CHAPTER 11

REFRIGERATION

1101.0 Scope.

Part I of this chapter covers refrigeration systems. Refrigeration systems, equipment, and devices, including the replacement of parts, alterations, and substitution of a different refrigerant, shall conform to the requirements of this chapter and other applicable provisions of this code.

Occupied spaces within refrigerated areas shall comply with this chapter and the applicable portions of the Building Code.

Part II covers cooling towers.

Part I – Refrigeration Systems

1102.0 Refrigerants.

The refrigerant used shall be of a type listed in Table 11-1 or as classified under Section 1103.0 as approved.

Exception: Lithium bromide absorption systems using water as the refrigerant.

1103.0 Refrigerant Classification.

Refrigerants shall be classified in accordance with the referenced standard for refrigerant designation and safety classification in Chapter 17.

1104.0 Classification of Refrigeration Systems.

Refrigeration systems shall be classified according to the degree of probability that a leakage of refrigerant could enter a normally occupied area.

1104.1 High-Probability System. Systems 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 occupied space described in Section 1105.2.

1104.2 Low-Probability System. Systems that cannot be considered as high-probability system are classified as low-probability systems. This class includes systems whose joints and connections in the refrigerant circuit are effectively isolated from the occupied space described in Section 1105.2.

1105.0 Requirements for Refrigerant and Refrigeration System Use.

1105.1 System Selection. Refrigeration systems shall be limited in application in accordance with Table 11-2 and the requirements of this section.

1105.2 Volume of Occupied Space. The quantity of refrigerant in a single, independent circuit of a high-probability system shall not exceed the amounts shown in Table 11-1 based on the volume of the occupied space. The volume of the smallest, enclosed, occupied space shall be used to determine the permissible quantity of refrigerant in a system that is located in, serves, or passes through such space.

Exceptions:

(1) If the airflow to any enclosed space served by a portion of an air-duct system cannot be shut off or reduced below one-quarter of its maximum, the cubical contents of the entire space served by that portion of the air-duct system shall be used to determine the permissible quantity of refrigerant in the system.

(2) Refrigerated process or storage areas meeting the requirements of Section 1105.3.

1105.3 Refrigerated Process and Storage Areas. Refrigerant quantities in evaporators and piping within rooms or spaces used exclusively for processing or storage of materials under refrigerated conditions shall not be limited, provided that exiting is provided per the Building Code and that:

1105.3.1 The refrigerated room or space is equipped with a refrigerant vapor detection and alarm system complying with Section 1121.0.

1105.3.2 The refrigerated room or space is sealed from all other portions of the building by vapor-tight construction and tight-fitting, gasketed doors.

Exception: Adjoining refrigerated rooms.

1105.4 Refrigerant Purity. New and reclaimed refrigerants are allowed to be used in refrigeration systems in accordance with this section. When requested, the installer shall furnish a declaration identifying the refrigerant by standard "R" designation and stating that it meets the requirements of Section 1105.4.1 or 1105.4.2.

Exception: The refrigerant used shall meet the purity specifications set by the manufacturer of the equipment in which it is used when that specification is different from Section 1105.4.1 or 1105.4.2.

1105.4.1 New and Reclaimed Refrigerants. New and reclaimed refrigerants shall meet the

referenced standard for refrigerant specifications in Chapter 17.

1105.4.2 Recovered Refrigerants. Reuse of recovered refrigerant that shows no sign of contamination is allowed, provided that it has been filtered and dried with a listed or approved recovery machine, in equipment belonging to the same owner as the equipment from which it was removed. Recovered refrigerants shall not be used in a different owner's equipment unless the refrigerant has been analyzed and found to meet the purity requirements of Section 1105.4.1.

1106.0 General Requirements.

1106.1 Human Comfort. Cooling systems used for human comfort shall comply with the return-air and outside-air provisions for furnaces in Sections 904.7 and 904.8 of this code. Cooling equipment used for human comfort in dwelling units shall be sized to satisfy the calculated loads determined in accordance with the reference standards in Chapter 17 or other approved methods.

1106.2 Supports and Anchorage. Supports and anchorage for refrigeration equipment and piping shall be designed in accordance with the Building Code as Occupancy Category H hazardous facilities. Supports shall be noncombustible.

Exceptions:

(1) Equipment containing Group A1 refrigerants may be supported by the same materials permitted for the building type.

(2) The use of approved vibration isolators specifically designed for the normal, wind, and seismic loads to which they may be subject shall be permitted.

A compressor or portion of a condensing unit supported from the ground shall rest on a concrete or other approved base extending not less than three (3) inches (76 mm) above the adjoining ground level.

1106.3 Access. An unobstructed readily accessible opening and passageway not less than thirty-six (36) inches (914 mm) in width and six (6) feet (1829 mm) eight (8) inches (203 mm) in height shall be provided and maintained to the compressor, valves required by this chapter, or other portions of the system requiring routine maintenance.

Exceptions:

(1) Refrigerant evaporators, suspended overhead, may use portable means of access.

(2) Air filters, brine control or stop valves, fan motors or drives, and remotely de-energized electrical connections may be provided access by an unobstructed space not less than thirty (30) inches (762 mm) in depth, width, and height. When an access opening is immediately adjacent to these items and the equipment can be serviced, repaired, and replaced from this opening, the dimensions may be reduced to twenty-two (22) inches (559 mm) by thirty (30) inches (762 mm) provided the largest piece of equipment can be removed through the opening.

(3) Cooling equipment, using Group A1 refrigerants or brine, located in an attic or furred space may be provided an access by a minimum opening and passageway thereto of not less than twenty-two (22) inches x thirty (30) inches

(4) Cooling or refrigeration equipment, using Group A1 or B1 refrigerants or brine, located on a roof or on an exterior wall of a building, may be provided access as for furnaces in Section 904.10 of this code.

1106.4 Illumination and Service Receptacles. In addition to the requirements of Section 309.0, permanent lighting fixtures shall be installed for all equipment required by this code to be accessible or readily accessible. Such fixtures shall provide sufficient illumination to safely perform the required tasks for which access is provided. Control of the illumination source shall be provided at the access entrance.

