-1,2,2-trifluoroethane	A1	2-0-0[b]	1.2	2,600	20	1,000
R-114[d]	$CClF_2CClF_2$	1,2-dichloro-1,2,2-tetrafluoroethane	A1	2-0-0[b]	8.7	20,000	140	1,000
R-115	$CClF_2CF_3$	chloropentafluoroethane	A1	—	47	120,000	760	1,000
R-116	CF_3CF_3	hexafluoroethane	A1	1-0-0	34	97,000	550	1,000
R-123	$CHCl_2CF_3$	2,2-dichloro-1,1,1-trifluoroethane	B1	2-0-0[b]	3.5	9,100	57	50
R-124	$CHClFCF_3$	2-chloro-1,1,1,2-tetrafluoroethane	A1	2-0-0[b]	3.5	10,000	56	1,000
R-125	CHF_2CF_3	pentafluoroethane	A1	2-0-0[b]	23	75,000	370	1,000
R-134a	CH_2FCF_3	1,1,1,2-tetrafluoroethane	A1	2-0-0[b]	13	50,000	210	1,000
R-141b	CH_3CCl_2F	1,1-dichloro-1-fluoroethane	—	—	0.78	2,600	12	500
R-142b	CH_3CClF_2	1-chloro-1,1-difluoroethane	A2	—	5.1	20,000	83	1,000
R-143a	CH_3CF_3	1,1,1-trifluoroethane	A2	2-0-0[b]	4.5	21,000	70	1,000
R-152a	CH_3CHF_2	1,1-difluorethane	A2	1-4-0	2	12,000	32	1,000
R-170	CH_3CH_3	ethane	A3	2-4-0	0.54	7,000	8.7	1,000
R-E170	CH_3OCH_3	dimethyl ether	A3	—	1	8,500	16	1,000
R-218	$CF_3CF_2CF_3$	octafluoropropane	A1	2-0-0[b]	43	90,000	690	1,000
R-227ea	CF_3CHFCF_3	1,1,1,2,3,3,3-heptafluoropropane	A1	—	36	84,000	580	1,000
R-236fa	$CF_3CH_2CF_3$	1,1,1,3,3,3-hexafluoropropane	A1	2-0-0[b]	21	55,000	340	1,000
R-245fa	$CHF_2CH_2CF_3$	1,1,1,3,3-pentafluoropropane	B1	2-0-0[b]	12	34,000	190	300
R-290	$CH_3CH_2CH_3$	propane	A3	2-4-0	0.56	5,300	9.5	1,000
R-C318	$-(CF_2)_4-$	octafluorocyclobutane	A1	—	41	80,000	660	1,000

(continued)