Exceptions:

(1) Lighting fixtures may be omitted when the fixed lighting of the building will provide the required illumination.

(2) Equipment located on the roof or on the exterior walls of a building.

1106.5 Protection from Mechanical Damage. Refrigeration systems and portions thereof shall not be located in an elevator shaft, dumbwaiter shaft, or a shaft having moving objects therein, nor in a location where they will be subject to mechanical damage.

1106.6 Electrical. Electrically energized components of refrigeration systems shall conform to the Electrical Code.

1106.7 Ventilation of Rooms Containing Condensing Units. Rooms or spaces other than a refrigeration machinery room complying with the requirements of this chapter in which any refrigerant-containing portion of a condensing unit is located shall be provided with one of the following means of ventilation:

1106.7.1 Permanent gravity ventilation openings of not less than two (2) square feet (0.19 m^2) net free area opening directly to the outside of the building or extending to the outside of the building by continuous ducts.

1106.7.2 A mechanical exhaust system arranged to provide a complete change of air in such room or space at least every 20 minutes and to discharge to the outside of the building.

Exceptions:

(1) A condensing unit in a room or space if the cubical content exceeds 1,000 cubic feet per horsepower (38.50 m^3/kW) of the unit.

(2) A condensing unit in a room or space that has permanent gravity ventilation having an area of two (2) square feet (0.19 m^2) or more to other rooms or openings exceeding 1,000 cubic feet per horsepower (38.50 m^3/kW).

1106.8 Prohibited Locations. Refrigeration systems or portions thereof shall not be located within a required exit enclosure. Refrigeration compressors exceeding five (5) horsepower (3.68 kW) rating shall be located at least ten (10) feet (3,048 mm) from an exit opening in a Group A; Group B; Group E; Group F; Group I; Group R, Division 1; or Group S Occupancy, unless separated by a one-hour fire-resistive occupancy separation.

1106.9 Condensation Control. Piping and fittings that convey brine, refrigerant, or coolants that during normal operation could reach a surface temperature below the dew point of the surrounding air and that are located in spaces or areas where condensation could cause a hazard to the building occupants or damage to the structure or electrical or other equipment shall be protected to prevent such an occurrence.

1106.10 Condensate. Condensate from air-cooling coils shall be collected and drained to an approved location. Drain pans and coils shall be arranged to allow thorough drainage and access for cleaning. Where temperatures can drop below freezing, heat tracing and insulation of condensate drains shall be installed.

1106.11 Defrost. When defrost cycles are required for portions of the system, provisions shall be made for collection and disposal of the defrost liquid in a safe and sanitary manner.

1106.12 Overflows. Where condensate or defrost liquids are generated in an attic or furred space and structural damage may result from overflow, provisions for overflow shall be provided.

1106.13 Condensate, Defrost, and Overflow Disposal. Disposal of condensate, defrost, or overflow discharges shall comply with Section 310.0.

1107.0 Refrigeration Machinery Rooms.

1107.1 When Required. Refrigeration systems shall be provided with a refrigeration machinery room when any of the following conditions exist:

1107.1.1 The quantity of refrigerant in a single, independent refrigerant circuit of a system exceeds Table 11-1 amounts.

1107.1.2 Direct- and indirect-fired absorption equipment is used.

Exceptions: Direct and indirect-fired lithium bromide absorption systems using water as the refrigerant.

1107.1.3 An A1 system having an aggregate combined compressor horsepower of 100 (73.55 kW) or more is used.

1107.1.4 The system contains other than a Group A1 refrigerant.

Exceptions:

(1) Lithium bromide absorption systems using water as the refrigerant.

(2) Ammonia-water absorption unit systems installed outdoors, provided that the quantity of refrigerant in a single system does not exceed Table 11-1 amounts and the discharge is shielded and dispersed.

(3) Systems containing less than 300 pounds (136 kg) of refrigerant R-123 and located in an approved exterior location.

(4) Systems containing less than 35 pounds (16 kg) of refrigerant R-717 and located in an approved exterior location.

Refrigeration machinery rooms shall house all refrigerant-containing portions of the system other than the piping and evaporators permitted by Section 1105.3, discharge piping required of this chapter, and cooling towers regulated by Part II of this chapter, and their essential piping.

1107.2 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 (2,032 mm) in height shall be maintained throughout, allowing free access to at least two sides of all moving machinery and

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

1107.3 Exits. Exits shall comply with the Building Code for special hazards.

1107.4 Refrigerant-Vapor Alarms. Machinery rooms shall have approved refrigerant-vapor detectors located in an area where refrigerant from a leak is likely to concentrate and that will activate visual and audible alarms. Alarms shall be activated at a value not greater than one-half the immediately dangerous to life or health (IDLH), or measurement consistent therewith; the PEL, or measurement consistent therewith; or 25 percent of the LFL, whichever is less.

1107.5 Separation. Refrigeration machinery rooms shall be separated from other portions of the building, as required in the special hazards provisions of the Building Code. Penetrations shall be sealed to inhibit the passage of refrigerant vapor.

1107.6 Combustion Air and Return Air. Combustion air or return air shall not be taken from or through a refrigeration machinery room.

Exceptions:

(1) Refrigeration machinery rooms used exclusively for direct-fired absorption equipment.

(2) Direct-vented combustion equipment.

1107.7 Special Requirements. Open flames or devices having an exposed surface exceeding 800°F (427°C) are prohibited in refrigeration machinery rooms.

Exceptions:

(1) Momentary temperature excursions such as electrical contacts in A1 and B1 systems.

(2) Refrigeration machinery rooms used exclusively for direct-fired absorption equipment.

1108.0 Refrigeration Machinery Room Ventilation.

1108.1 General. Refrigeration machinery rooms shall be provided with a continuous source of outside air for ventilation and removal of rejected heat.

1108.2 Refrigeration Machinery Rooms. Refrigeration machinery rooms shall be provided with dedicated mechanical exhaust systems. The exhaust systems shall have the capacity to achieve each of the following:

1108.2.1 Continuously maintain the refrigeration machinery room at 0.05 inch (12.44 Pa) water gauge negative relative to adjacent spaces calculated by:

$$Q = 2610 A_e \sqrt{\Delta p} \qquad \text{(Equation 11-1)}$$

Exception: Refrigeration machinery rooms located in entirely detached structures and more than twenty (20) feet (6,096 mm) from property lines or openings into buildings.

1108.2.2 Continuously provide 0.5 cubic foot per minute of airflow per gross square foot (2.54 $L/s/m^2$) of floor area within the refrigeration machinery rooms as calculated by:

$$Q = 0.5 A_{gf} \qquad \text{(Equation 11-2)}$$

1108.2.3 Limit the temperature rise within the refrigeration machinery room to a maximum of 104°F (40°C) as calculated by:

$$Q = \sum q / 1.08 \Delta T \qquad \text{(Equation 11-3)}$$

1108.2.4 Provide emergency purge of escaping refrigerant as calculated by:

$$Q = 100 \sqrt{G} \qquad \text{(Equation 11-4)}$$

WHERE:

q = Btu/h of all heat-producing equipment.

Q = air-flow rate, cubic feet per minute (cfm).

Δp = pressure difference, inches water gauge.

A_e = equivalent leakage area, square feet (see the Building Code).

A_{gf} = gross floor area, square feet.

ΔT = temperature difference between machinery room and supply air (°F).

G = refrigerant mass in largest system, lbs.

1108.3 Distribution of Ventilation. Exhaust inlets or permanent openings shall be located to provide ventilation throughout the entire refrigeration machinery room.

1108.4 Intermittent Control of the Ventilation Systems. Fans providing refrigeration machinery room temperature control or automatic response to refrigerant gas in order to maintain concentrations below the PEL may be automatically controlled to provide intermittent ventilation as conditions require.

1108.5 Emergency Control of the Ventilation Systems. Fans providing emergency purge ventilation for refrigerant escape shall have a clearly identified switch of the break-glass type providing "on"only control immediately adjacent to and outside of each refrigerant machinery room exit. Purge fans shall also respond automatically to the refrigerant concentration detection system set to activate the ventilation system at no more than 25 percent of the LFL, or 50 percent of the IDLH, or a measure equivalent thereto, whichever is less. An emergency purge control shall be provided with a manual reset only.

1108.6 Central Control of Ventilation Systems. Mechanical ventilation systems shall have switches to control power to each fan. The switches shall be key operated or within a locked, glass-covered enclosure at an approved location adjacent to and outside of the principal entrance to the machinery room. Necessary keys shall be located in a single approved location. Switches controlling fans providing continuous ventilation shall be of the two-position, on-off type. Switches controlling fans providing intermittent or emergency ventilation shall be of the three-position, automatic on-off type. Switches shall be labeled identifying both the function and the specific fan controlled. Two colored and labeled indicator lamps responding to the differential pressure created by airflow shall be provided for each switch. One lamp shall indicate flow; the other shall indicate no flow.

1108.7 Ventilation Discharge. Exhaust from mechanical ventilation systems shall be discharged at least twenty (20) feet (6,096 mm) from a property line or openings into buildings. Discharges capable of exceeding 25 percent of the LFL, or 50 percent of the IDLH, shall be equipped with approved treatment systems to reduce the discharge concentrations to these values or lower.

Exception: When an approved engineering analysis of plume dispersion demonstrates that the limiting values will not be exceeded at the property line.

1108.8 Fans. Fans and associated equipment intended to operate the emergency purge of other than Group A1 or Group B1 refrigerants shall meet the requirements for a Class I, Division 1 hazardous location as specified in the Electrical Code.

1108.9 Ventilation Intake. Makeup air intakes to replace the exhaust air shall be provided to the refrigeration machinery room directly from outside the building. Intakes shall be located as required by other sections of the code and fitted with backdraft dampers or similar approved flow-control means to prevent reverse flow. Distribution of makeup air shall be arranged to provide thorough mixing within the refrigeration machinery room to prevent short circuiting of the makeup air directly to the exhaust.

1109.0 Refrigeration Machinery Room Equipment and Controls.

1109.1 General. Equipment, piping, ducts, vents, or similar devices that are not essential for the refrigeration process, maintenance of the equipment, or for the illumination, ventilation, or fire protection of the room shall not be placed in or pass through a refrigeration machinery room.

Equipment essential to the refrigeration process often includes, but is not always limited to, the following:

1109.1.1 Refrigeration compressors.

1109.1.2 Condensing units.

1109.1.3 Pumps, associated piping, and automatic control valves for refrigerant, condenser water, and brine or chilled water.

1109.1.4 Refrigeration control devices and panels.

1109.1.5 Machinery room ventilation equipment (see Section 1108.0).

1109.1.6 Cooling towers or portions thereof (see Chapter 11, Part II).

1109.1.7 Refrigerant receivers and accumulators.

1109.1.8 Refrigerant vapor-detection and alarm systems (see Section 1121.0).

1109.1.9 Machinery room fire sprinkler system exclusive of its shutoff valves.

1109.1.10 Machinery room lighting and service receptacles.

1109.1.11 Motor control centers and electrical panels for machinery room systems.

1109.2 Electrical. Electrical equipment and installations shall comply with the Electrical Code. The refrigeration machinery room shall not be required to be a hazardous (classified) location except as provided in Section 1108.8.

1109.3 Storage. Storage of materials in a refrigeration machinery room shall be as permitted in the Fire Code.

1109.4 Emergency Control. A clearly identified switch of the break-glass type providing "off"-only control of electrically energized equipment and devices within the refrigeration machinery room shall be provided immediately adjacent to and

outside of each refrigeration machinery room exit. In addition, emergency shutoff shall also be automatically activated when the concentration of refrigerant vapor exceeds 25 percent of the LFL.

1110.0 Refrigerant Piping, Containers, and Valves.

1110.1 General. Materials used in the construction and installation of refrigeration systems shall be suitable for the refrigerant, refrigerant oil, or brine in the system. Material or equipment that will deteriorate due to the chemical action of the refrigerant, the oil, or combination of both, shall not be installed.