TABLE 1103.1
REFRIGERANT CLASSIFICATION, AMOUNT AND OEL

CHEMICAL REFRIGERANT	FORMULA	CHEMICAL NAME OF BLEND	REFRIGERANT CLASSIFICATION	DEGREES OF HAZARD[a]	[M] AMOUNT OF REFRIGERANT PER OCCUPIED SPACE			
					Pounds per 1,000 cubic feet	ppm	g/m^3	OEL[e]
R-400[d]	zeotrope	R-12/114 (50/50)	A1	2-0-0[b]	10	28,000	160	1,000
R-400[d]	zeotrope	R-12/114 (60/40)	A1		11	30,000	170	1,000
R-401A	zeotrope	R-22/152a/124 (53/13/34)	A1	2-0-0[b]	6.6	27,000	110	1,000
R-401B	zeotrope	R-22/152a/124 (61/11/28)	A1	2-0-0[b]	7.2	30,000	120	1,000
R-401C	zeotrope	R-22/152a/124 (33/15/52)	A1	2-0-0[b]	5.2	20,000	84	1,000
R-402A	zeotrope	R-125/290/22 (60/2/38)	A1	2-0-0[b]	8.5	33,000	140	1,000
R-402B	zeotrope	R-125/290/22 (38/2/60)	A1	2-0-0[b]	15	63,000	240	1,000
R-403A	zeotrope	R-290/22/218 (5/75/20)	A1	2-0-0[b]	7.6	33,000	120	1,000
R-403B	zeotrope	R-290/22/218 (5/56/39)	A1	2-0-0[b]	18	70,000	290	1,000
R-404A	zeotrope	R-125/143a/134a (44/52/4)	A1	2-0-0[b]	31	130,000	500	1,000
R-405A	zeotrope	R-22/152a/142b/C318 (45.0/7.0/5.5/2.5)	—	—	16	57,000	260	1,000
R-406A	zeotrope	R-22/600a/142b (55/4/41)	A2	—	4.7	21,000	25	1,000
R-407A	zeotrope	R-32/125/134a (20/40/40)	A1	2-0-0[b]	18	78,000	290	1,000
R-407B	zeotrope	R-32/125/134a (10/70/20)	A1	2-0-0[b]	20	77,000	320	1,000
R-407C	zeotrope	R-32/125/134a (23/25/52)	A1	2-0-0[b]	17	76,000	270	1,000
R-407D	zeotrope	R-32/125/134a (15/15/70)	A1	2-0-0[b]	15	65,000	240	1,000
R-407E	zeotrope	R-32/125/134a (25/15/60)	A1	2-0-0[b]	16	75,000	260	1,000
R-408A	zeotrope	R-125/143a/22 (7/46/47)	A1	2-0-0[b]	21	95,000	340	1,000
R-409A	zeotrope	R-22/124/142b (60/25/15)	A1	2-0-0[b]	7.1	29,000	110	1,000
R-409B	zeotrope	R-22/124/142b (65/25/10)	A1	2-0-0[b]	7.3	30,000	120	1,000
R-410A	zeotrope	R-32/125 (50/50)	A1	2-0-0[b]	25	130,000	390	1,000
R-410B	zeotrope	R-32/125 (45/55)	A1	2-0-0[b]	24	130,000	390	1,000
R-411A	zeotrope	R-127/22/152a (1.5/87.5/11.0)	A2	—	2.9	14,000	46	990
R-411B	zeotrope	R-1270/22/152a (3/94/3)	A2	—	2.8	13,000	45	980
R-412A	zeotrope	R-22/318/142b (70/5/25)	A2	—	5.1	22,000	82	1,000
R-413A	zeotrope	R-218/134a/600a (9/88/3)	A2	—	5.8	22,000	94	1,000
R-414A	zeotrope	R-22/124/600a/142b (51/28.5/4/16.5)	A1	—	6.4	26,000	100	1,000
R-414B	zeotrope	R-22/124/600a/142b (50/39/1.5/9.5)	A1	—	6	23,000	95	1,000

(continued)