1110.2 Nonferrous Materials. Copper and brass refrigeration piping, valves, fittings, and related parts used in the construction and installation of refrigeration systems shall be approved for the intended use.

1110.3 Ferrous Materials. Iron and steel refrigeration piping, valves, fittings, and related parts shall be approved for the intended use. Pipe more than two (2) inches (50 mm) iron pipe size shall be electric-resistance welded or seamless pipe.

1111.0 Erection of Refrigerant Piping.

1111.1 General. Piping and tubing shall be installed so as to prevent vibration and strains at joints and connections.

1111.2 Support. In addition to the requirements of Section 1106.2, piping and tubing shall be securely fastened to a permanent support within six (6) feet (1,829 mm) following the first bend in such tubing from the compressor and within two (2) feet (610 mm) of each subsequent bend or angle. Piping and tubing shall be supported at points not more than fifteen (15) feet (4,572 mm) apart.

1111.3 Protection from Damage. Refrigerant piping and tubing shall be installed so that it is not subject to damage from an external source. Soft annealed copper tubing shall not be larger than 1-3/8 inch (35 mm) nominal size. Mechanical joints shall not be made on tubing larger than 3/4 inch (20 mm) nominal size. Soft annealed copper tubing conveying refrigerant shall be enclosed in iron or steel piping and fittings, or in conduit, molding, or raceway that will properly protect the tubing against mechanical injury from an exterior source.

Exceptions:

(1) Tubing entirely within or tubing within five (5) feet (1,524 mm) of a refrigerant compressor when so located that it is not subject to external injury.

(2) Copper tubing serving a dwelling unit, when such tubing contains Group A1 refrigerant and is placed in locations not subject to damage from an external source.

1111.4 Visual Inspection. Refrigerant piping and joints shall be exposed to view for visual inspection and acceptance by the Authority Having Jurisdiction prior to being covered or enclosed.

Exception: Copper tubing enclosed in iron or steel piping conduit, molding, or raceway, provided there are no fittings or joints concealed therein.

1111.5 Prohibited Locations. Refrigerant piping shall not be located within a required exit.

1111.6 Underground Piping. Refrigerant piping placed underground shall be protected against corrosion.

1111.7 Joints. Iron or steel pipe joints shall be of approved threaded, flanged, or welded types. Exposed threads shall be tinned or coated with an approved corrosion inhibitor. Copper or brass pipe joints of iron pipe size shall be of approved threaded, flanged, or brazed types. Copper tubing joints and connections shall be approved flared, lapped, swaged, or brazed joints.

1111.8 Identification. Piping shall meet the reference standard for identification. The type of refrigerant, function, and pressure shall be indicated.

1112.0 Refrigerant Control Valves.

1112.1 Location. Stop valves shall be installed in the refrigerant piping of a refrigeration system at the following locations:

1112.1.1 At the inlet and outlet of a positive-displacement-type compressor, compressor unit, or condensing unit.

1112.1.2 At the refrigerant outlet from a liquid receiver.

1112.1.3 At the refrigerant inlet of a pressure vessel containing liquid refrigerant and having an internal gross volume exceeding three (3) cubic feet (108 m^3).

Exceptions:

(1) Systems with nonpositive-displacement compressors.

(2) Systems having a pump-out receiver for storage of the charge.

(3) Systems containing less than 110 pounds (49.9 kg) of Group A1 refrigerant.

(4) Self-contained systems that do not

require a stop valve at the inlet of the receiver.

1112.2 Support. Stop valves installed in copper refrigerant lines of 3/4 inch (20 mm) or less outside diameter shall be securely supported independently of the tubing or piping.

1112.3 Access. Stop valves required by this section shall be readily accessible from the refrigeration machinery room floor or a level platform.

1112.4 Identification. Stop valves shall be identified by tagging in accordance with the reference standard for identification. A valve chart shall be mounted under glass at an approved location near the principal entrance to a refrigeration machinery room.

1113.0 Pressure-Limiting Devices.

1113.1 When Required. Pressure-limiting devices shall be provided on all systems operating above atmospheric pressure.

Exception: Factory-sealed systems containing less than twenty-two (22) pounds (9.98 kg) of Group A1 refrigerant listed by an approved agency.

1113.2 Setting. The maximum setting to which a pressure-limiting device may be set by use of the adjusting means provided shall not exceed the design pressure of the high side of a system not protected by a pressure-relief device or 90 percent of the pressure setting of the pressure-relief device installed on the high side of a system.

Exception: In systems using other than positive-displacement compressors that are protected by a pressure-relief device, the setting may be the design pressure of the high side of the system, provided the pressure-relief device is located in the low side, subject only to low-side pressure, and there is a permanent, unvalved relief path between the high side and the low side of the system.

1113.3 Connection. Pressure-limiting devices shall be connected between the pressure-imposing element and stop valve on the discharge side without intervening stop valves in the line leading to the pressure-limiting device.

1113.4 Operation. When the system is protected by a pressure-relief device, the pressure-limiting device shall stop the action of the pressure-imposing element at a pressure not more than 90 percent of the setting of the pressure-relief device.

1114.0 Pressure-Relief Devices.

1114.1 General. Refrigeration systems shall be protected by a pressure-relief device or other means designed to safely relieve pressure due to fire or abnormal conditions.

1114.2 Positive-Displacement Compressor. A positive-displacement compressor shall be equipped by the manufacturer with a pressure-relief device of adequate size and pressure setting to prevent rupture of the compressor or other component located between the compressor and the stop valve on the discharge side.

1114.3 Liquid-Containing Portions of Systems. Liquid-containing portions of systems, including piping, that can be isolated from pressure-relief devices required elsewhere and that can develop pressures exceeding their working design pressures due to temperature rise, shall be protected by the installation of pressure-relief devices.

1114.4 Evaporators. Evaporators located within eighteen (18) inches (457 mm) of a heating element or coil shall be fitted with a pressure-relief device.

Exceptions:

(1) Self-contained equipment.

(2) Factory-built coil assemblies specifically designed for installation on the discharge of forced-air heating units.

(3) If the connected and unvalved volume of the low side of the system meets the following:

$$V_1 > [W_1 - (V_2 - V_1) / V_{gt}] V_{gc} \quad \text{(Equation 11-5)}$$

WHERE:

V_1 = low-side volume, cubic feet.

V_2 = total volume of system, cubic feet.

W_1 = total weight of refrigerant in system, pounds.

V_{gt} = specific volume of refrigerant vapor at 110°F (43°C), cubic feet per pound.

V_{gc} = specific volume at critical temperature and pressure, cubic feet per pound.

(4) Reheat coils using the refrigerant for heat recovery.

1114.5 Actuation. Pressure-relief devices shall be direct-pressure actuated. Each part of a refrigeration system that can be valved off and that contains one or more pressure vessels having internal diameters greater than six (6) inches (150 mm) and containing liquid refrigerant shall be protected by a pressure-relief device.

1114.6 Stop Valves Prohibited. Stop valves shall not be located between a pressure-relief device and the portion of the system protected thereby.

1114.7 Location. Pressure-relief devices shall be connected as nearly as practical to the portion of the system protected thereby, above the liquid refrigerant level, and accessible for inspection and repair.

Exception: Fusible plugs on the high side may be located above or below the liquid refrigerant level.

1114.8 Materials. Seats and discs of pressure-relief devices shall be constructed of suitable material to resist corrosion or other chemical action caused by the refrigerant. Seats and discs of cast iron are prohibited.

1115.0 Pressure-Relief Device Settings.

1115.1 Pressure-Relief Valve Setting. Pressure-relief valves shall actuate at a pressure not exceeding the design pressure of the parts of the system protected.

1115.2 Rupture Member Setting. Rupture members used in lieu of, or in series with, a relief valve shall have a nominal rated rupture pressure not exceeding the design pressure of the parts of the system protected. Rupture members installed ahead of relief valves need not be larger, but shall not be smaller, than the relief-valve inlet.

1116.0 Marking of Pressure-Relief Devices.

1116.1 Pressure-Relief Valves. Pressure-relief valves for refrigerant-containing components shall be set and sealed by the manufacturer or by an approved assembler. Pressure-relief valves shall be marked by the manufacturer with the data required to show compliance with this chapter.

Exception: Relief valves for systems with design pressures of fifteen (15) psig (103.35 kPa) or less may be marked by the manufacturer with pressure-setting capacity.

1116.2 Rupture Members. Rupture members for refrigerant pressure vessels shall be marked with the data required to show compliance with this chapter.

1116.3 Fusible Plugs. Fusible plugs shall be marked with the melting temperatures in °F (°C) to show compliance with this chapter.

1117.0 Overpressure Protection.

1117.1 General. Pressure vessels shall be provided with over-pressure protection as required by this section.

1117.2 Type of Protection. Pressure vessels with three (3) cubic feet (0.085 m^3) internal gross volume or less may use a single pressure-relief device or a fusible plug. Pressure vessels over three (3) cubic feet (0.085 m^3) but less than ten (10) cubic feet (0.283 m^3) internal gross volume may use a single pressure-relief device but not a fusible plug. Pressure vessels of ten (10) cubic feet (0.283 m^3) or more internal gross volume shall use a single rupture member or dual pressure-relief valve.

1117.3 Three-Way Valve Required. When dual pressure-relief valves are used, they shall be installed with a three-way valve to allow testing or repair.

Exception: A single relief valve of the required relieving capacity may be used on low-side pressure vessels of ten (10) cubic feet (0.283 m^3) or more when meeting the requirements of Section 1117.8, Exception 2.

1117.4 Parallel Pressure-Relief Devices. Two or more pressure-relief devices in parallel to obtain the required capacity shall be considered as one pressure-relief device. The discharge capacity shall be the sum of the capacities required for each pressure vessel being protected.

1117.5 Discharge Capacity. The minimum required discharge capacity of pressure-relief devices for each pressure vessel shall be determined by the following:

$$C = fDL \qquad \text{(Equation 11-6)}$$

WHERE:

C = minimum required discharge capacity of the relief device in pounds of air per minute.

D = outside diameter of vessel, feet.

L = length of vessel, feet.

f = factor dependent upon type of refrigerant from Table 11-3.

1117.6 Rating of Pressure-Relief Valves. Pressure-relief valves shall be of approved types and capacities. The rated discharge capacity of a pressure-relief valve shall be expressed in pounds of air per minute. 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.

1117.7 Rating of Rupture Members and Fusible Plugs. The rated discharge capacity of a rupture member or fusible plug discharging to atmosphere under critical flow conditions in pounds of air per minute shall be determined by the following formulas:

$$C = 0.8P_1d^2 \qquad \text{(Equation 11-7)}$$

$$d = 1.12\sqrt{C/P_1} \qquad \text{(Equation 11-8)}$$

WHERE:

C = rated discharge capacity of air, pounds per minute.

d = smallest internal diameter of the inlet pipe, retaining flanges, fusible plug, rupture member, inches.

For rupture members:

P_1 = (rated pressure psig x 1.1) + 14.7 (Equation 11-9)

For fusible plugs:

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

1117.8 Discharge Location. Pressure-relief devices shall discharge to the atmosphere unless otherwise prohibited by this chapter at a location at least fifteen (15) feet (4,572 mm) above the adjoining grade level and at least twenty (20) feet (6,096 mm) from an opening into a building. The discharge termination shall be fitted with an approved diffuser directed to prevent spray of discharged refrigerant on personnel or entry of foreign material or water into the discharge piping. Discharge piping connected to the discharge side of a fusible plug or rupture member shall have provisions to prevent internal plugging of the pipe caused by the fusible plug or rupture-member function.

Exceptions:

(1) Systems containing less than 110 pounds (49.9 kg) of a Group A1 refrigerant.

(2) A pressure-relief valve may discharge into the low side of the system if the pressure-relief valve is of a type not affected by back pressure, provided the low side is equipped with pressure-relief devices of equal relieving capacity. The low-side pressure-relief device shall be set and discharged as required by this section. Fusible plugs or rupture members shall not be used for pressure relief into the low side.