TABLE 1103.1—continued
REFRIGERANT CLASSIFICATION, AMOUNT AND OEL

CHEMICAL REFRIGERANT	FORMULA	CHEMICAL NAME OF BLEND	REFRIGERANT CLASSIFICATION	DEGREES OF HAZARD[a]	[M] AMOUNT OF REFRIGERANT PER OCCUPIED SPACE			
					Pounds per 1,000 cubic feet	ppm	g/m^3	OEL[e]
R-415A	zeotrope	R-22/152a (82.0/18.0)	A2	—	12	57,000	190	1,000
R-415B	zeotrope	R-22/152a (25.0/75.0)	A2	—	9.3	52,000	120	1,000
R-416A	zeotrope	R-134a/124/600 (59/39.5/1.5)	A1	2-0-0[b]	3.9	14,000	62	1,000
R-417A	zeotrope	R-125/134a/600	A1	2-0-0[b]	3.5	13,000	56	1,000
R-418A	zeotrope	R-290/22/152a (1.5/96.0/2.5)	A2	—	13	59,000	200	1,000
R-419A	zeotrope	R-125/134a/E170 (77.0/19.0/4.0)	A2	—	19	70,000	310	1,000
R-420A	zeotrope	R-134a/142b (88.0/12.0)	A1	2-0-0[b]	12	45,000	190	1,000
R-421A	zeotrope	R-125/134a (58.0/42.0)	A1	2-0-0[b]	17	61,000	280	1,000
R-421B	zeotrope	R-125/134a (85.0/15.0)	A1	2-0-0[b]	21	69,000	330	1,000
R-422A	zeotrope	R-125/134a/600a (85.1/11.5/3.4)	A1	2-0-0[b]	18	63,000	290	1,000
R-422B	zeotrope	R-125/134a/600a (55.0/42.0/3.0)	A1	2-0-0[b]	16	26,000	250	1,000
R-422C	zeotrope	R-125/134a/600a (82.0/15.0/3.0)	A1	2-0-0[b]	18	62,000	290	1,000
R-422D	zeotrope	R-125/134a/600a (65.1/31.5/3.4)	A1	2-0-0[b]	16	58,000	260	1,000
R-423A	zeotrope	R-134a/227ea (52.5/47.5)	A1	2-0-0[c]	19	59,000	310	1,000
R-424A	zeotrope	R-125/134a/600a/600/601a (50.5/47.0/1.0/0.6)	A1	2-0-0[b]	6.2	23,000	100	970
R-425A	zoetrope	R-32/134a/227ea (18.5/69.5/12.0)	A1	2-0-0[b]	16	67,000	250	1,000
R-426A	zeotrope	R-125/134a/600a/601a (5.1/93.0/1.3/0.6)	A1	—	5.2	20,000	83	990
R-427A	zeotrope	R-32/125/143a/134a (15.0/25.0/10.0/50.0)	A1	—	18	76,000	280	1,000
R-428A	zeotrope	R-125/143a/290/600a (77.5/20.0/0.6/1.9)	A1	—	23	83,000	370	1,000
R-429A	zeotrope	R-E170/152a/600a (60.0/10.0/30.0)	A3	—	0.81	6,300	13	1,000
R-430A	zeotrope	R-152a/600a (76.0/24.0)	A3	—	1.3	8,000	21	1,000
R-431A	zeotrope	R-290/152a (71.0/29.0)	A3	—	0.69	5,500	11	1,000
R-432A	zeotrope	R-1270/E170 (80.0/20.0)	A3	—	0.13	1,200	2.1	710
R-433A	zeotrope	R-1270/290 (30.0/70.0)	A3	—	0.34	3,100	5.5	880
R-434A	zeotrope	R-125/143a/600a (63.2/18.0/16.0/2.8)	A1	—	20	73,000	320	1,000
R-435A	zeotrope	R-E170/152a (80.0/20.0)	A3	—	1.1	8,500	17	1,000
R-436A	zeotrope	R-290/600a (56.0/44.0)	A3	—	0.5	4,000	8	1,000
R-436B	zeotrope	R-290/600a (52.0/48.0)	A3	—	0.5	4,000	8	1,000
R-437A	zeotrope	R-125/134a/600/601 (19.5/78.5/1.4/0.6)	A1	—	5	19,000	81	990

(continued)

TABLE 1103.1—continued
REFRIGERANT CLASSIFICATION, AMOUNT AND OEL

CHEMICAL REFRIGERANT	FORMULA	CHEMICAL NAME OF BLEND	REFRIGERANT CLASSIFICATION	DEGREES OF HAZARD[a]	[M] AMOUNT OF REFRIGERANT PER OCCUPIED SPACE			
					Pounds per 1,000 cubic feet	ppm	g/m^3	OEL[e]
R-500[e]	azeotrope	R-12/152a (73.8/26.2)	A1	2-0-0[b]	7.6	30,000	120	1,000
R-501[d]	azeotrope	R-22/12 (75.0/25.0)	A1	—	13	54,000	210	1,000
R-502[e]	azeotrope	R-22/115 (48.8/51.2)	A1	2-0-0[b]	21	73,000	330	1,000
R-503[e]	azeotrope	R-23/13 (40.1/59.9)	—	2-0-0[b]	—	—	—	1,000
R-504[d]	azeotrope	R-32/115 (48.2/51.8)	—	—	29	140,000	460	1,000
R-507A	azeotrope	R-125/143a (50/50)	A1	2-0-0[b]	32	130,000	520	1,000
R-508A	azeotrope	R-23/116 (39/61)	A1	2-0-0[b]	14	55,000	220	1,000
R-508B	azeotrope	R-23/116 (46/54)	A1	2-0-0[b]	13	52,000	200	1,000
R-509A	azeotrope	R-22/218 (44/56)	A1	2-0-0[b]	24	75,000	390	1,000
R-510A	azeotrope	R-E170/600a (88.0/12.0)	A3	—	0.87	7,300	14	1,000
R-600	$CH_3CH_2CH_2CH_3$	butane	A3	1-4-0	0.1	1,000	2.4	1,000
R-600a	$CH(CH_3)_2$-CH_3	isobutane (2-methyl propane)	A3	2-4-0	0.6	4,000	9.6	800
R-601a	$(CH_3)_2CHCH_2CH_3$	isopentane	A3	—	0.2	1,000	2.9	600
R-717	NH_3	ammonia	B2	3-3-0[c]	0.014	320	0.22	25
R-718	H_2O	water	A1	0-0-0	—	—	—	—
R-744	CO_2	carbon dioxide	A1	2-0-0[b]	4.5	40,000	72	5,000
R-1150	CH_2=CH_2	ethene (ethylene)	A3	1-4-2	—	—	—	200
R-1270	CH_3CH=CH_2	Propene (propylene)	A3	1-4-1	0.1	1,000	1.7	500