1118.0 Discharge Piping.

The area of the discharge pipe from the pressure-relief device or fusible plug shall be at least as large as the outlet area of the pressure-relief device or fusible plug. A discharge pipe accepting discharge from more than one relief device or fusible plug shall be sized and have a maximum length of the common discharge not less than that required by the sum of the rated capacities of all relief valves discharging into the header at the lowest pressure setting of any of the relief valves discharging into the header.

The maximum length of the discharge piping permitted to be installed on the outlet of a pressure-relief device shall be determined by:

$$L = 9P^2d^5/16C^2 \quad \text{(Equation 11-10)}$$

WHERE:

C = minimum required discharge capacity, pounds of air per minute.

d = internal diameter of pipe, inches.

L = length of discharge pipe, feet.

For relief valves and rupture disks:

P = (rated pressure psig x 1.1) + 14.7 (Equation 11-11)

For fusible plugs $P = P_1$ where:

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

1119.0 Special Discharge Requirements.

1119.1 General. Systems containing other than Group A1 or B1 refrigerants shall discharge to atmosphere only through an approved flaring device.

Exceptions:

(1) Ammonia systems complying with Section 1120.0.

(2) Ammonia absorption systems serving a single dwelling unit.

(3) When the Authority Having Jurisdiction determines upon review of a rational engineering analysis that significant fire, health, or environmental hazard would not result from the proposed atmospheric release.

(4) Lithium bromide absorption system using water as the refrigerant.

1119.2 Design Requirements. Flaring devices shall be designed to incinerate the entire discharge. The products of refrigerant incineration shall not pose health or environmental hazards. Incineration shall be automatic upon initiation of discharge, shall be designed to prevent blow-back, and shall not expose structures or materials to threat of fire. Standby fuel, such as LPG, and standby power shall have the capacity to operate for 1.5 times the required time for complete incineration of the charge.

1119.3 Testing. Flaring systems shall be tested to demonstrate their safety and effectiveness. A report

from an approved agency shall be submitted detailing the emission products from the system as installed.

1120.0 Ammonia Discharge.

Ammonia shall discharge into a tank of water that shall be used for no purpose except ammonia absorption. At least one (1) gallon (3.785 L) of fresh water shall be provided for each pound (454 g) of ammonia in the system. The water used shall be prevented from freezing without the use of salt or chemicals. The tank shall be substantially constructed of not less than 1/8 inch (3.2 mm) or No. 10 MSG steel. The horizontal dimensions of the tank shall be equal to or less than one-half the height. The tank shall have a hinged cover or, if of the enclosed type, shall have a vent hole at the top. Pipe connections shall be through the top of the tank. The discharge pipe from the pressure-relief valves shall discharge ammonia in the center of the tank near the bottom but not more than thirty (30) feet (9,144 mm) below the surface of the water.

Exception: An ammonia-water absorption unit system installed outdoors serving a dwelling unit, provided the discharge is shielded and dispersed.

1121.0 Detection and Alarm Systems.

1121.1 General. When required by this chapter, approved refrigerant-vapor detection and alarm systems shall utilize alarm signaling devices providing a sound pressure level of at least 15 dB above the operating ambient noise sound pressure level of the space in that they are installed and providing an approved, distinctive visual alarm. Alarms shall be activated within the space and as required in Section 1121.3 whenever the refrigerant vapor PEL is exceeded. In other than machinery rooms, such systems shall also automatically stop the flow of refrigerant to evaporators within the space and stop the flow of refrigerant in all supply lines leaving the machinery room whenever the refrigerant vapor concentration is detected at or above 50 percent of the IDLH or 25 percent of the LEL. Detection of refrigerant vapor concentrations at or above 25 percent of the LEL shall automatically de-energize all electrical power within the space that does not meet the requirement for a Class I, Division 1, Group D electrical installation.

1121.2 Power and Supervision. Detection and alarm systems shall be powered and supervised as required for fire alarm systems in the Fire Code.

1121.3 Annunciation. Detection and alarm systems shall be annunciated for all refrigerants at an approved location in accordance with the Fire Code.

1121.4 Installation, Maintenance, and Testing. Detection and alarm systems shall be installed, maintained, and tested in accordance with the Fire Code.

1122.0 Equipment Identification.

In addition to labels required elsewhere in this code, a refrigeration system shall be provided with labels complying with the requirements of this section.

1122.1 A condenser, receiver, absorber, accumulator, and similar equipment having an internal volume of more than three (3) cubic feet (0.085 m^3) and containing refrigerant shall be equipped with a permanent label setting forth the type of refrigerant in such vessel.

1122.2 In a refrigeration machinery room and for a direct refrigerating system of more than ten (10) horsepower (7.457 kW), there shall be a permanent sign at an approved location giving the following information:

1122.2.1 Name of contractor installing the equipment.

1122.2.2 Name and number designation of refrigerant in system.

1122.2.3 Pounds of refrigerant in system.

1123.0 Testing of Refrigeration Equipment.

1123.1 Factory Tests. Refrigerant-containing parts of units shall be tested and proved tight by the manufacturer at the design pressure for which they are rated. The test pressure applied to the high side of each factory-assembled refrigeration system shall be equal to the design pressure of the high side. The test pressure applied to the low side of each factory-assembled refrigeration system shall be equal to the design pressure of the low side.

Exception: Units with a design pressure of fifteen (15) psig (103.42 kPa) or less shall be tested at a pressure not less than 1.33 times the design pressure.

1123.2 Field Tests. Refrigerant-containing parts of a system that is field-erected shall be tested and proved tight to the Authority Having Jurisdiction after complete installation and before operation. The high and low sides of each system shall be tested and proved tight at not less than the lower of the pressure in Table 11-4 or the setting of the pressure-relief device.

Exceptions:

(1) Compressors, condensers, evaporators,

coded pressure vessels, safety devices, pressure gauges, control mechanisms, and systems that are factory tested.

(2) Refrigeration systems containing Group R-22, not exceeding five (5) tons of refrigeration capacity (17.58 kW), and field-piped using approved, factory-charged line sets may be proved tight by observing retention of pressure on a set of charging gauges and soaping connections while the system is operating.

1123.3 Test Medium. Oxygen, flammable or combustible gases, or gas mixtures shall not be used for leak testing. The means used to build up the test pressure shall have either a pressure-limiting device or a pressure-reducing device with a pressure-relief device and a gauge on the outlet side. The pressure-relief device shall be set above the test pressure but low enough to prevent permanent deformation of system components.

1123.4 Declaration. A dated declaration of test shall be provided for systems containing fifty-five (55) pounds (24.95 kg) or more of refrigerant. The declaration shall give the name and number designation of the refrigerant and the field test pressure applied to the high side and the low side of the system. The declaration of test shall be signed by the installer.

1123.5 Brine Systems. Brine-containing portions of a system shall be tested at 1.5 times the design pressure of the system using brine as the test fluid.

1124.0 Maintenance and Operation.

Refrigeration systems shall be operated and maintained as required by the Fire Code.

1125.0 Storage of Refrigerants and Refrigerant Oils.

Refrigerants and refrigerant oils not charged within the refrigeration system shall be stored as required by the Fire Code.

Part II – Cooling Towers

1126.0 General.

Cooling towers, evaporative condensers, and fluid coolers shall be readily accessible. When located on roofs, such equipment having combustible exterior surfaces shall be protected with an approved automatic fire-extinguishing system.

1127.0 Support and Anchorage.

Cooling towers, evaporative condensers, and fluid coolers shall be supported on noncombustible grillage designed in accordance with the Building Code. Seismic restraints shall be as required by the Building Code.

1128.0 Water Supply.

Water supplies and backflow protection shall be as required by the Uniform Plumbing Code.

1129.0 Drainage.

Drains, overflows, and blow-down provisions shall have an indirect connection to an approved disposal location. Discharge of chemical waste shall be as approved by the appropriate regulatory authority.

1130.0 Chemical Treatment Systems.

Chemical treatment systems shall comply with the Fire Code. When chemicals used present a contact hazard to personnel, approved emergency eye-wash and shower facilities shall be installed.

1131.0 Location.

Cooling towers, evaporative condensers, and fluid coolers shall be located such that their plumes cannot enter occupied spaces. Plume discharges shall be at least five (5) feet (1,524 mm) above or twenty (20) feet (6,096 mm) away from any ventilation inlet to a building. Location on the property shall be as required for buildings by the Building Code.

1131.1 [For OSHPD 1, 2, 3 & 4] *Plume discharge shall be at least twenty-five (25) feet (7620 mm) from any ventilation inlet to a building.*

1132.0 Electrical.

Electrical systems shall be in accordance with the Electrical Code. Equipment shall be provided with a vibration switch to shut off fans operating with excessive vibration. In climates commonly subject to electrical storms, lightning protection shall be provided on roof-mounted equipment.

1133.0 Refrigerants and Hazardous Fluids.

Equipment containing refrigerants as a part of a closed-cycle refrigeration system shall comply with Part I of this chapter. Equipment containing other fluids that are flammable, combustible, or hazardous shall comply with the Fire Code.

TABLE 11-1
Refrigerant Groups[1], Properties[2], and Allowable Quantities[3, 13]
(Data reprinted with permission from The American Society of Heating, Refrigerating, and Air-Conditioning Engineers)

Refrig-erant	Chemical Formula	Chemical Name[4] (Composition for Blends)	Safety Group[1]	PEL[5] (ppm)	IDLH[6] (ppm)	Pounds per 1,000 cf of Space[7]
R-11	CCl_3F	Trichlorofluoromethane	A1	C1000[8]	4,000[10]	1.60
R-12	CCl_2F_2	Dichlorodifluoromethane	A1	1,000	40,000	12.00
R-13	CCF_3	Chlorotrifluoromethane	A1	1,000	67,000	18.00
R-13B1	$CBrF_3$	Bromotrifluoromethane	A1	1,000	57,000	22.00
R-22	$CHClF_2$	Chlorodifluoromethane	A1	1,000[10]	42,000[11]	9.4
R-23	CHF_3	Trifluoromethane	A1	--	--	--
R-113	CCl_2FCClF_2	1,1,2-trichloro-1,2,2 -trifluoroethane	A1	1,000	4,500	1.90
R-114	$CClF_2CClF_2$	1,2-dichloro-1,1,2,2 -tetraflouroethane	A1	1,000	50,000	9.40
R-123	$CHCl_2CF_3$	2,2-dichloro-1,1,1, -trifluoroethane	B1	1,010	4,000[11]	1.60
R-124	$CHClFCF_3$	2-chloro-1,1,1,2 -tetrafluoroethane	A1	--	--	--
R-134a	CF_3CH_2F	1,1,1,2-tetrafluoroethane	A1	1,000[10]	50,000[11]	16.00
R-170	CH_3CH_3	Ethane	A3	1,000	6,400	0.50
R-236fa	$CF_3CH_2CF_3$	1,1,1,3,3,3-hexafluoropropane	A1	--	--	--
R-245fa	$CF_3CH_2CHF_2$	1,1,1,3,3-pentafluoropropane	A3	--	--	--
R-290	$CH_3CH_2CH_3$	Propane	A3	1,000	4,400	0.50
R-400	azeotrope	R-12/114	A1	--	--	--
R-401A	azeotrope	R-22/152a/124 (53/13/34)	A1	--	--	--
R-401B	azeotrope	R-22/152a/124 (61/11/28)	A1	--	--	--
R-401C	azeotrope	R-22/152a/124 (33/15/52)	A1	--	--	--
R-402A	azeotrope	R-125/290/22 (60/2/38)	A1	--	--	--
R-402B	azeotrope	R-125/290/22 (38/2/60)	A1	--	--	--
R-404A	azeotrope	R-125/143a/134a (44/52/4)	A1	--	--	--
R-407A	azeotrope	R-32/125/134a (20/40/40)	A1	--	--	--
R-407B	azeotrope	R-32/125/134a (10/70/20)	A1	--	--	--
R-407C	azeotrope	R-32/125/134a (23/25/52)	A1	--	--	--
R-407D	azeotrope	R-32/125/134a (15/15/70)	A1	--	--	--
R-407E	azeotrope	R-32/125/134a (25/15/60)	A1	--	--	--
R-408A	azeotrope	R-125/143a/22 (7/46/47)	A1	--	--	--
R-409A	azeotrope	R-22/124/142b (60/25/15)	A1	--	--	--
R-410A	azeotrope	R-32/125 (50/50)	A1	--	--	--
R-416A	azeotrope	R-134a/124/600 (59/39.5/1.5)	A1	--	--	--