For SI: 1 pound = 0.454 kg, 1 cubic foot = 0.0283 m^3.

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

b. 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.

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

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

e. Occupational Exposure Limit based on the OSHA PEL, ACGIH TLV-TWA, the AIHA WEEL or consistent value on a time-weighted average (TWA) basis (unless noted C for ceiling) for an 8 hr/d and 40 hr/wk.

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.

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 m^2) 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 the *Electrical Code* where the quantity of any Group A2, B2, A3 or B3 refrigerant, other than ammonia, 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 horsepower (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 m^2).

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

1105.1 Access. *Access* to machinery rooms shall be restricted to authorized personnel. A sign shall be posted on the machinery room door prohibiting *access* by others.

1105.2 Dimensions. A machinery room shall be dimensioned so as to provide clearances required by Chapter 3. There shall be clear head room of not less than $7^1/_4$ feet (2210 mm) below *equipment* and *appliances* located over passageways.

1105.3 Doors. Each machinery room shall have self-closing, weather-stripped doors opening in the direction of egress travel. Doors and door openings shall comply with the requirements of the *Building Code*.

1105.4 Openings. Openings to other parts of the building that permit passage of escaping refrigerant to other parts of the building are prohibited. 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.

Exceptions:

1. Egress doors serving the machinery room.
2. *Access* doors and panels in air ducts and air-handling units, provided that such openings are gasketed and tight fitting.

1105.5 Refrigerant detector. Machinery rooms shall contain a refrigerant detector with an audible and visual alarm. The detector, or a sampling tube that draws air to the detector, shall be located in an area where refrigerant from a leak will 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 approved locations

Exception: Detectors are not required for ammonia system complying with Section 1106.8.

1105.6 Tests. Periodic tests of the mechanical ventilating system shall be performed in accordance with manufacturer's specifications and as required by the code official.

1105.7 Fuel-burning appliances. Fuel-burning appliances and *equipment* having open flames and that use *combustion* air from the *machinery room* shall not be installed in a *machinery room*.

Exceptions:

1. Where the refrigerant is carbon dioxide or water.

2. 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, or where a refrigerant vapor detector is employed to automatically shut off the *combustion* process in the event of refrigerant leakage.

1105.8 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:

$$F = \sqrt{G} \qquad \textbf{(Equation 11-1)}$$

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

where:

F = The free opening area in square feet (m^2).

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

1105.8.1 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.

1105.8.2 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.

1105.8.3 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 $m^3/s \cdot m^2$) of *machinery room* area or 20 cfm (0.009 m^3/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.

1105.8.4 Quantity—emergency conditions. Upon actuation of the refrigerant detector required in Section 1105.5, the mechanical ventilation system shall *exhaust air* from the *machinery room* in the following quantity:

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

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

where:

Q = The airflow in cubic feet per minute (m^3/s).

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

1105.9 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.

1105.10 Emergency pressure control system. Refrigeration systems containing more than 6.6 pounds (3 kg) of flammable, toxic or highly toxic refrigerant or ammonia shall be provided with an emergency pressure control system in accordance with Section 606.10 of the *Fire Code*.

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.

1106.2 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 Construction requirements. The machinery room shall be separated from other occupied space with smoke-tight, 1-hour fire-resistance-rated construction.

1106.4 Opening protection. Opening protection between the machinery room and other occupied spaces shall be *approved*, self-closing, tight-fitting fire doors with a minimum fire-resistance rating of $^3/_4$ hour.