Table 11-1 (*Continued*)

Refrigerant Groups[1], Properties[2], and Allowable Quantities[3]

R-500	azeotrope	R-12/152a (73.8/26.2)	A1	1,000[10]	47,000[10]	12.00
73.8%	CCl_2F_2	Dichlorodifluoromethane				
26.2%	CH_3CHF_2	1,1-difluoroethane				
R-502	azeotrope	R-22/115(48.8/51.2)	A1	1,000[10]	65,000[11]	19.00
48%	$CHClF_2$	Chlorodifluoromethane				
51.2%	$CClF_2CF_3$	1-chloro-1,1,2,2,2 -pentafluoroethane				
R-503	azeotrope	R-23/13 (48.8/51.2)	A1	1,000	67,000	15.00
R-507A	azeotrope	R-125/143a (50/50)	A1	--	--	--
R-508A	azeotrope	R-23/116 (39/61)	A1	--	--	--
R-508B	azeotrope	R-23/116 (46/54)	A1	--	--	--
R509A	azeotrope	R-22/218 (44/56)	A1	--	--	--
R-600	$CH_3CH_2CH_2CH_3$	Butane	A3	800	3,400	0.51
R-600a	$CH(CH_3)_2CH_3$	Isobutane (2-methyl propane)	A3	800	3,400	0.51
R-717	NH_3	Ammonia	B2	5,012	500	0.022
R-718	H_2O	Water	A1	--	--	--
R-744	CO_2	Carbon Dioxide	A1	5,000	50,000	5.70
R-1150	$CH_2=CH_2$	Ethene (ethylene)	A3	1,000	5,200	0.38
R-1270	$CH_3CH=CH_2$	Propene (propylene)	B3	1,000	3,400	0.37

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

1 Refrigerant safety group designation is in accordance with Section 1102.0.

2 Refrigerant properties are those needed for this chapter.

3 Allowable quantities are for high-probability systems under Section 1103.0 only.

4 Chemical name shown is the preferred name.

5 PEL is that designated in 29 CFR 1910.1000 unless otherwise indicated.

6 IDLH is that designated by NIOSH unless otherwise designated.

7 Pounds of refrigerant in a high-probability system per 1,000 cubic feet (28.3 kg/m^3) of occupied space. See Section 1104.0. This column does not apply to refrigerant machinery rooms or areas covered by Section 1106.0.

8 The PEL value shown is the TLV-C recommended by ACGIH.

9 The IDLH value shown is reduced from that designated by NIOSH in light of cardiac sensitization potential.

10 A PEL has not yet been established; the value given was determined in a consistent manner.

11 An IDLH has not yet been established; the value given was determined in a consistent manner.

12 OSHA PEL is 50 ppm; ACGIH TLV-TWA is 25 ppm.

|| 13 ***[For OSHPD 1, 2, 3 (Surgical Clinics) & 4]*** *The quantity of refrigerant in each system is limited to 50% of the amount listed. Exception: kitchens, laboratories, and mortuaries.*

TABLE 11-2
Permissible Refrigeration Systems[1]

Occupancy Group and Division	High-Probability System	Low-Probability System	Machinery Room
A–1	Group A1 only	Any	Any
A–2.1	Group A1 only	Any	Any
A–3	Group A1 only	Any	Any
A–4	Group A1 only	Any	Any
B	Group A1 only[2]	Any	Any
E–1	Group A1 only	Any	Any
E–2	Group A1 only	Any	Any
E–3	Group A1 only	Any	Any
F-1	Group A1 only[2]	Any	Any
F-2	Any[2]	Any	Any
H–1	Any	Any	Any
H–2	Any	Any	Any
H–3	Any	Any	Any
H–4	Group A1 only	Any	Any
H–5	Group A1 only	Any	Any
H–6	Group A1 only	Any	Any
H–7	Any	Any	Any
[For OSHPD 1, 2 ,3 & 4] I–1.1	*None*	*Any*	*Any*
I–1.2	Group A1 only	Any	Any
I-2	Group A1 only	Any	Any
[For OSHPD 1, 2 ,3 & 4] I-3	*None*	*Any*	*Any*
M	Group A1 only[2]	Any	Any
R–1	Group A1 only	Any	Any
R–2	Group A1 only	Any	Any
R–3	Group A1 only	Any	Any
S-1	Group A1 only[2]	Any	Any
S-2	Any[2]	Any	Any
S-3	Group A1 only	Any	Any
S-4	Group A1 only	Any	Any
S-5	Group A1 only	Any	Any
U-1	Any	Any	Any
U-2	N/A	N/A	N/A

Note: N/A—Not applicable.
[1]See Section 1105.0.
[2]Any refrigerant may be used within a high-probability system when the room or space complies with Section 1105.3.

TABLE 11-3
Value of for Equation 11–6

Refrigerant Number	*f*
11	1.0
12	1.6
22	1.6
113	1.0
114	1.6
115	2.5
123	1.0
134a	1.6
152a	1.0
500	1.6
502	2.5
717	0.5
744	1.0

TABLE 11-4
Field Leak Test Pressures in psig (kPa)

Refrigerant Number	High Side Water Cooled	High Side Air Cooled	Low Side
11	15	35	15
12	140	220	140
22	230	360	230
113	15	15	15
114	40	80	40
115	275	340	275
123	15	30	15
134a	150	250	150
152a	130	220	130
500	165	265	165
502	250	385	250
717	235	390	235
744*	N/A	N/A	N/A

Note: psi x 6.89476 = kPa, N/A—Not applicable.
*Special design required; test pressures typically exceed 1,000 psig (6890 kPa).