1106.5 Pipe penetrations. All pipe penetrations of the interior walls, ceiling or floor of machinery rooms shall be sealed vapor tight and protected in accordance with the *Building Code*.

1106.6 Exterior openings. Openings in exterior walls of machinery rooms shall not be located under any exit, stairway or exit discharge.

1106.7 Egress. Each machinery room shall be provided with a minimum of one exit door that opens directly to the outside.

Exception: Self-closing, tight-fitting doors opening into a vestibule leading directly outside.

1106.8 Ammonia room ventilation. Ventilation systems in ammonia machinery rooms shall be operated continuously at the emergency ventilation rate determined in accordance with Section 1105.8.4.

Exceptions:

1. Machinery rooms equipped with a vapor detector that will automatically start the ventilation system at the emergency rate determined in accordance with Section 1105.8.4, and that will 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 the *Electrical Code.*

1106.9 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 the *Electrical Code.*

Exception: Ammonia machinery rooms.

1106.10 Remote controls. Remote control of the mechanical *equipment* and appliances located in the *machinery room* shall be provided at an *approved* location immediately outside the machinery room and adjacent to its principle entrance.

1106.10.1 Refrigeration system. A clearly identified switch of the break-glass type shall provide off-only control of electrically energized *equipment* and appliances in the *machinery room*, other than refrigerant leak detectors and *machinery room* ventilation.

Exception: In machinery rooms where only nonflammable refrigerants are used, electrical *equipment* and appliances, other than compressors, are not required to be provided with a cutoff switch.

1106.10.2 Ventilation system. A clearly identified switch of the break-glass type shall provide on-only control of the *machinery room* ventilation fans.

1106.11 Emergency signs and labels. Refrigeration units and systems shall be provided with *approved* emergency signs, charts, and labels in accordance with the *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 Piping location. Refrigerant piping that crosses an open space that affords passageway in any building shall be not less than 7 feet 3 inches (2210 mm) above the floor unless the piping is located against the ceiling of such space. Refrigerant piping shall not be placed in any elevator, dumbwaiter or other shaft containing a moving object or in any shaft that has openings to living quarters or to means of egress. Refrigerant piping shall not be installed in an enclosed public stairway, stair landing or means of egress.

1107.2.1 Piping in concrete floors. Refrigerant piping installed in concrete floors shall be encased in pipe ducts. The piping shall be isolated and supported to prevent damaging vibration, stress and corrosion.

1107.2.2 Refrigerant penetrations. Refrigerant piping shall not penetrate floors, ceilings or roofs.

Exceptions:

1. Penetrations connecting the basement and the first floor.
2. Penetrations connecting the top floor and a machinery penthouse or roof installation.
3. Penetrations connecting adjacent floors served by the refrigeration system.
4. Penetrations by piping in a direct system where the refrigerant quantity does not exceed Table 1103.1 for the smallest occupied space through which the piping passes.
5. In other than industrial occupancies and where the refrigerant quantity exceeds Table 1103.1 for the smallest space, penetrations for piping that connects separate pieces of *equipment* that are either:
   5.1. Enclosed by an *approved* gas-tight, fire-resistive duct or shaft with openings to those floors served by the refrigeration system or
   5.2. Located on the exterior of the building where vented to the outdoors or to the space served by the system and not used as an air shaft, closed court or similar space.

1107.3 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.

1107.4 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.

1107.5 Materials for refrigerant pipe and tubing. Piping materials shall be as set forth in Sections 1107.5.1 through 1107.5.5.

1107.5.1 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).

1107.5.2 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.

1107.5.3 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 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 $^{7}/_{8}$-inch (22.2 mm) OD size.

1107.5.4 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.

1107.5.5 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.

1107.6 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.

1107.7 Exposure of refrigerant pipe joints. Refrigerant pipe joints erected on the premises shall be exposed for visual inspection prior to being covered or enclosed.

1107.8 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.

1107.8.1 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 1107.8, 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.

1107.8.2 Copper tubing. Stop valves used with soft annealed copper tubing or hard-drawn copper tubing $^{7}/_{8}$-inch (22.2 mm) OD standard size or smaller shall be securely mounted, independent of tubing fastenings or supports.

1107.8.3 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 nameplate, 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 $^{5}/_{8}$-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.